AMiT Wi-Fi systems overview

Abstract

This document describes basic architectural and technical aspects of AMiT Wi-Fi systems. It is intended to provide basic understanding of the system, which should allow the reader to make informed decisions when considering such a solution.

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Document: an0001_en_01.pdf

Appendix

File: –

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Table of contents

Revision history

Version	Date	Author of change	Changes
001	7. 6. 2016	–	New document

Related documentation

1. **WRTB1** – LTE Router – datasheet, for example WRTB1CC034201 datasheet
   file: wrtb1cc034201_d_en_xxx.pdf
2. **WRTB1xx** – LTE Router – Operation manual
   file: wrtb1xx_g_en_xxx.pdf
3. **WAPB1C201** – Wi-Fi Access Point – datasheet
   file: wapb1c201_d_en_xxx.pdf
4. **WAPB1C101** – Wi-Fi Access Point – datasheet
   file: wapb1c101_d_en_xxx.pdf
5. **WAPB1xx** – Wi-Fi Access Point – Operation manual
   file: wapb1xx_g_en_xxx.pdf

1. Introduction

This document provides an overview of Wi-Fi systems offered by AMiT company. These systems are designed to provide passengers with on-board Wi-Fi connection to the Internet, utilizing several GSM/UMTS/HSPA+/LTE modems.

Additionally, some more technical aspects of the system are discussed and basic guide how to choose an appropriate solution is provided.

1.1. How to read this document

The document should allow you to safely jump to any chapter you need to consult.

For brief introduction and feature overview, see chapter “3 Features of the system”. For hardware feature overview, see chapter “5 Hardware features and limitations”.

To understand how the Internet connection works, refer to chapter “4 Principle of operation”. Questions about SIMs should be answered chapter “4.4.1 SIM placement”.

Chapter “8 System designer’s guide to Wi-Fi system”, provides some tips on how to choose the right design for your project.

And finally chapter “6 Antennae connection”, is here to help you, should you have any difficulties regarding proper antennae connection.

2. Terminology

2.1. Common abbreviations

CDMA
Common name used for IS-95 – 2nd generation of mobile networks used mostly only in the USA

GLONASS
Global Navigation Satellite System

GPS
Global Positioning System

GSM
Global System for Mobile Communications – 2nd generation of mobile networks

HSPA+
High Speed Packet Access – late update for 3rd generation of mobile networks

LTE
Long Term Evolution – 4th generation of mobile networks

QoS
Quality of Service – techniques for prioritization of network traffic

SIM
Subscriber Identity Module – Identity module used in GSM and its successors

UMTS
Universal Mobile Telecommunications System – 3rd generation of mobile networks

WAP
Wireless access point, sometimes denoted as WAPxxx (example model name: WAPB1C201)

WRT
Wireless router and internet gateway, sometimes denoted as WRTxxx (example model name: WRTB1CC034201)

2.2. Technical terms

2.2.1 Link aggregation

Link aggregation, **channel bonding**, **channel teaming**, and **port trunking** are all synonyms.

Link aggregation, in principle, means, that multiple physical connections, i.e. multiple links, between two nodes are used as one logical connection. That implies applications can only see one connection.

To speak about **link aggregation**, there have to be exactly two nodes, i.e. endpoints, between which the links are aggregated.

Note that link aggregation does not imply load balancing, although it is usually good idea to use it. (Use cases without load balancing would be for example, fast redundancy.)

2.2.2 Load balancing

In terms of network connections, **load balancing** means distributing data transfers over multiple paths so that maximum possible throughput is achieved.

Load balancing does not imply link aggregation! E.g. two passengers connected to the same wireless network can independently browse the web, each of them using different gateway to the Internet – since gateways do not have common endpoint which they would use to connect further to the Internet, we cannot speak about link aggregation.

3. Features of the system

3.1. Basic features

The system is designed to provision passengers with connectivity to the Internet through wireless ethernet (Wi-Fi). In order to provide this connectivity, the system itself connects to the Internet through several mobile network modems at once. The most core features can be summarized as:

- Provides wireless ethernet (Wi-Fi) – 802.11a/b/g/n/ac
- Uses up to four 2G/3G/4G (LTE) modems
- Can have up to four SIMs for each modem (for international travel)
- Uses link aggregation and load balancing over mobile networks with leading edge algorithms
- Designed in accordance with EN 50155:2007

In case of international transport, system uses built-in GPS to identify border transfer and switch all modems with appropriate SIM installed to local operators of the entered country. This way, no international fees (data roaming) have to be paid.

For ease of use, system is also provided with detailed, real-time internal diagnostics, which can be run locally or in centralized manner on system server located on the ground[1].

Finally, some jurisdictions require Internet Service Providers (ISPs) to log information about who and how uses their connections. System is prepared for these situations and allows logging of all required information to system server located on the ground[1].

3.2. Advanced features

Amongst elementary functions like IP routing, Ethernet bridging and DHCP server, the system can provide following features in these respective areas:

- Security
  - Captive portal
  - Passenger isolation (from both system network and other passengers' devices)
  - Firewall, both stateful and stateless
  - Ethernet VLANs (802.1Q)
  - Web Content Filter
- Service quality
  - Caching DNS server
  - QoS (IP DiffServ)
  - Traffic shaping
  - Web cache (caching web proxy)
- Management
  - Limited web management UI provided directly by WRT device
  - Centralised management through ground server[1]
  - Centralised update through ground server[1]
  - Centrally available detailed usage statistics and connection logging[1]

[1] Does not apply to case where there is no ground server in the system.

- Other services
  - Customer services can be incorporated into the system
  - Wi-Fi roaming (seamless transition of connection between access points)
  - WRT can provide GPS/GLONASS location and time data to other systems
  - System can provide Ethernet backbone to other systems or be incorporated to already existing Ethernet network

4. Principle of operation

System can work in one of the three modes:

1. Link aggregation mode
2. Load balancing with supervising server
3. Load balancing without server

These modes differ in operating costs and in features they provide. These modes only differ in the way the system gains the Internet connectivity – infrastructure inside a train is not affected.

4.1. Link aggregation mode

In this mode, **WRT** connects through all LTE modems to a server run by customer, which provides the actual Internet connectivity. The server in this mode is called **bonding server** and it must be present in order to perform link aggregation and load balancing on mobile networks.

More detailed description of operation can be found in section “4.1.3 Description of operation”.

4.1.1 Advantages

- Maximum speed and reliability of Internet connection
- Seamless link aggregation and load balancing – every user can communicate through several mobile networks at once and thus can use full connection capacity
- Seamless failover – failure of single modem will not break users’ connections, as long as at least one modem stays connected
- Built-in remote monitoring
- Web content filtering possible on ground-based server
- Firewall and web content filter setup from one point
- Full-featured QoS on both ends of the bottleneck
- Full-featured firewall on both ends of the bottleneck
- Operational and localization data archiving

4.1.2 Disadvantages

- High cost of server connectivity in comparison to other modes
- Securing connection stability costs some throughput, which is thus limited to approx. 50 Mbps for passengers (we expect this limit to increase in near future)

4.1.3 Description of operation

The WRT uses all its modems to connect to the bonding server. This allows the two to use all connections between them like physical links over which they establish a logical link with both link aggregation and load balancing. All allowed traffic is then forwarded through this logical link.

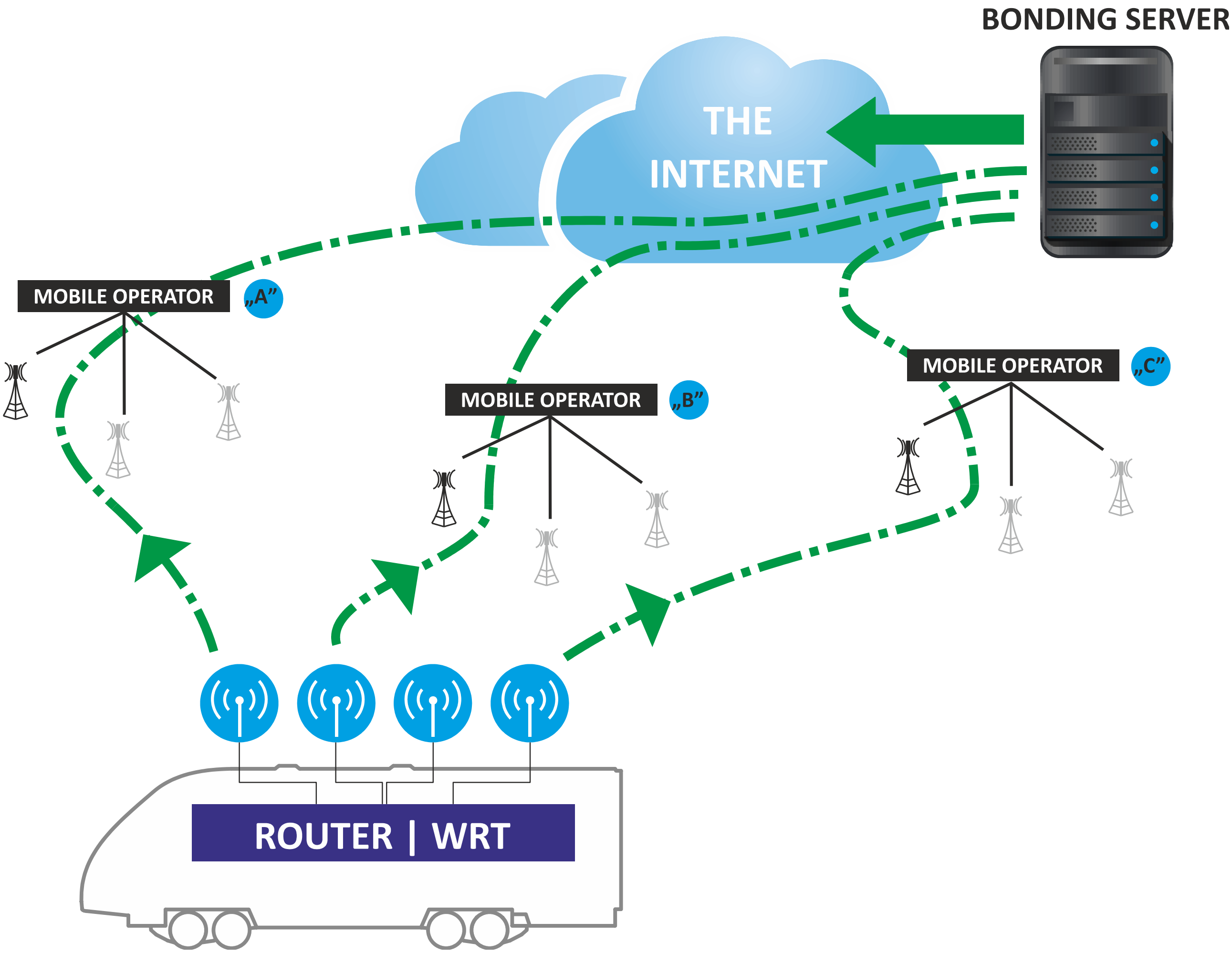

Fig. 1 – Link aggregation mode overview

The data flow from train goes into WRT, where it is pushed into the logical link. Then it goes through selected modem (the one which works well at the moment), through network of the mobile operator, through the Internet and then to the bonding server, where it is picked up from the logical link. Then it is sent to its destination in the Internet.

The data flow of replies from the Internet goes back to the bonding server, where it is pushed into the logical link with respective WRT. It goes back through the Internet and network of a mobile operator to the WRT modem, where it is picked up from the logical link and sent to the device for which the reply is destined to.

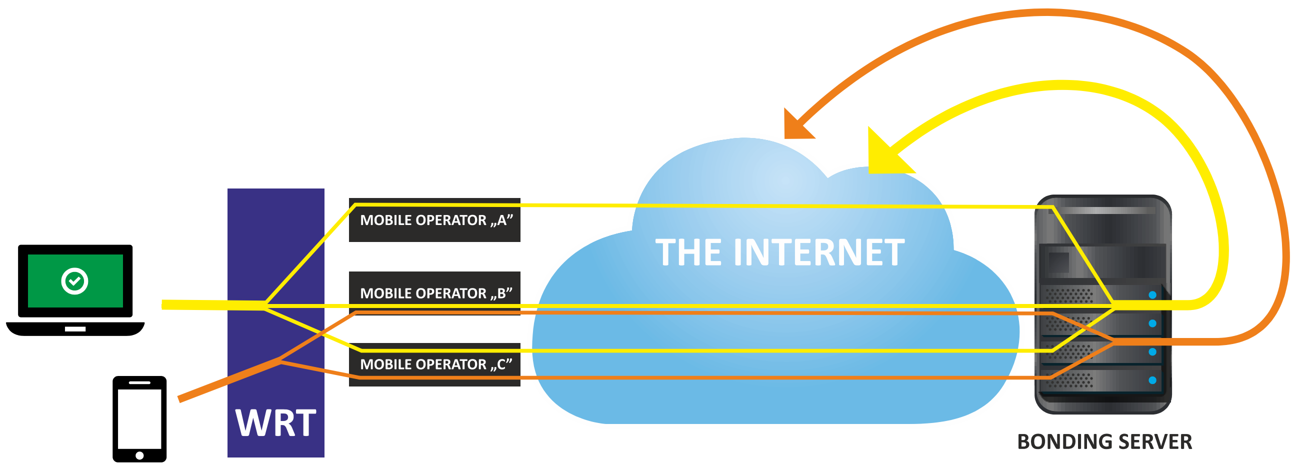

Fig. 2 – Link aggregation mode – logical connectivity scheme

Fig. 2 demonstrates two example user data flows and how they are handled. Fig. 3 shows how failure is handled seamlessly for the user in link aggregation mode.

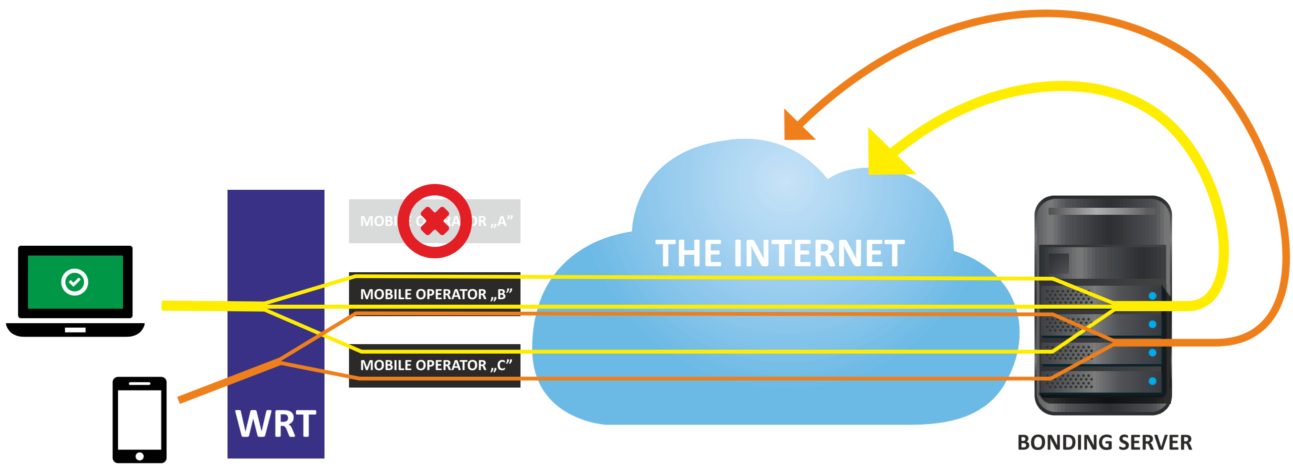

Fig. 3 – Link aggregation mode – logical connectivity scheme on link failure

4.1.4 Bonding server

Bonding server is required in order to run the system in Link aggregation mode. One bonding server is expected to be able to serve up to 50 **WRT** units.

Bonding server also serves as a supervising server - it can be used for centralized configuration and serves as a common storage for operational and localization data.

Server hardware and housing (including HW and SW service and management, Internet connectivity and other running costs) are arranged by customer. AMiT provides software part of the server in form of application package for Debian GNU/Linux operating system and its installation by specialized personnel.

Bonding server requirements

Hardware should be at least:
- 4 CPU cores @2.4 GHz
- 8 GB of RAM
- 2 × 1 TB HDD in RAID if localization and operational data will be stored, otherwise, 100GB is sufficient

Network connection requirements:
- Public IPv4 address is required
- Minimal network throughput (symmetrical) as in Table 1

Number of **WRT** routers	Minimal connectivity (Mbps)
1	30
5	70
10	120
20	200

Table 1 – Required bonding server connectivity

4.2. Load balancing with supervising server

In load balancing mode, data flows to the Internet directly through networks of mobile operators.

Every new passenger connection is assigned one currently active mobile connection (modem). This assignment cannot be changed later.

Supervising server can be used for centralized configuration and serves as a common storage for operational and localization data.

Detailed description of operation can be found in section “4.2.3 Disadvantages”.

4.2.1 Advantages

- More raw throughput (up to 100 Mbps, not available for single user connection)
- Built-in remote monitoring
- Firewall and web content filter setup from one point
- Operational and localization data archiving
- Significantly reduced cost of server connectivity

4.2.2 Disadvantages

- Worse load balancing – if user connections assigned to one modem start consuming bandwidth, they will have to share the limits of that particular modem, even if other modems have free bandwidth to spare
- Worse load balancing – in case connection of a modem gets worse, all assigned user connections will deteriorate as well
- No link aggregation – failure of a modem connection implies failure to all user connections assigned to that particular modem
- QoS cannot be set for the Internet side of the connection bottleneck

4.2.3 Description of operation

The WRT uses all modems as direct connections to the Internet and assigns a modem to each user connection it is requested to arrange.

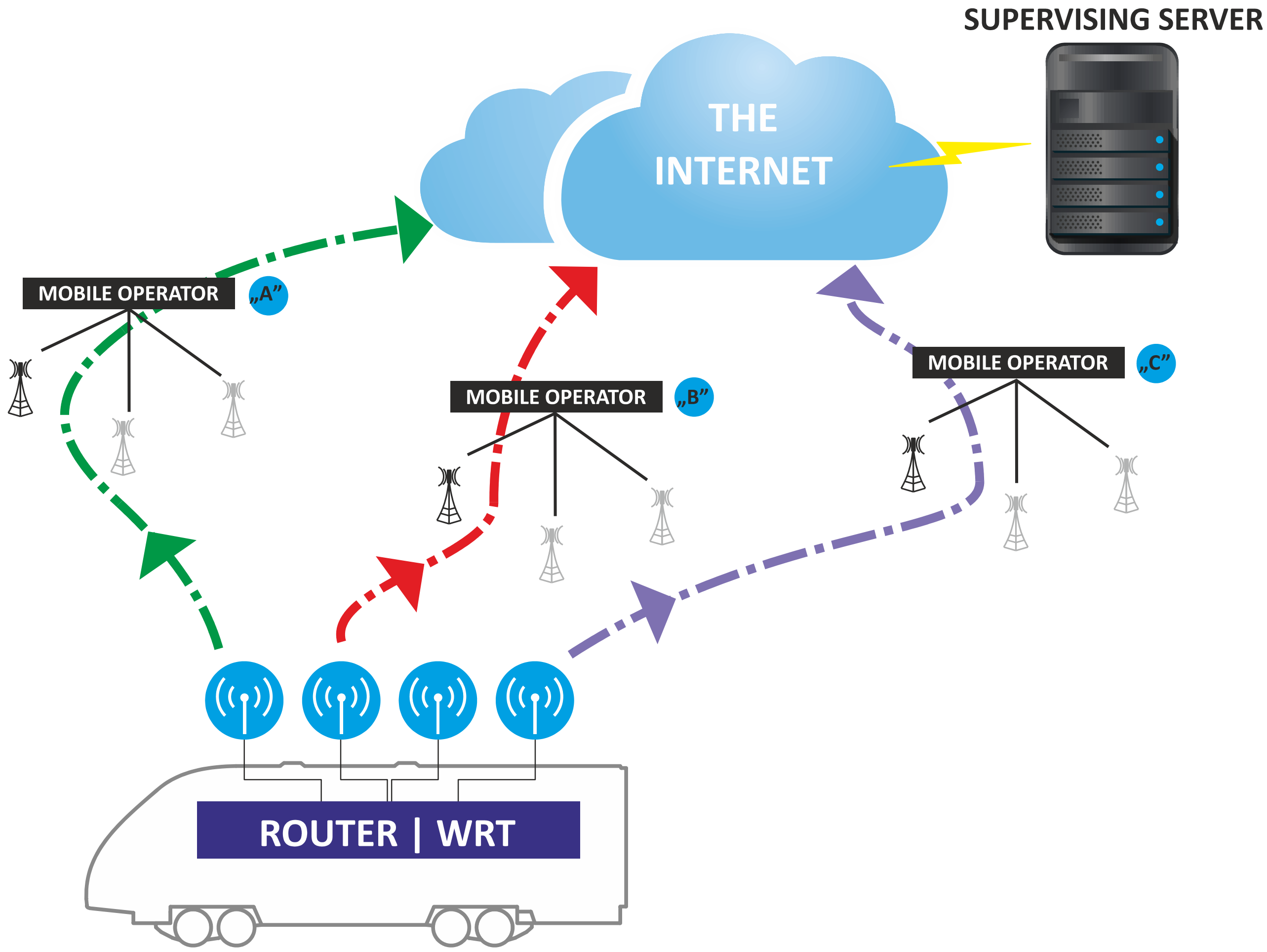

Fig. 4 – Load balancing with supervising server mode overview

Note that once the assignment is done, it cannot be changed (it would break the ability of the communication partner to properly recognize communication streams and to reply).

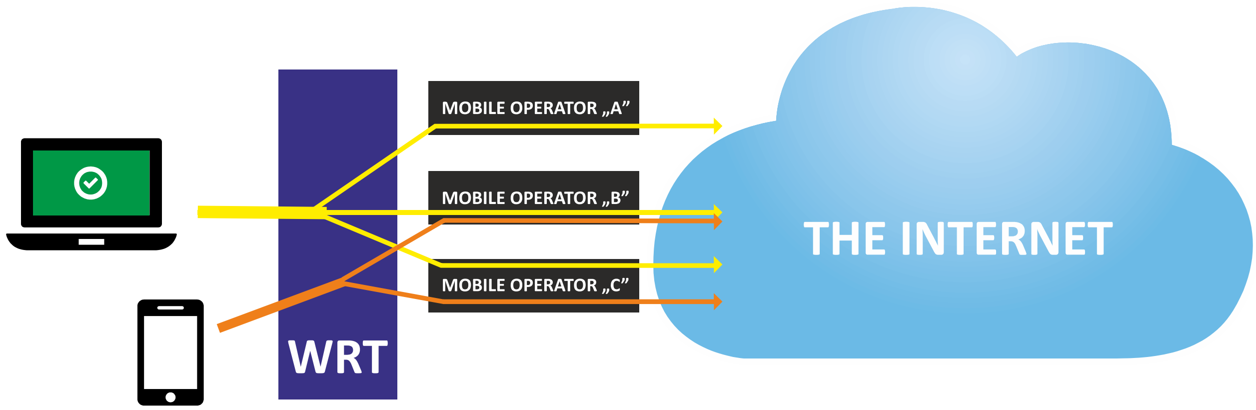

Fig. 5 – Load balancing with supervising server – logical connectivity scheme

This naturally breaks the ability of the system to perform seamless failover, thus allowing users' connections to break - Fig. 5 and Fig. 6 demonstrate this. This is a flaw, which is necessarily common to all similar solutions without bonding server due to common usage of NAT[2] in IP networking.

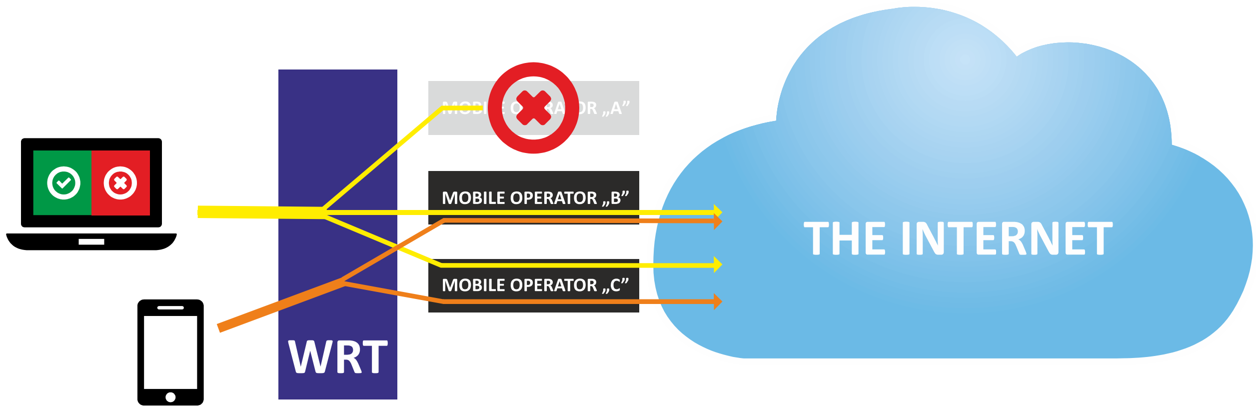

Fig. 6 – Load balancing with supervising server - logical connectivity scheme on link failure

Load balancing algorithm

Load balancing over multiple mobile network modems works in a round-robin manner with slight preference of 4G networks over 3G networks.

4.2.4 Supervising server

Supervising server is required for operational and localization data archiving, as well as for central management of **WRT** units. One supervising server is expected to be able to serve up to 50 **WRT** units.

Server hardware and housing (including HW and SW service and management, Internet connectivity and other running costs) are arranged by customer. AMiT provides software part of the server in form of application package for Debian GNU/Linux operating system and its installation by specialized personnel.

Supervising server requirements

Hardware should be at least:
- 2 CPU cores @2.4 GHz
- 4 GB RAM
- 1 TB HDD if localization and operational data will be stored, otherwise, 100GB is sufficient

Network connection requirements:
- Public IPv4 address is required
- Minimal network throughput on downstream is 7.2 kbps per attached WRT unit

[2] Network Address Translation – a technique commonly used to save public IP addresses

4.3. Load balancing without server

This mode is the same as Load balancing with supervising server, except there is no supervising server. Please, see chapter “4.2 Load balancing with supervising server” for overview.

4.3.1 Advantages

- More raw throughput
- No server – further reduction of operating costs

4.3.2 Disadvantages

- No remote monitoring
- No setup from one point
- No operational and localization data archiving
- Worse load balancing – if user connections assigned to one modem start consuming bandwidth, they will have to share the limits of that particular modem, even if other modems have free bandwidth to spare
- Worse load balancing – in case connection of a modem gets worse, all assigned user connections will deteriorate as well
- No link aggregation – failure of a modem connection implies failure to all user connections assigned to that particular modem
- QoS cannot be set for the Internet side of the connection bottleneck

4.3.3 Description of operation

Except for the fact that there is no server at all in this mode (no bonding nor supervising server), the operation is exactly the same as in case of Load balancing with supervising server. For description see chapter “4.2.3 Description of operation”.

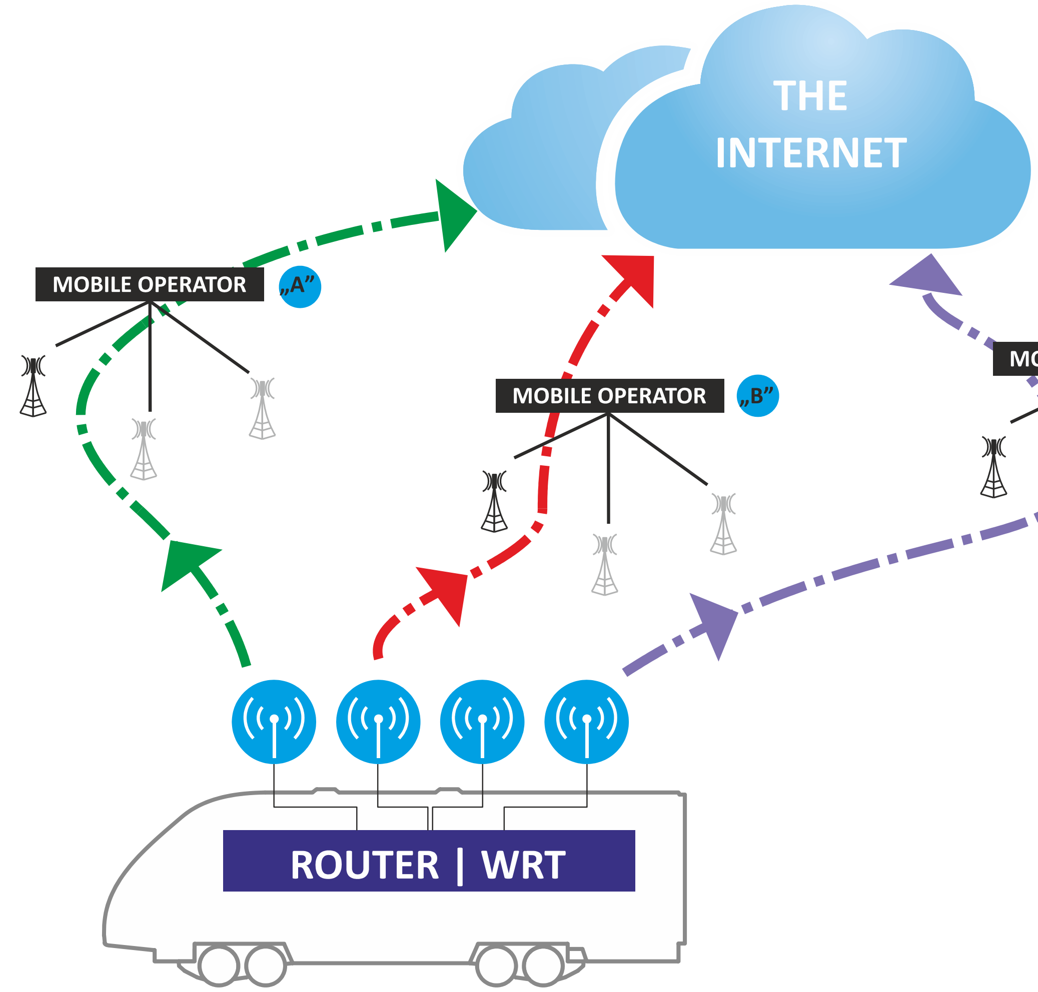

Fig. 7 – Load balancing mode overview

4.4. Features common for all modes

In all modes, WRT routers secure the Internet connectivity for their trains using mobile networks. WRT can use as many networks at a time, as many modems it has, provided that every modem has a SIM and networks in question have coverage in the area.

4.4.1 SIM placement

Please note that having **two modems connected to the same network has no benefit**. The network would divide the available bandwidth between these two modems, therefore leaving the throughput the same as in the case of only one modem.

Also note that **each modem uses only one SIM at a time**. This is usual limitation. Moreover, **switching active SIM only occurs on national border crossing**, because switching active SIM is a very time consuming operation.

Simply put, for best results, have a modem with SIM for every local mobile network operator.

For international travel

To prevent costly international roaming fees, the device can be equipped with multiple SIM slots for each modem. That allows user to install one set of SIMs for each country the host vehicle will go through. Note that WRT prevents all mobile network roaming by default.

Thanks to GPS, the WRT unit detects border crossing and automatically switches all its modems, one by one, to SIMs of operators native to the country it enters (if such modules are available). The transition is performed carefully to not break user connections[3].

An example

Example of WRT fit with three modems with German and French SIM cards:
Let's consider three French mobile operators denoted as FR1-FR3 and three German mobile operators denoted as DE1-DE3. The SIM cards from these operators are inserted into a WRT as in Table 2.

	Modem 1	**Modem 2**	**Modem 3**
SIM Slot A	FR1	DE2	FR3
SIM Slot B	DE1	FR2	DE3
SIM Slot C	–	–	–

Table 2 – Example of WRT fitted with German and French SIM cards

If the WRT is located in France, WRT modems automatically select French operators (the red colour, Italic).

	Modem 1	**Modem 2**	**Modem 3**
SIM Slot A	*FR1*	DE2	*FR3*
SIM Slot B	DE1	*FR2*	DE3
SIM Slot C	–	–	–

Table 3 – Example of SIMs active in France

All modems try to connect to networks of their selected installed SIMs. Connected modems are used for communication. SIM switching only takes place at a French – German border. The crossing of the state border is detected using a GPS/GLONASS based predictive algorithm. If the algorithm recognizes the train is approaching a border, modems starts to disconnect and switch active SIMs. The appropriate SIMs are selected according to their ID number, which identifies, amongst other things, their local country as well. When the border crossing is over, situation looks like in Table 4.

	Modem 1	**Modem 2**	**Modem 3**
SIM Slot A	FR1	*DE2*	FR3
SIM Slot B	*DE1*	FR2	*DE3*
SIM Slot C	–	–	–

Table 4 – Example of SIMs active in Germany

At any time during the switching process, at least one modem is always trying to keep the connection up for clients. Border cross is thus without connection gaps. If more SIMs from one country are installed inside one modem, it will always use only one of them in that country. It will never switch to another – the modem is not designed to do so.

[3] In order to not break user connections, Link aggregation mode must be used.

SIM requirements

The SIMs to be used should be provided by network operators local to the country of operations of the vehicle. Unlimited data plan without bandwidth cap (FUP – Fair User Policy) is strongly recommended. WRT supports 2G/3G/4G networks. 4G (LTE) compliant SIM is recommended if available.

The PIN code should be removed from SIM cards prior to installation into the WRT.

Mobile network roaming mechanism should be disabled by mobile network operator.

5. Hardware features and limitations

The system usually consists of one **WRT** (router) and zero or more **WAP** (Wi-Fi access points), interconnected via Gigabit Ethernet. All devices comply with EN 550155 ed. 3.

5.1. WRT – the Internet gateway

WRT units are designed to serve as gateways to the Internet. For this purpose, they integrate:

- 1 to 6 Gigabit Ethernet M12 ports (1 interface with dedicated port + 1 interface with an integrated switch)
- 0 to 2 Wi-Fi, IEEE 802.11a/b/g/n/ac, SISO, MIMO (2 × 2)
- 0 to 1 CDMA
- 1 to 4 2G/3G/4G LTE modem
- GPS/GLONASS receiver

5.1.1 Dedicated Ethernet interface vs. internal switch

The interface with dedicated port is intended for connecting private network of the train system. For security reasons, the interface is, by default, completely isolated from the network providing passengers with the Internet connectivity.

The other ports, connected to the internal switch are designed to connect WAP units to the network providing passengers with the Internet connectivity.

5.1.2 SIM card slots

Each LTE modem has 1 to 4 SIM card slots. At any time, maximum of one SIM slot will be used by each modem. Transitions between SIM slots are only performed when national border crossing is detected (based on GPS/GLONASS information). It is therefore useless for a modem to be provided with more than one SIM card from the operators of the same country.

For more information, see chapter “4.4.1 SIM placement”.

5.2. WAP - Wi-Fi access points

WAP units are designed to provide wireless ethernet connectivity wherever signal from **WRT** cannot be reached at all or where it would be weak. Main features of **WAP** are:

- 2 Wi-Fi, IEEE 802.11a/b/g/n/ac, SISO, MIMO (2 × 2)
- 1 or 2 Gigabit Ethernet M12 ports

Variants with two Gigabit Ethernet ports are designed as inner nodes in a daisy-chain of **WAP** units. The other variant is designed to be the end node of such chain. This approach significantly reduces cabling complexity.

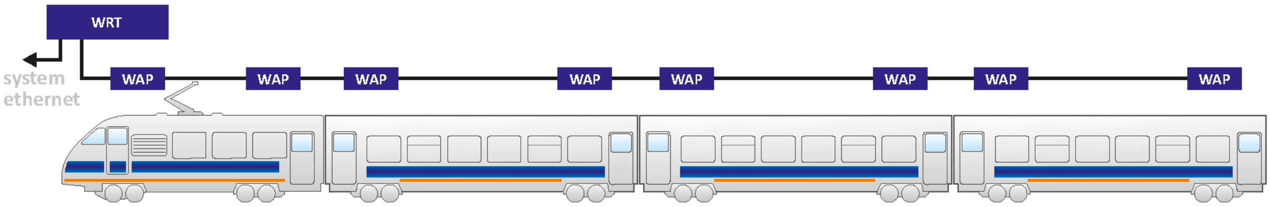

Fig. 8 – Typical usage of WRT and several daisy-chained WAP units on a train

6. Antennae connection

The scheme on Fig. 9 illustrates example connection of all antennae to the WRT (precisely WRTB1AD043201 in this example), including cable types and their maximum lengths.

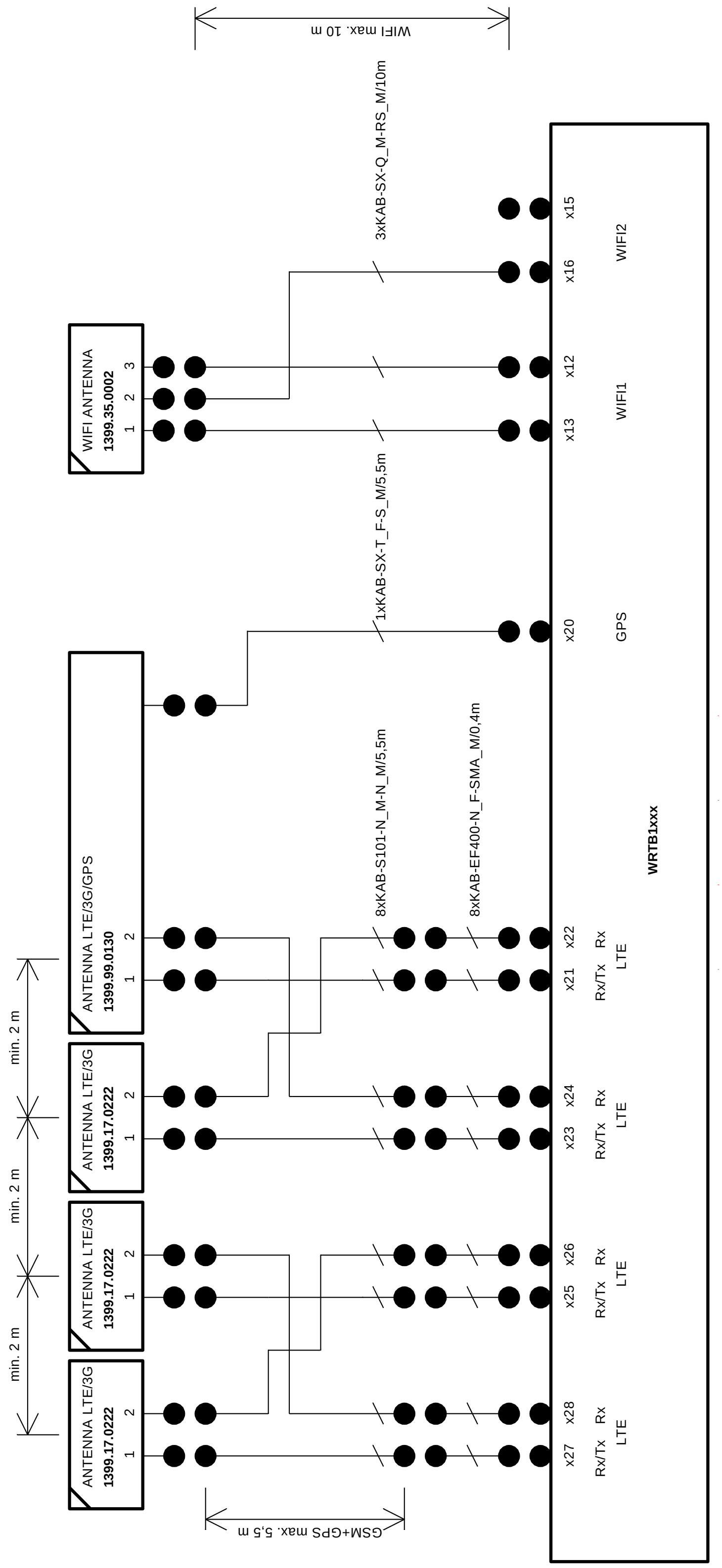

Fig. 9 – Antennae connection example scheme

6.1. Mobile network (LTE) antennae connection

6.1.1 4G LTE MIMO and diversity

MIMO (Multiple Input Multiple Output) denotes ability of an LTE modem to obtain data from compatible LTE network in two independent streams, hence getting up to double download speed. To use this feature, the modem must have both antenna connectors connected to antennae.

Diversity denotes ability of a modem to use additional antenna for noise cancellation. The antenna is used for receiving only. Noise cancellation helps get better download speeds on all generations of mobile networks.

In case a second antenna is connected, MIMO is used for LTE networks which supports MIMO and diversity is used otherwise. When only one antenna is connected to a modem, neither MIMO nor diversity can be applied.

6.1.2 Primary and secondary antenna (Rx/Tx, Rx)

Primary antenna (denoted Rx/Tx) is used for both receiving and sending data and must be connected in order for the system to work properly.

Secondary antenna (denoted Rx only) is used for either MIMO or diversity. In case the secondary antenna is not connected, the system will work, but MIMO and diversity capabilities will not.

6.1.3 LTE antenna cable recommendations

KAB-EF400-N_F-SMA_M/0.4m adaptor and KAB-S101-N_M-N_M/5.5m cable is recommended. The cable (without adaptor) should be no longer than 5.5 metres.

6.1.4 LTE antennae connection recommendations

All used modems must have primary (Rx/Tx) antenna connected. It is recommended to also connect secondary (Rx only) antenna to each modem – the secondary antenna should be placed at least 2 metres away from the primary antenna.

For connection example, including used cable types and their maximum lengths, see Fig. 9.

6.2. GPS/GLONASS antenna connection

In case where the system obtains location information from other systems, no GPS/GLONASS antenna is needed.

6.2.1 GPS/GLONASS antenna cable recommendation

KAB-SX-T_F-S_M/5.5m is recommended.

6.2.2 GPS/GLONASS antenna connection recommendation

Cable length should not exceed 5.5 metres.

6.3. Wi-Fi (802.11 a/b/g/n/ac) antennae connection

6.3.1 Wi-Fi (802.11 n/ac) MIMO

MIMO (Multiple Input Multiple Output) denotes ability of hardware to use multiple input data streams and multiple output data streams. In other words, hardware can use two antennae independently at the same time. This basically means communication in both directions can flow at up to double speed.

MIMO will only be used when two antennae are connected to the adaptor.

6.3.2 Wi-Fi antenna cable recommendation

KAB-SX-Q_M-RS_M/10m is recommended. Cable length should not exceed 10 metres.

6.3.3 Wi-Fi antennae connection recommendation

First, note that both WRT and WAP units come with up to two Wi-Fi (802.11 a/b/g/n/ac) adaptors. Each adaptor, which is to be used, must be connected to at least one antenna.

Each adaptor has two antenna connectors. These connectors are completely equal. That means it does not matter in which connector which antenna is connected, and in case you only want to connect one antenna to an adaptor, you can chose any of the two.

Cable length is recommended to not exceed 10 metres. It is usually better to move antenna a metre from its optimal position than to exceed this recommended maximum cable length by that metre.

Finally, when designing antenna placement, attention must be paid to its directional characteristics.

Two antennae connection

For optimal wireless ethernet performance, all antenna connectors should be connected. This can be realized using two 1399.35.0002 antennae, using connectors 1 and 3 on one antenna to connect WIFI1 and the same connectors on the other antenna for WIFI2 (see Fig. 10).

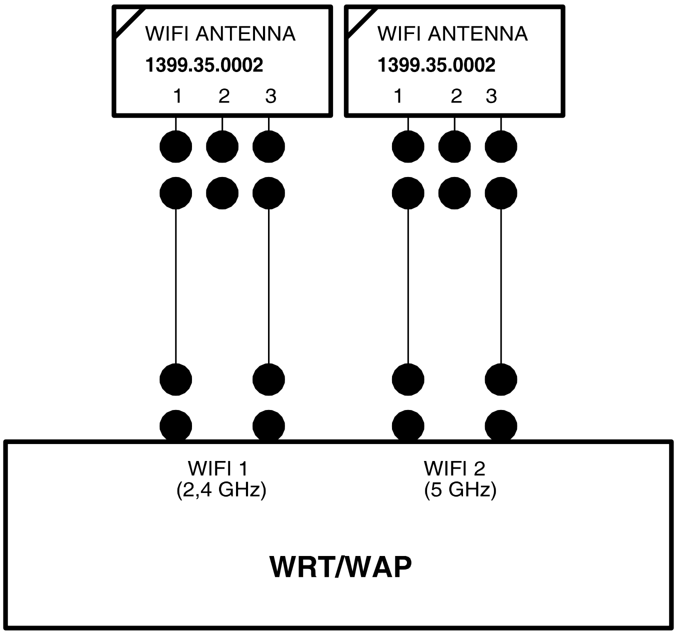

Fig. 10 – Typical usage with two Wi-Fi antennae

One antenna connection

As a less expensive solution, we recommend using one 1399.35.0002 antenna, where WIFI1 (2.4 GHz) is connected to antenna connectors 1 and 3 and WIFI2 (5 GHz) is connected on antenna connector 2.

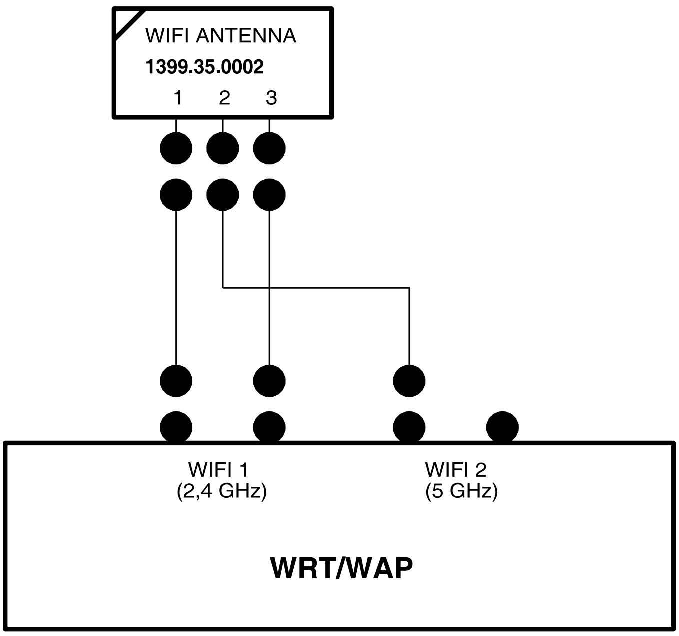

Fig. 11 – Typical usage with one Wi-Fi antenna

7. Typical usage

Usually, one WRT is used per train. If technically possible – antennae cables would not be too long – the WRT built-in Wi-Fi access point is used (as on Fig. 12).

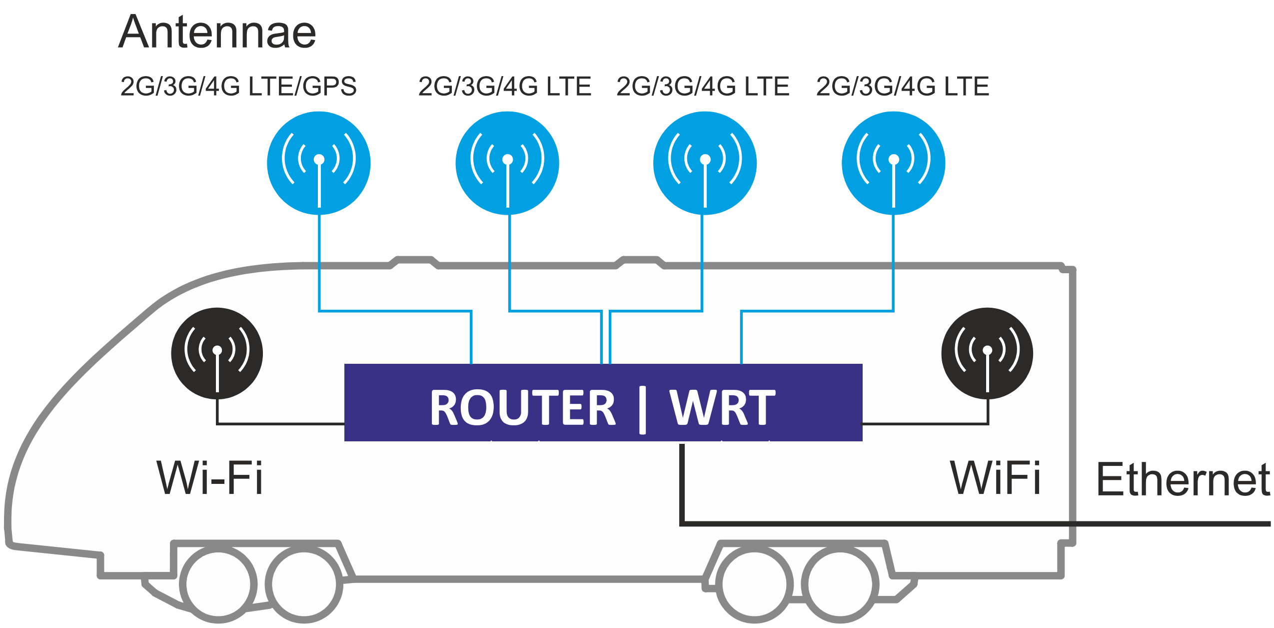

Fig. 12 – A train car hosting WRT using built-in Wi-Fi

Wi-Fi in the rest of the train is then provided by series of WAP units (as on Fig. 13).

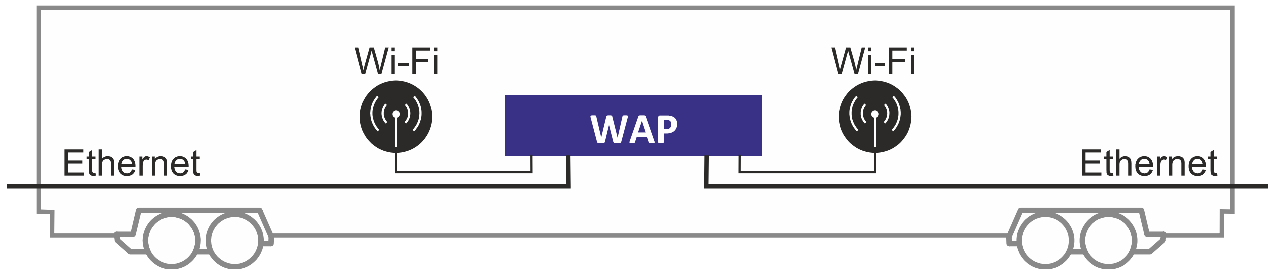

Fig. 13 – A train car with single area covered by Wi-Fi by WAP

If there are more areas to cover, be it other train cars or just spaces separated by wall which Wi-Fi signal cannot penetrate, additional WAP units are used (as on Fig. 14).

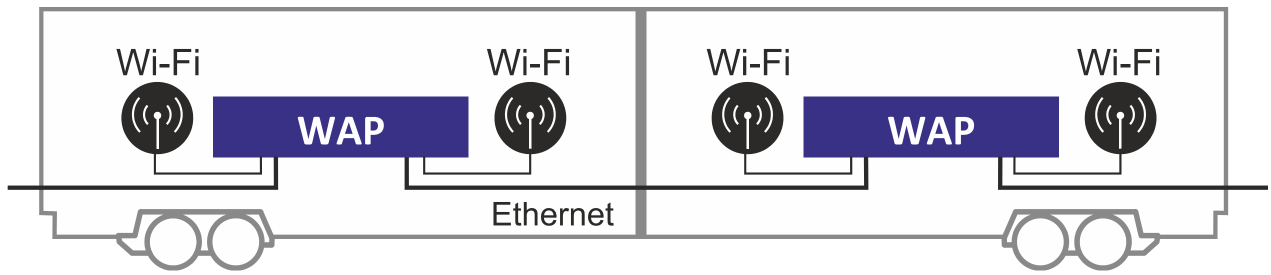

Fig. 14 – A train car with two areas covered by Wi-Fi signal using two WAP access points

It is also possible to split WAP unit antennae in two places to provide connectivity for both areas (as on Fig. 15).

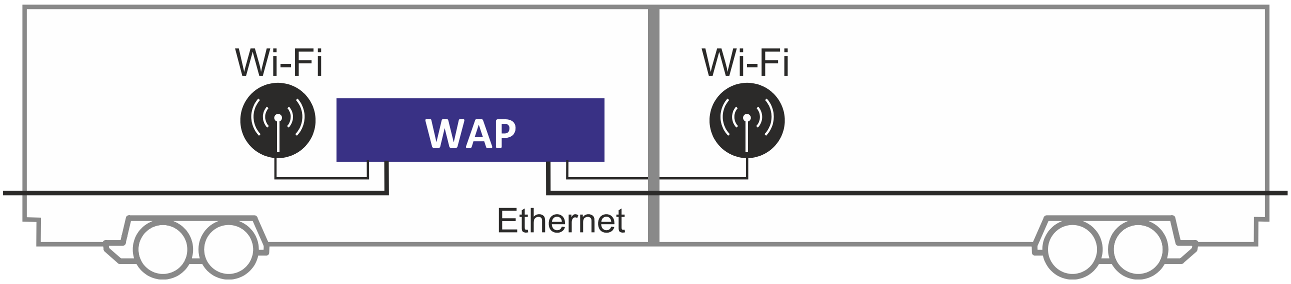

Fig. 15 – A train car with two areas covered by Wi-Fi signal using one WAP access point

And for cases where using WRT built-in Wi-Fi access point is impractical or impossible (for example due to antenna cable length restrictions), WRT without built-in Wi-Fi access point module is used and required areas are covered using WAP units, as one would expect (see Fig. 16).

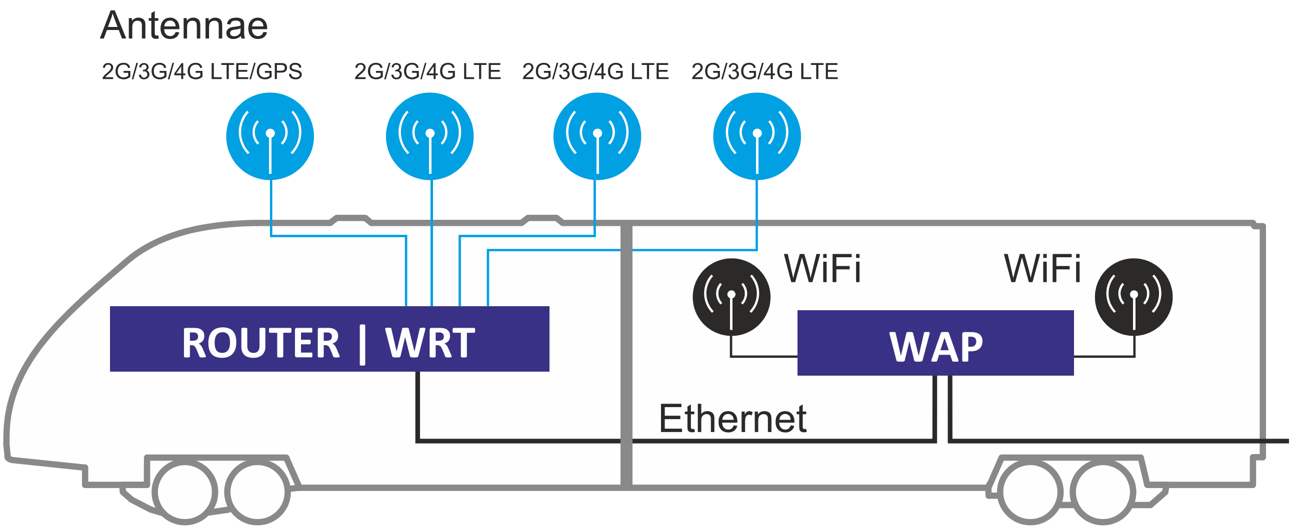

Fig. 16 – A train car hosting WRT without built-in Wi-Fi, covered by WAP

8. System designer's guide to Wi-Fi system

In this chapter, series of questions will be presented. These questions represent basic design choices of the system. Questions presented here are provided with a guide to help you choose the best solution. Each guide is divided into two parts. First part tries to provide a brief guide. Second part then presents additional information, where applicable, either in a form of an example or as somewhat deeper technical description.

8.1. Obtaining Internet connectivity

Obtaining connectivity to the Internet is work for WRT device. Single device per train is usually used. This subchapter will discuss decisions related to this device. Distribution (Wi-Fi in the train) will be discussed later in the subchapter "8.2 Wi-Fi – distributing the connectivity".

8.1.1 How many modems should my WRT have?

In short
As many as mobile networks you will connect to simultaneously.

In more detail
Each modem can connect to one mobile network. Therefore, as many mobile networks can be used, as many modems there are in the WRT. Using more than one modem to connect to the same network does not make sense – it only causes the network to distribute the same bandwidth between the two modems, making each of them run at half the speed. Hence, we came with equality between number of used mobile networks and modems in the WRT unit.

8.1.2 How many SIMs per modem should my WRT have?

In short
As many as different countries the vehicle will cross border with.

Example
Let's suppose we have international express train which goes from Germany to Poland through Czech Republic. WRT on such train should have 3 SIMs per modem – one for German mobile network operator, one for Czech and one for Polish. This way, each modem can internally switch SIM on both borders and keep operating without mobile network roaming (which would increase the running costs).

8.1.3 Should WRT be provided with location data or use its internal GPS?

In short
If your system has location data already and you want to save on a GPS antenna, you can pass the data to the WRT instead of connecting the antenna. Or the other way: you can connect the GPS antenna and use the WRT as a source of location information for the rest of your system.

In more detail
The WRT unit only uses location data for border crossing detection. If the train stays in one country only, the lack of location information is unlikely to be a severe problem. For an international train, however, the lack of location information can confuse the unit and fluent operation cannot be guaranteed.

8.1.4 Should I use GSM MIMO/diversity antennae?

In short
For maximum service quality, both primary and secondary antennae should be connected on all used modems in WRT unit. As a cost-reduction measurement, it is possible to omit secondary antennae.

In more detail
Topic of LTE MIMO and diversity is discussed in subchapter “6.1.1 4G LTE MIMO and diversity”.

8.1.5 Should I use bonding server?

In short
For best connection stability and maximum reliability, you should use bonding server. For savings on operating cost, you can run the system without bonding server.

In more detail
Usage of bonding server has many benefits, but also a few drawbacks. For more detailed description see chapter “4 Principle of operation”.

8.1.6 Should I use supervision?

In short
In some countries, logging of users’ connections is mandatory. In other countries, such logging is strictly prohibited. This is therefore mostly determined by the laws of the country of operation.

Please note that you need a server for such logging – in case you have a bonding server, it can already do this for you. In the other case, you will need to use a supervising server. (Presence of the server does not imply logging, but it is required for the logging to work.)

In more detail
More detailed description about working modes can be found in chapter “4 Principle of operation”.

8.2. Wi-Fi – distributing the connectivity

Distribution of connectivity to the Internet is realized through Wireless Ethernet (Wi-Fi) networks. These wireless local area networks are provided by Wi-Fi adapters of the WRT (if present) and through additional WAP units connected to WRT through wired Ethernet.

8.2.1 Do I want 2.4 GHz band, 5 GHz band or both?

In short
2.4 GHz band is the most compatible one and almost any Wi-Fi device can use it. 5 GHz is less used today and therefore less susceptible to noise from other networks. For best results we recommend using both.

8.2.2 Do I want to use Wi-Fi MIMO?

In short
If you expect greater data flows somewhere, you should consider using multiple antennae there to enhance connection speed and overall signal quality.

In more detail
Wi-Fi MIMO is discussed in subchapter “6.3.1 Wi-Fi (802.11 n/ac) MIMO”.

8.2.3 How many antennae will I need?

In short
You will need an antenna for every area you want to cover, which would not get strong enough signal from neighbouring areas already.

We usually suggest using a 3-way antenna 1399.35.0002, where 2.4 GHz Wi-Fi is connected in two plugs for MIMO and third plug is used for 5 GHz.

In more detail
This depends on whether you want to use only one or both of the Wi-Fi bands, whether you want one of it or both to be connected for MIMO and how many areas you want to cover.

Let A be the number of areas you need to cover. Then

- If you only need one of 2.4 GHz or 5 GHz bands and no MIMO, then 1 × A
- If you need both 2.4 GHz and 5 GHz bands or only one of them with MIMO, then 2 × A
- If you need both 2.4 GHz and 5 GHz and MIMO on just one of them, then 3 × A
- If you need both 2.4 GHz and 5 GHz and both with MIMO, then 4 × A

The obtained number expresses how many antenna connectors you should get in total, which may be greater number than the actual number of antennae required (usually two to three times greater).

Please note this number is valid for optimal case only, where all antenna connectors are used on all antennae. In practice, you might run into solutions where not all antenna connectors will be used.

For more detailed information regarding Wi-Fi antennae connection see subchapter “6.3 Wi-Fi (802.11 a/b/g/n/ac) antennae connection”.

8.2.4 How many WAP units (Wi-Fi access points) will I need?

In short
Generally speaking, for every band (2.4 GHz, 5 GHz) used, you will need one Wi-Fi adaptor[4] per area (per connected primary antenna, to be precise).

[4] Each WRT and each WAP can be equipped with up to two Wi-Fi adaptors.

Example

Let’s say we have 5 areas to cover, each having one 3-way antenna to be connected for 2.4 GHz band in MIMO and for 5 GHz band as a single antenna. Assuming we have two Wi-Fi adaptors in our WRT already, we will need 4 WAP units:

5 (areas) * 2 (used bands) = 10 (Wi-Fi adaptors required)

thus

10 (adaptors required) – 2 (adaptors integrated in WRT) = 8 (additional adaptors required)

and hence

8 (additional adaptors required) / 2 (adaptors per WAP unit) = 4 (WAP units required)

9. Technical support

All necessary information regarding AMiT Wi-Fi systems can be obtained by contacting AMiT Technical support team. The best way to contact our technical support is to e-mail at **support@amit.cz**.

10. Warning