InfiNet wireless

Train-to-Ground

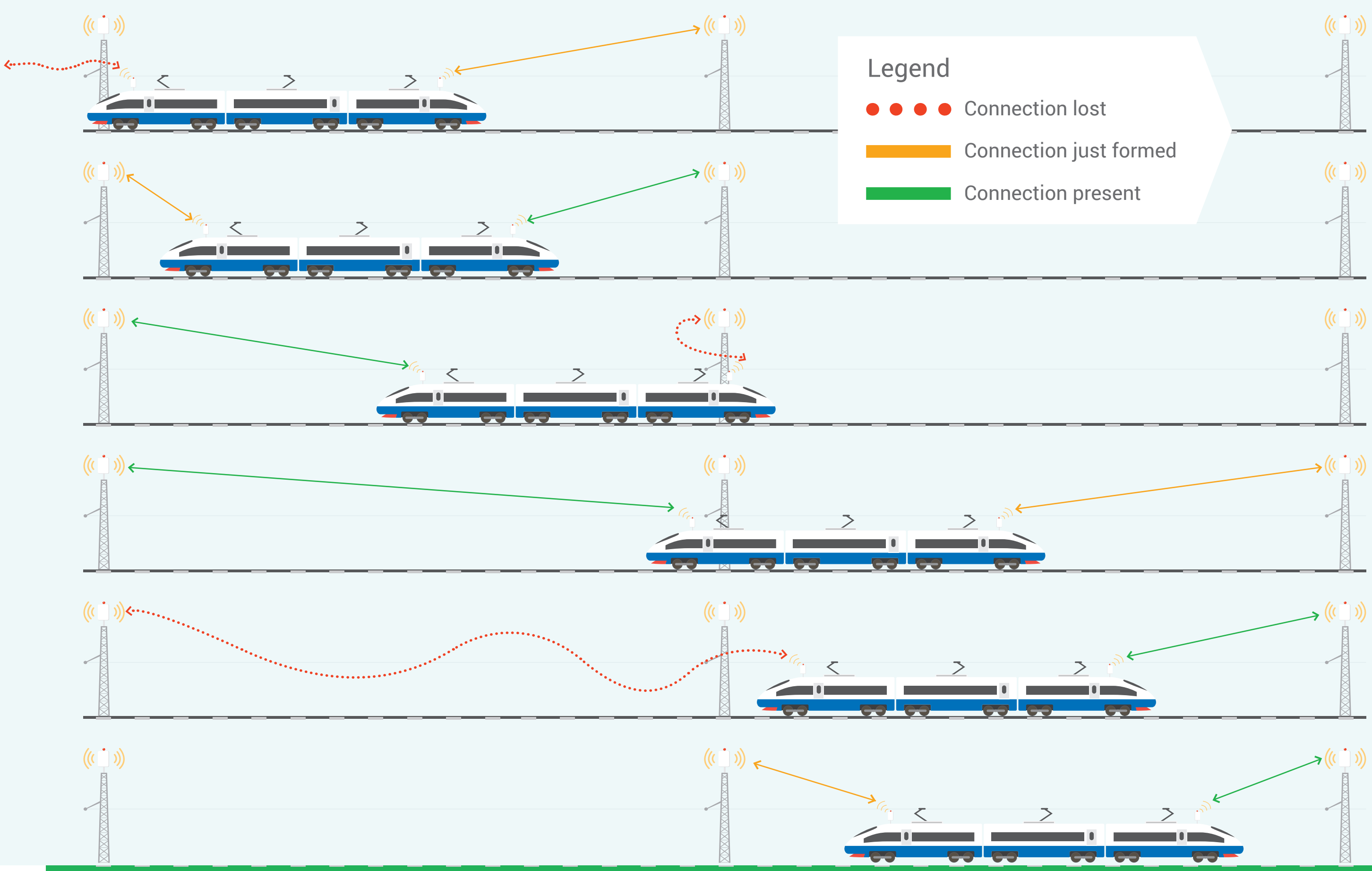
- Wireless solution for uninterruptable data transfer and video communication in motion between train and data center
- Provides broadband services to passengers including Wi-Fi streaming services like YouTube
- Video surveillance and security services work at the same time as customer services
- Unique scalable architecture for metro & rail projects. IW units can create different topologies and provide quick handover and redundancy capabilities

Application Notes

Train-to-ground Challenges

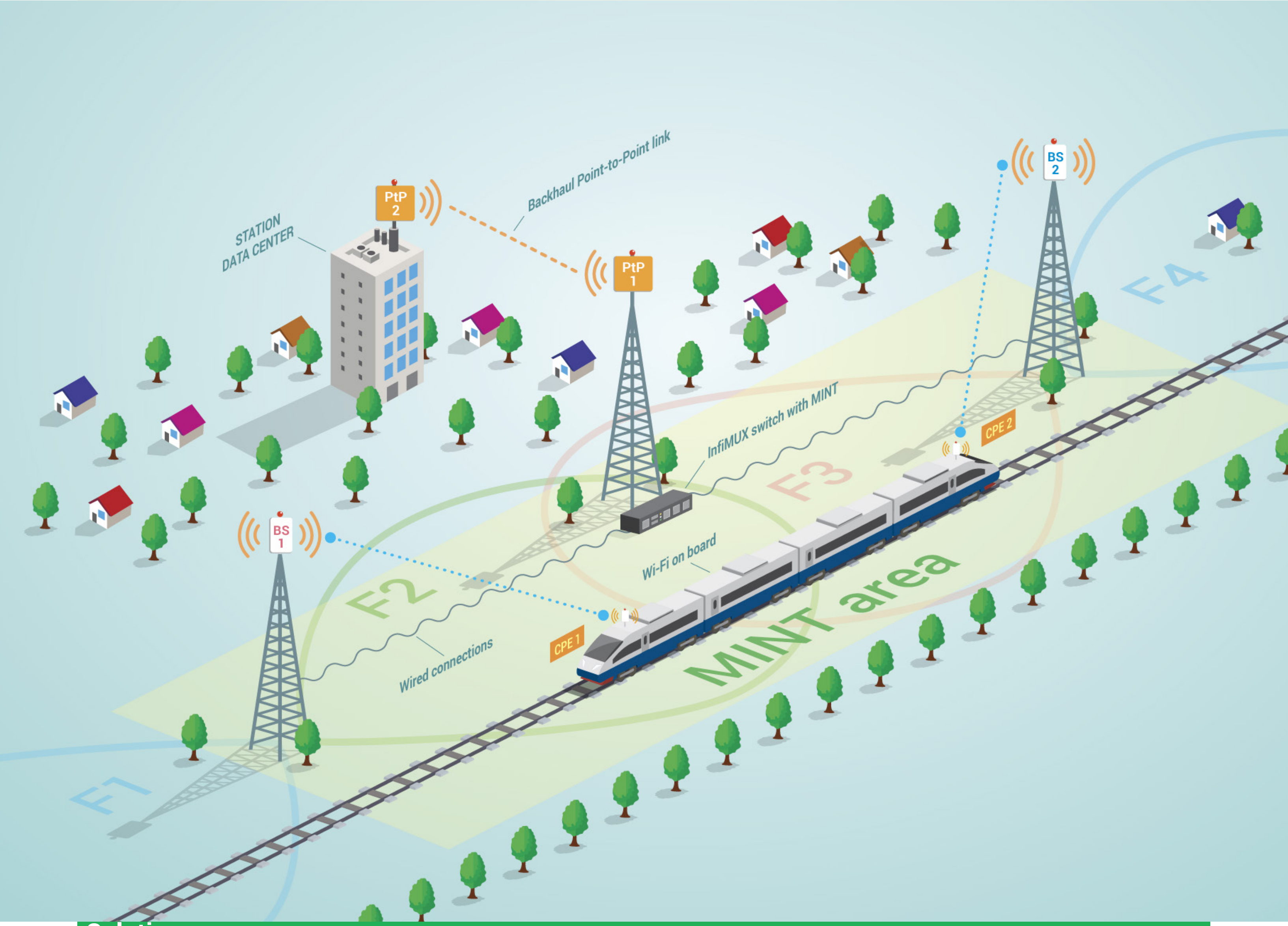
Each train project (for surface and subway) has two main tasks to fulfill.

Task #1	Handover between Base Stations (BS)
Challenges	
Coverage	Wireless links experience disconnects, especially in tunnels. Modern communication, online interactive services and video surveillance are highly sensitive to ANY loss of connectivity. Safety implications require zero disconnects in order to control the situation onboard.
Reliable communication	Metro tunnels are not straight; trains are very fast and multiple reflections, interferences and high noise level incur significant challenges to wireless broadband systems.
Persistent high quality provision	Services provided onboard trains should have reliable quality for different services types including real-time applications, VoIP, streaming services, video surveillance and security services.



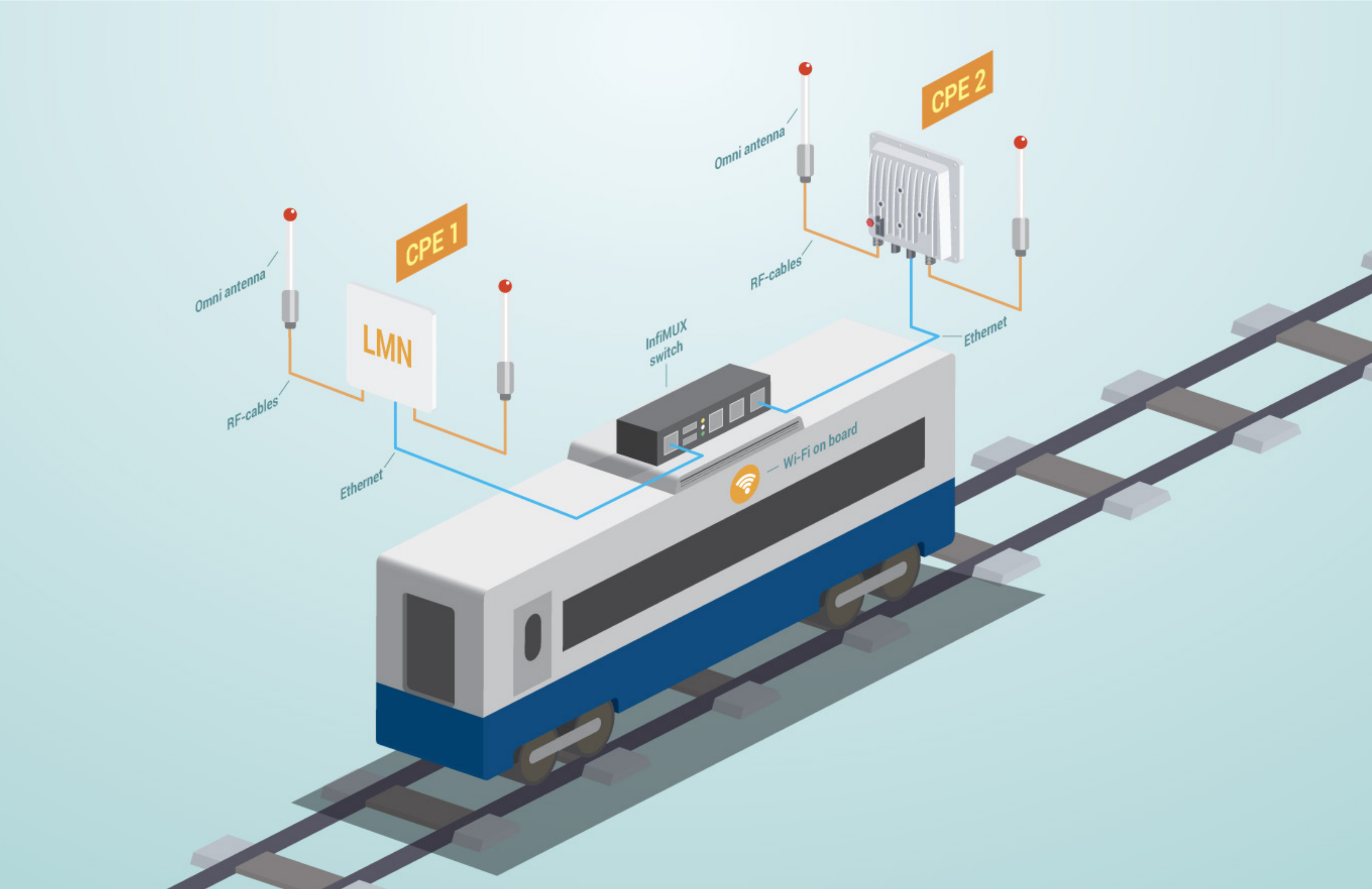
Solutions	
Coverage provision	The BS location and frequencies plan should consider trains to be always within the coverage zone of at least one BS. Therefore BS coverage zones should intersect each other.
Communication reliability	The handover process should ensure that at least one of CPEs always has connection to one BS. At least two CPEs are required. IW recommends the installation of one CPE on the front and the second on the back of the train. Distances between BS locations can be adjusted to provide enough signal margin to have a reliable handover process. CPE locations on trains, due to antenna diversity and signal duplication, provides redundant connections forcing at least one live wireless link all the time. Synchronized communication (due to TDMA technology) between BS and CPE eliminates reflections and mutual interferences.
High quality control	MINT protocol main benefit: minimal time for data delivery with constant link quality check. Therefore MINT guarantees utilization of the best connection all the time no matter how frequent the reconnection of CPE's between BS. The passengers onboard the train will have minimum latency for interactive services and video surveillance will show live picture without delays.

Task #2	Keep bidirectional traffic flow of customer's services continuous no matter which BS the CPE is connected to
Challenges	
Redundant L2 topologies cause switch loops	Common solution has drawbacks due to the frequent re-connects between BS. Additional CPE installations to have more than one active connection from the train could results in unpredicted delays due to the switch loops, or due to the STP protocol operation (required to select one path and block one path).
Inefficient path	In motion, during transition between BS (due to movement along the metro rails) the MAC-addresses of the L2 data traffic path will always change. Therefore, distribution switches will freeze switching preserving the inactive L2 path through unused BS until the expiration of inactive L2 path.



Solutions	
Redundancy and route optimization	MINT protocol has the capability to work with multiple redundant paths, to optimize data flow using all available connections from one customer point to another. IW recommends the use of at least two CPEs in order to have two different paths to deliver customer traffic. Path selection and traffic flow switches between paths handled by the unique IW transport protocol MINT.
Inefficient path	MINT encapsulates Ethernet protocol and distribution switches use MINT demarcation units (between MINT and Ethernet) as the final MAC-address to send and receive traffic. Switches located within MINT area do not participate in global MAC-address learning (due to MINT-over-Ethernet technology) – they work only with adjacent MINT neighbors and with their MAC-addresses.

Typical solution architecture



- Two BS units connected back-to-back form multi-sector BS for mobile CPE connections. Each BS unit should have radio horizon aligned along the rails.
- It is recommended to set different frequencies (F1, F2, F3, F4) to 4 different sequential sectors to avoid mutual interferences.
- On the front of each train two omni antennas mounted and connected to one CPE1.
- The back face of the train (easily converted to front) also has two omni antennas connected to another CPE2.
- Inter-wagon communication could use IW units as well. Two CPEs easily fulfills this requirement.
- Each IW unit has configuration for MINT-over-Ethernet to establish both full and closed MINT area.
- InfiMUX switches will aggregate links, act as border switch between Ethernet and MINT areas, load balance traffic.

Equipment selection

BASE STATIONS – mounted back-to-back along the train route. Each BS antenna utilizes diversity and ensures data delivery by second channel. Moreover, it is possible to ensure additional redundancy and reliability via the installation of additional BS in adjacent locations. It is recommended to place BS on the tunnel ceiling (walls are less recommended). Metro projects require that the distance between each pair of BS should be from 600 meters to 1 km depending on the tunnel shape and signal propagation and reflections. Open ground projects require each BS to be located from 3 to 6 km from each other depending on the ground profile.

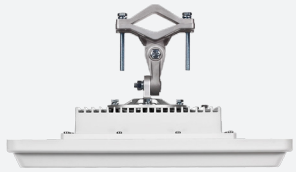
BS UNITS RECOMMENDATIONS

Mmxb with 16 dBi wide-beam integrated antenna

IW recommends the use of 16 dBi antennas for wide metro tunnels, especially with two or more railways

Mmx with 23 dBi narrow-beam integrated antenna

IW recommends the use of 23 dBi antennas for single tunnels, especially with long passages between metro stations (and long passages between BS too)



SUBSCRIBER TERMINALS – at least two mounted in each train.

IW recommends using connectorized version of CPE to give the flexibility to choose different antenna types depending on customer requirements. Each CPE uses two omni antennas, suitable for train mount, for example shark-wave antennas. For surface projects, it is for one of the antenna to have directional radiation pattern.

CPE UNITS RECOMMENDATIONS

Lmn unit with 2x N-type (F) connectors for external antenna

InfiMUX switch

The main features of InfiMUX:

- Border unit between Ethernet and MINT protocols
- Aggregation for multiple MINT units
- Load-balancer for multiple MINT links

Solution Key Features And Highlights

- Fast uninterruptable handover process. Typical handover time is less than 50 ms.
- Redundancy path optimization in order to deliver data as fast as possible.
- High capacity throughput up to 180 Mbps max per each CPE.
- Low latency and predictable jitter due to TDMA protocol.
- Advanced QoS to guarantee required SLA service.
- Non Line-of-Sight and near Line-of-Sight operation.
- Controlled Uplink/Downlink ratio.
- Train speed could be up to 150 km/h.
- 4950-6050 MHz frequencies supported for 5 GHz units while central frequency change step is only 125 kHz.
- IP67 and IP66 protection available for all units.
- Compliance with HAZLOC and ATEX certificates to operate in hazardous and potentially explosive atmospheres.