WHITE PAPER

Implementing Passenger Wi-Fi Networks: Five Key Considerations

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Moxa is a leading provider of edge connectivity, industrial networking, and network infrastructure solutions for enabling connectivity for the Industrial Internet of Things. With over 30 years of industry experience, Moxa has connected more than 50 million devices worldwide and has a distribution and service network that reaches customers in more than 70 countries. Moxa delivers lasting business value by empowering industry with reliable networks and sincere service for industrial communications infrastructures. Information about Moxa's solutions is available at www.moxa.com.

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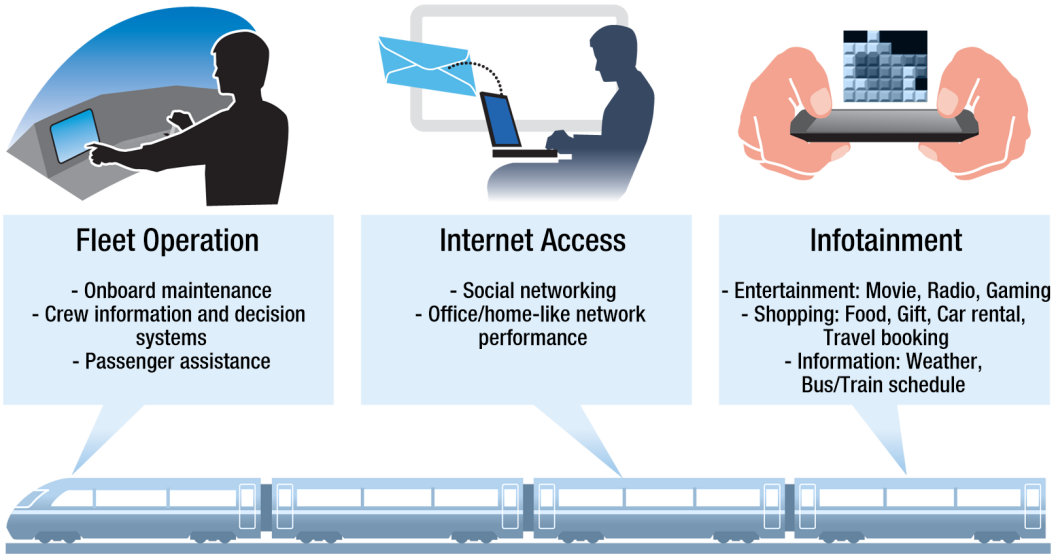
Overview

In recent years, the use of mobile devices for information and communication has changed passengers' expectations about railway travel. As well as expecting a comfortable journey, passengers are increasingly demanding Internet access and the ability to work on board, to make efficient use of their travel time.

According to a railway industry survey[1], 65% of the respondents plan to provide Wi-Fi connectivity to passengers by 2016 and 60% expect to provide content over Wi-Fi within five years.

Beyond simple Internet access, railway operators have also begun to recognize that they can leverage on-board Wi-Fi networks to support a variety of operational and passenger infotainment applications. A digitally-connected fleet enables real-time system status reporting and better information flow. These services make operations more efficient, reducing costs, improving service quality, and raising customer satisfaction.



[1] http://nomad-digital.com/uploads/ND_A4_Industry_White_Paper_240315_high-res.pdf

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Connecting hundreds of passengers to the Internet at the same time is a daunting task, far harder than operating a simple home or office Wi-Fi network. This whitepaper discusses the challenges of on-board Wi-Fi networks and the top five considerations for selecting products to serve a high-density Wi-Fi environment.

Challenges of a High-Density On-board Wi-Fi Network

The huge growth in use of smartphones and Wi-Fi-enabled mobile devices is the catalyst for the increased usage and ubiquity of Wi-Fi connectivity in public places. In response to the explosive growth in data volume, service providers are off-loading traffic from their cellular networks to Wi-Fi networks. Additionally, the changes in user behavior and data network landscape have created a huge challenge for railway operators: to provide enough bandwidth for each passenger in a high-density environment. A traditional enterprise Wi-Fi deployment—just aiming to provide coverage—is no longer enough. In a high-density Wi-Fi infrastructure, operators must look for a solution that combines reliability, coverage, bandwidth capacity, and reliability, to ensure a seamless user experience.

Five Keys to Successful High-Density Wi-Fi Deployment

Here are the top five factors to consider when choosing a Wi-Fi solution for high-density deployment in industrial applications—beyond supporting the same standard features as general-purpose access points.

1. Reliability

An access point (AP) plays a central role in connecting passengers to the on-board Wi-Fi network. However, although many enterprise solutions are available, few meet the requirements of rolling stock operations. Access points suitable for use on trains must include the following characteristics:

- **Wide Operating Temperature:** On-board APs could be exposed to extreme hot or cold. The EN 50155 standard specifies the operating temperature criteria for different classes of devices. The EN 50155 Tx Class defines the widest operating temperature range of -40 to 70°C. To ensure on-board network reliability, APs should be tested to conform to the classification level required for rolling stock applications.

EN 50155 classification and operating temperature range

Standard	Operating Temperature Range
EN 50155 T1 Class	-25 to 55°C
EN 50155 T2 Class	-40 to 55°C
EN 50155 T3 Class	-25 to 70°C
EN 50155 Tx Class	-40 to 70°C

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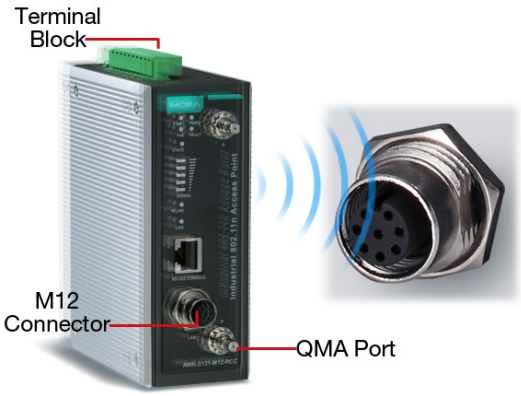
- **Anti-vibration/Anti-shock Connector Design:** In an on-board Wi-Fi network, APs usually need to be physically connected to various devices. Many of these devices use a variety of interfaces, such as serial ports, LAN ports, and digital input/output channels. However, shock and vibration are a fact of life on moving trains. APs with an M12 connector for digital communication and QMA antenna ports will ensure reliable cable connections, able to withstand the tough conditions.



- **Dual Isolation Protection:** Stronger electromagnetic protection can help minimize the possibility of system downtime and deliver continuous wireless transmission. Dual isolation is very crucial especially for gas turbine/diesel locomotive applications to prevent sparks when the devices are powered on and off. At the same time, to protect the wireless devices, isolation between systems and the connectors of power inputs and antennas is required.

- **Versatile Power Input:** Power voltage on trains does not always stay constant. There can be sudden changes in voltage simply from the starting or stopping of the train. These voltage dips and surges can damage electronic components and render an AP inoperable. To ensure reliable network connectivity on trains, choose a Wi-Fi solution with at least a 30% voltage tolerance range.

2. High Throughput

It is difficult to predict how much bandwidth each passenger needs to enjoy seamless network connectivity whilst travelling. Estimates are usually based on studies of application usage and user behavior. In an average home or office, 50 or 100 Mbps is adequate to enable Internet access for multiple devices simultaneously. However, with passengers having more than one device, and considering other factors constraining AP throughput, a study concludes that passengers are often left with 2 to 3 Mbps of bandwidth for applications.

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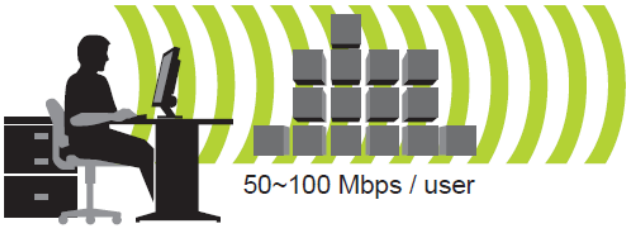
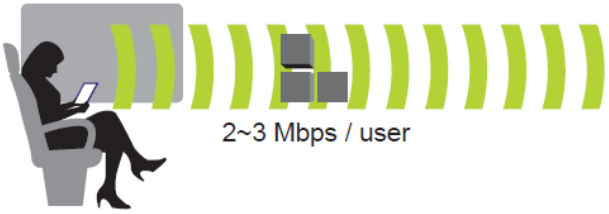


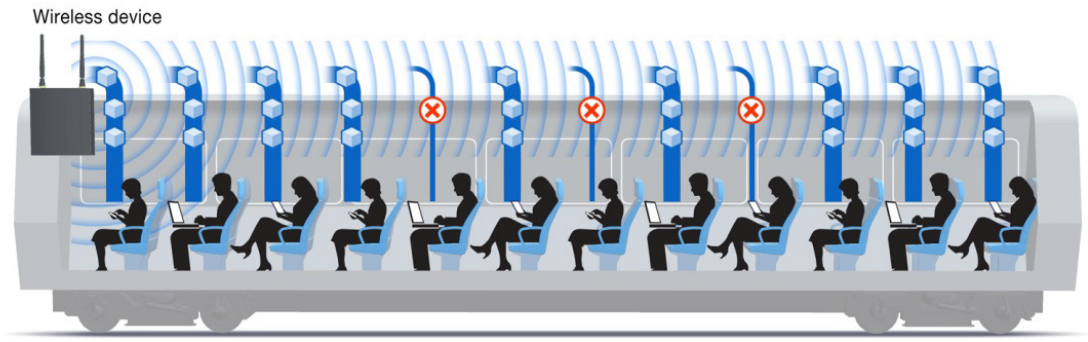


In addition, the type of Wi-Fi technologies (a/b/g/n/ac) and applications used can affect the total network capacity. For example, an AP supports varying speeds, but throughput degradation is unavoidable if the network is to support devices in legacy modes. On the other hand, passenger Wi-Fi service types or packages may also impact and limit the throughputs offered to passengers.

By taking into account the multiple factors, such as the complexities of the technologies and user behavior, railway operators can design a Wi-Fi network with high throughput to ensure a positive user experience.

3. High Density Connectivity

If a conventional wireless network is deployed in a high-density user environment, it is not hard to predict the result: poor user experience. Especially at live events and on trains where hundreds of users are trying to access the Wi-Fi network at the same time. To provide a good user experience, one study recommends deploying one AP for every 60 users. For example, a train carriage that carries 100 passengers will require at least two APs, with both 2.4 GHz and 5 GHz channels, each serving as many passengers as possible in different bands. If not enough APs are deployed, some passengers may experience poor connection quality.



Bandwidth-intensive applications such as YouTube reduce the number of users an AP can service. Therefore, in addition to a good AP/user ratio, knowing which applications need to

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be supported and their bandwidth requirements allows better AP placement and improves bandwidth utilization. This table shows bandwidth required by common applications.

Bandwidth Requirements for Common Applications

Application	Bandwidth
Netflix HD Quality[2]	5 Mbps
FaceTime[3]	500 Kbps - 1 Mbps
YouTube[4]	500 Kbps - 1 Mbps
Web Browsing	1.5 Mbps
Skype (HD)[5]	1 Mbps
Facebook video calls[6]	500 Kbps

While challenging, finding out how application bandwidth requirements affect capacity is an important step towards designing a high-performance, high-density Wi-Fi network.

4. Client Load Balancing

When too many client devices try to connect to an AP, the bandwidth available for each client device decreases, eventually resulting in poor connectivity and user experience. With client load balancing, railway operators can limit the number of client devices that can connect to an AP. When this limit is reached, the AP can refuse any new connection requests, forcing client devices to connect to other APs, thereby sharing the available radio channels evenly among client devices in the area. Additionally, client load balancing allows APs to prevent client devices from connecting to a congested channel, encouraging an even distribution of available bandwidth for all client devices.

Although, APs cannot force client devices to connect to a specific channel under the IEEE 802.11 specification used by Wi-Fi, there are mechanisms to ensure uniform client associations on all channels on the Wi-Fi network.

Because a client device always connects to the AP with the strongest channel, an inconsistent load condition can still occur in a high-density environment with uniform client distribution. For example, if a large number of client devices happened to be active in a single train carriage, they could connect to only one AP, causing slow connections or even no connection for some passengers and leaving other APs with light loads.

[2] https://support.netflix.com/en/node/306

[3] http://support.apple.com/kb/HT 4534

[4] https://support.google.com/youtube/answer/78358?hl=en

[5] https://support.skype.com/en/faq/FA1417/how-much-bandwidth-doesskype-need

[6] https://www.facebook.com/help/325947034156919/

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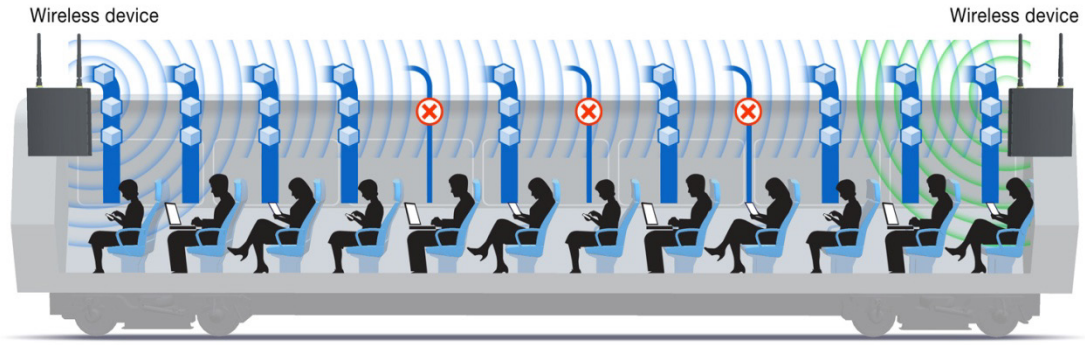


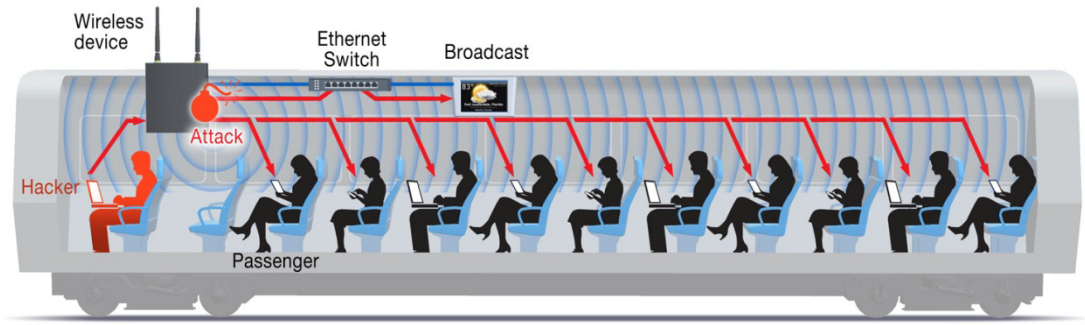
To provide maximum bandwidth for all client devices and enable the even distribution of client devices in a high-density environment, an AP should support effective automatic client load balancing that takes into account the following factors:

- Optimum number of client devices on a channel
- Signal strength
- Favoring 5 GHz channels over 2.4 GHz channels

5. Wireless Client Isolation

Railway operators must implement client isolation in a public Wi-Fi network to prevent client devices from communicating with one another; they can only access the Internet. This serves two purposes—it increases network security and limits broadcast traffic.

Every device that connects to on-board APs belongs to the same network, including onboard systems such as broadcast or other control systems. However, unlike a home network where one can freely access resources on different devices, passengers and train operators do not need to access each other's devices. In fact, they do not want to share resources or information with others, especially with any hackers lurking on a public wireless network.



Wireless client isolation prevents wireless clients from directly communicating with other wireless devices on the same network. This provides an added layer of protection against passengers gaining access to other devices for malicious purposes.

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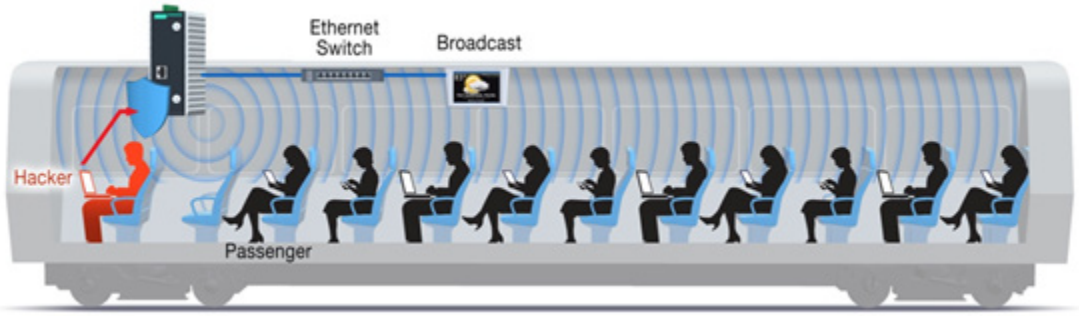

Although broadcast traffic is essential in network discovery and content delivery, it is mostly redundant on a public Wi-Fi network. By using client isolation to limit broadcast traffic between wireless devices, passengers can utilize the bandwidth that would otherwise be used for broadcast traffic, enhancing overall network performance.

Conclusion

The rise of smartphones and other mobile devices has driven the demand for ubiquitous Internet access, including access for train passengers. An intelligent Wi-Fi solution for a high-density environment allows railway operators to provide both cost-effective operational applications and passenger infotainment applications that can generate additional revenue streams.

The design of a high-density Wi-Fi network is a complex process. By considering a number of important factors – network reliability, data rate, mixed mode client ratios, load balancing, and network security – railway operators can choose an effective Wi-Fi solution that meets the requirements of rolling stock applications.

To learn more about Moxa's AWK-RCC series wireless devices tailor-made for railway onboard high-density environments, please visit the product website:

https://www.moxa.com/product/AWK-3131A-M12-RCC.htm

To know more about Moxa's onboard passenger Wi-Fi solution, please visit the microsite:
https://www.moxa.com/Event/integrated-solutions/railway/passenger-wi-fi/index.htm

More Info

Visit Moxa's website at www.moxa.com/rail for product details, or subscribe to our railway newsletter at www.moxa.com/railnews to stay up-to-date with the latest railway trends and learn about Moxa's newest IP-based solutions for railway applications.

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