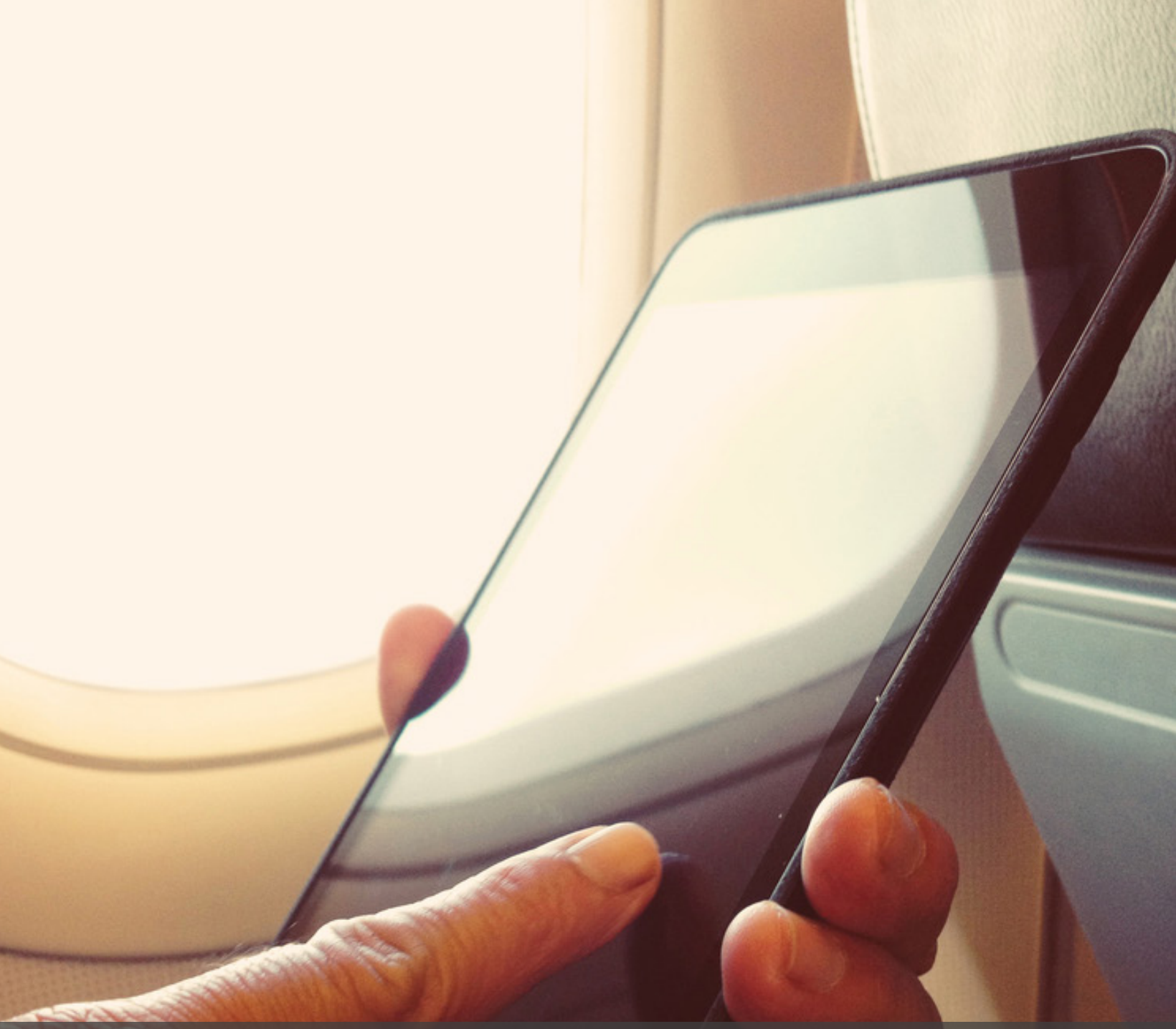

Mobility:

The journey from access point-based solutions to Firetide

Firetide, Inc. White Paper

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Introduction

Transportation systems present unique challenges for mobile connectivity. With vehicles and their passengers frequently in motion, any potential issues must be identified and prevented by the IP network as soon as they arise, necessitating real-time data transactions across a series of reliable base stations. At the same time, the safety of passengers, operating personnel and first responders must be ensured, via incorporated Wi-Fi, video surveillance and other means of high-speed 24/7 communication. This network infrastructure also bears the burden of enabling and extending new solutions such as operational analytics, digital signage and location-based services.

Connectivity has become the lifeblood of everything from internal activities such as liability protection to customer-facing amenities like on-train Wi-Fi access. As such, it demands a network solution that is versatile and capable of meeting a wide range of requirements as far as performance, security, safety and scalability are concerned, while also being optimized for the high-speed environments of modern transits. Are the approaches to mobility that are available today up to meeting these standards for design and operation?

Access points and the evolving table stakes for mobile and wireless connectivity solutions

For a long time, access point arrangements have provided the foundation for the connectivity infrastructure in transportation, as well as in verticals such as oil and natural gas extraction and public utilities (e.g., electricity supply). In all of these settings, there has always been the fundamental need to maintain a consistent connection across the multiple domains and networks that various Ethernet-enabled devices, from laptops to video cameras, regularly move between at very fast speeds. For an optimal experience, other core requirements should now include:

- Switching times of less than 1 millisecond during roaming.
- More than 100 Mbps of available capacity, even under trying (e.g., high-speed locomotion circumstances.
- High, but non-spiking, throughput for maximum network stability.
- Scalability for additional deployments and more intensive levels of usage.
- Low overall latency, jitter and packet loss.

The ability of traditional AP-based approaches to connectivity to meet all of these specific needs is not guaranteed. For starters, transportation providers in particular now expect to run their voice, video and data applications simultaneously across their widely dispersed infrastructures, an exercise that requires purpose-built products and platforms rather than generic access points. For context, a June 2015 survey of 71 transport operators, authorities and station owners, conducted by the International Association of Public Transport, discovered that virtually all responders had surveillance cameras installed on their premises.

Moreover, the vast majority of these groups and individuals also already had cameras and/or recordings in place at their facilities. Well over half – upward of 70 percent – of them had video applications set up at their stations, depots and rail yards, and/or onboard their rolling stocks. Video surveillance is also just one app among many within the transportation sphere, which has become one of the most demanding environments for mobile connectivity today.

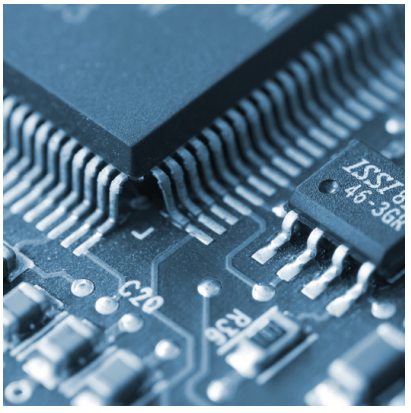
More specifically, IP cameras for video may be utilized alongside Voice-over-Internet-Protocol (VoIP) systems for HD voice communications, Internet access for enhancing security procedures and passenger Wi-Fi that is deployed from the same infrastructure, without the need for its own separate network. It is clear that the stakes for mobile connectivity have risen substantially over time to include the precision and top-flight performance discussed above, delivered from networking solutions built from the ground up for around the clock voice, video and data operations across great distances.

Seamless roaming, uninterrupted video and, ultimately, fiber-like performance from wireless networks are now table stakes for facilitating the experience that organizations in transit and elsewhere, not to mention the passengers and all other customers they serve, expect. Whether AP-centric models can reliably provide this level of baseline consistency is an important question to answer as transportation firms et al consider upgrading their infrastructure for an increasingly connected world.

Understanding what a robust mobile connectivity solution should provide in transportation

To see what the ideal answer to mobile connectivity issues in transportation of today looks like, it is crucial to first see where traditional solutions - namely ones oriented exclusively around APs – have fallen short. We can categorize their shortcomings in a few main areas: IT integration, network performance and ultimate scalability and flexibility.

These three buckets broadly capture the beginning, middle and end of network deployments, from how they are set up to how they are evolved for new use cases and requirements. Let's look at each one in a bit more detail to see what could be improved about AP-based solutions.



IT integration

Setting up network infrastructure, in this case access points, can quickly become complicated due to different types of associated equipment (e.g., assorted Ethernet switches), various security policies and disparate approaches to virtualization and segmentation across a network. Add in the vast distances covered by buses, trains, subways and public safety vehicles, as well as their fast speeds (up to 50 miles per hour or more in some instances), and there is a potent recipe for something to be off just enough to result in lost time and money, plus suboptimal connectivity for official personnel and end users alike.

Ideally, mobile connectivity would be available with one touchpoint for IP management and a single virtual switch. The entire network would in this way be centrally managed, policies could be painlessly integrated and VLAN setup would be seamless. The stakes for VLAN failure are high, as it is quite simple to make a mistake in implementing one that ends up disrupting the workloads running on a physical server and results in interrupted connectivity.

Access and backhaul should be available in a combined solution that is easy to integrate into everyday IT networking. The inclusion of Simple Network Management Protocol support would also allow for integration of wireless base stations with commonly used systems such as HP OpenView and IBM NetView.

Network performance

Speaking of which, these sorts of interruptions and other hiccups across the network have in the past given traditional wireless networks, built primarily around APs, a reputation for being unsuited for handling some mission-critical applications. This perception is unfortunate, since choosing the wireless route can not only save significant CAPEX on fiber and other typical cabling, but also allow for much more rapid scaling than any strictly wired setup.

To effectively run voice, video and data applications over wireless infrastructure in transportation, the network must have carrier-grade reliability, capable of ensuring faultless failover during the event of a fiber break. Moreover, it should be able to achieve close to zero downtime by way of rerouting its application traffic through smart wireless equipment with superior throughput compared

with popular wired alternatives such as Fast Ethernet, T1 lines and OC-3 fiber. Flow-based instead of destination-based routing is ideal for balancing traffic across the entire infrastructure, optimizing throughput and improving overall network performance.

Digging into a few more specifics, handover between voice and video traffic should be hassle-free (i.e., with no packet loss) and literally gigabytes of data should be offloadable within the short windows of time in which vehicles may pass a camera or other piece of IP-enabled equipment. Jitter and latency must be minimized along the way in order to ensure secure end-to-end transmissions - any degradation in latency can jeopardize safe voice or video backhaul. Per hop encryption and decryption are also integral for completely secure performance.

Ultimate scalability and flexibility

With many network architectures, adding more hops is a surefire way to decrease overall throughput. This degradation happens when relying upon Wi-Fi/AP-based mesh networks as well as with PTP/PTMP products, with throughput dropping with each additional wireless hop.

Just as throughput typically falls as hops increase, latency rises at the same time, especially with traditional approaches to routing. The underlying issue is that the associated protocols were not designed from the ground up for bandwidth-intensive applications such as multi-stream video and HD voice in mind, nor were they often architected to be low-overhead.

All of these limitations can make network scalability particularly challenging in light of how they are added on top of the more apparent cost deterrents that come with extending traditional mobility infrastructure. A better scenario would entail being able to effortlessly add many nodes to the network without risking any degradation in performance or breaking the bank of implementation costs.

Use cases: In what scenarios are mobile connectivity solutions expected to excel?

With an ideal connectivity solution in place, one that could overcome the shortcomings – in particular in initial IT integration, subsequent network performance and ultimately scalability and flexibility into the future - elucidated above, what would it actually achieve? As mentioned at the beginning, expectations have never been higher for wireless networks, which are counted on by transit providers and their customers to bundle reliable services with maximum convenience.

There are many circumstances under which the particular quality of wireless connectivity makes or breaks the efficacy of voice, video and data applications. Let's look at a few examples:

Customer and personnel safety

Onboard incidents on trains or other forms of mass transit can be both unpredictable and highly disruptive to everyone's safety. Video, especially of the live variety, is often a valuable resource in these situations because it provides a real-time window into what is happening on the ground. Response tactics from police in the vicinity can be adjusted - granted, that is, they can receive a usable video feed from the cameras designated for specific vehicles.

Real-time video requires a combination of high throughput and low latency (around 1 ms per wireless hop). APs and PTP/PTMP may not offer this level of reliability. However, more modern alternatives can supply it in spades to help minimize the impact of any onboard disturbances through support for video.

They may also enable effective communications between other first responder teams, such as easy connections between buses and police vehicles during crises. Offloading is especially important in such contexts for sharing video and other data when a vehicle pulls into a station or comes within proximity of a first responder.

Passenger Wi-Fi

Commuters and travelers of all sorts have grown accustomed to having dependable wireless connectivity wherever they go. For example, the perceived value of integrated Wi-Fi in transportation was underscored in a 2014 study from Honeywell, which found that more than one-third of airline passengers would be willing to show up for a flight up to three hours in advance if doing so would result in superior wireless speeds.

The same report revealed that 29 percent would swap a guaranteed ticket for a standby one if it meant that the onboard Wi-Fi would match the performance of their home Internet connections. Many others admitted to a willingness to forego meal service or even available lavatories for better mobile connectivity. With ground transportation, from buses to subway trains, Wi-Fi can similarly be a source of competitive advantage and positive customer experience, as long as it has strong infrastructure to draw upon and simplified management (e.g., being deployable without the need for a separate network).

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Business operations

Robust wireless connectivity is a powerful asset in streamlining how a business is operated. With the right levels of speed and reliability, a wireless network can provide real-time insights into evolving conditions in and around the organization's infrastructure. These effects could include those of inclement weather, congested traffic and emergency situations.

A solution with the abilities of self-learning and self-forming can help businesses adjust to these changes on the fly, without a loss in service or even any degradation in performance. Immediate responses can be drawn up, plus the wireless mesh infrastructure can be formed into ad hoc response centers as the incident may require.

In the same way, temporary networks can be rolled out to help with specific workflows or threat assessments. A mobile command center could be supported with strategically placed, plenum-rated wireless equipment, in tandem with a built-in 4-port 10/100 Mbps Ethernet switch designed to support digital video cameras, GPS receivers, multimedia communications systems and mobile data terminals.

Tollway connectivity

Many transportation systems are making the transition to cashless options. Toll booth operators in particular have every incentive to streamline the often slow process of handling motorist transactions, through the use of strong connectivity to process electronic payments on the fly and in potentially large quantities.

Cabling is usually too expensive to be practical for this situation. Top-flight wireless can fill the gaps by automating toll collection, enabling electronic messaging and lessening the overall operational need for manpower and manual actions.

Intelligent transportation systems

Traffic analysis and HD video are dependable tools for combating the all-too-common congestion in many of today's car-centric cities. Together, they can form a solid foundation for intelligent transportation systems (ITS) that smartly route passengers to optimal routes and relay real-time information to municipal agencies so that they can come up with the proper responses.

These ITS are on the rise. The U.S. Center for Transportation Analysis at the Oak Ridge National Laboratory has charted the steady growth in the number of freeway miles covered by surveillance cameras, traffic data collection technologies and Dynamic Message Signs (i.e., digital signage) between 2000 and 2013. Given the scale of many highway systems, wired connectivity will not be feasible – effective wireless will be the only practical option.

Firetide wireless mesh networks and the future of high-speed connectivity everywhere

These diverse use cases, along with many others, require a level of performance that, as we can see from the essential relationships between hops/throughput and hops/latency, traditional approaches to mesh networking cannot supply. Enter Firetide's patented, award-winning wireless mesh solutions, which have the proven ability to extend high-speed network infrastructure in the demanding transportation field and provide excellent 24/7 mobile connectivity for everyone from passengers to security teams.

The Firetide advantage

Transportation infrastructure requires fiber-like reliability from a wireless network. In reaching this level of performance, Firetide wireless mesh networks go above and beyond the PTP/PTMP and Wi-Fi/AP-based solutions of the past by implementing:

- Truly redundant mesh topologies that connect each node to every other node in order to support efficient load balancing and self-healing.
- Lowest possible latency, without any of the degradation seen in traditional AP arrangements; up to 15 hops are supported at under 1 ms for each hop.
- Flow-based routing for optimizing aggregate throughput.
- Linear scalability thanks to mobile nodes that can be attached to available static ones in order to transfer data even at high speeds.
- Safe end-to-end packet transmission protected by 256-bit key size AES encryption.
- Real-time responsiveness - which was always beyond the reach of legacy approaches to mobility – for applications such as IP-based video surveillance, VoIP telephony and wireless networking at depots.
- A familiar distributed Ethernet paradigm and intelligent algorithms, which together support seamless roaming across multiple wireless mesh networks.

- Fiber-quality bandwidth that enhances the roaming experience and also enables the utilization of multiple HD video streams.
- Automated wireless offloading of recorded video.
- Sustainability at speeds greater than 90 mph in transit.

The result is a comprehensive connectivity platform that delivers more than just high speeds and zero downtime. It also ensures the safety of passengers and operators, the protection of property and liability and the availability of a wide and growing range of services.

Moreover, Firetide solutions excel where their predecessors struggled, namely in the areas of IT integration, network performance and ultimate scalability and flexibility discussed in depth above. The distributed Ethernet design allows for no hassle setup, mesh wireless between nodes such as the Firetide 7020 ensures carrier-grade reliability and, finally, the built-in spectrum analysis, capacity planning and antenna alignment tools within Firetide products enable rapid deployment.

The Firetide HotPort 7000 Wireless Mesh Nodes, Mobility Controller, HotView Pro Network Management Software and HotPoint Wireless Access Point are the building blocks of robust modern mobile connectivity. In concert, they support the simultaneous delivery of multiple high-bandwidth services, with pain-free roaming and intuitive management and hardware placement options.

Firetide solutions in action

Hypothetical or claimed network results are fine, but how do these solutions actually behave in the real world? Practical applications for Firetide, such as offloading and live viewing, have been thoroughly proven in the field throughout the world. Transit providers such as the Massachusetts Bay Transit Authority, the Seoul Metropolitan Subway in South Korea and the City of Scottsdale (Arizona) have implemented Firetide solutions to provide the future-proof connectivity needed in transportation.

Approximately 1,500 mesh nodes are spread out across the world's longest subway system, being implemented on more than 200 trains and in 148 stations in the area.

For instance, for the MBTA a series of mesh nodes are in place within buses, trains and emergency vehicles, as well as in stations and parking lots. This deep infrastructure allows for the offloading of video to police vehicles as necessary, providing an important boon to overall public safety by helping first responders stay ahead of criminal activity.

Similar benefits have come from deployments in Seoul and Scottsdale. In Seoul, approximately 1,500 mesh nodes are spread out across the world's longest subway system, being implemented on more than 200 trains and in 148 stations in the area. These implementations support the capture of real-time video and the broadcast of information from moving trains. Passengers accordingly get access to real-time data, while operators can readily view conditions at the upcoming stations without network issues hampering oversight efforts.

The Traffic Management Center in Scottsdale uses 90 Firetide HotPort 7020 wireless mesh nodes in addition to 86 pan-tilt-zoom digital cameras placed at some of the city's busiest intersections. Using these devices, personnel at the TMC can effectively and continuously monitor traffic from afar. This close attention and oversight can be used to reroute vehicles to help alleviate congestion. Plus, it helps during the traffic spikes that can occur during special events like big sports games, in emergency situations and whenever inclement weather conditions strike.

Superior mobile connectivity for today and tomorrow

Top-notch voice, video and data mobility have become table stakes in transportation and many other industries. However, solutions based on strict Wi-Fi/AP and PTP/PTMP are more often than not unable to deliver the experiences that operators, first responders and passengers have now come to expect.

Firetide's wireless mesh solutions have addressed the key shortcomings in their predecessors and paved the way for the spread of mobility that can support many concurrent high-bandwidth applications like voice and video. As a result, everyone's safety can be improved, data can be put to work in settings such as ITS and tollways and transportation infrastructure can be optimized for future uses like the Internet of Things.

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