WI-FI CALLING

Technote (English translation)

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1 Introduction

This document explains what Wi-Fi calling is, on which components the operation of Wi-Fi calling depends and what benefits a Ruckus environment can have on the operation of Wi-Fi calling.

1.1 Goal

The purpose of this document is to familiarize the reader with basic concepts and configurations for Wi-Fi calling.

1.2 Target audience

This document is written for technical staff who are looking for information about Wi-Fi calling and want to make optimal use of it.

1.3 Prior knowledge/requirements

To take full advantage of what is described in this document, it is important that you have basic knowledge of the following subjects:

- Basic knowledge of networks
- Basic knowledge of SmartZone
- Basic knowledge of Smartphones of various types you like to use (Apple, Android)

2 Basic concepts

2.1 3gppcore

The term 3gpp core is used as a referral to all elements that are needed for an operational core network of a provider.

2.2 3G

3G is the abbreviation for 3th Generation technology and is a telecommunications standard for data transfer that was developed in 2001. 3G is a standard that allows simultaneous calling and data. The maximum speed is between 7 and 8 megabit / sec. It is possible to make several connections at the same time, so that the maximum speed is around 30 Mbit / s. 3G works for most Dutch providers with 900 MHz and 2100 MHz. The 3G standard has now almost been replaced by the 4G standard. With the 5G standard coming in the near future, various providers will soon switch off 3G. Calls via 3G are set up as standard based on the mobile number.

2.3 4G

4G is the abbreviation for 4th Generation technology and is a telecommunications standard for data transfer developed in 2010. 4G is also referred to as LTE. The maximum transfer speed for 4G when walking or standing still is around 1000Mbps. The most used frequencies for 4G in Europe are 800 MHz, 900 MHz, 1800 MHz and 2600 MHz. For the Netherlands, the frequencies were auctioned in 2012 among four Telecom providers: KPN, T-Mobile, Vodafone and Tele2.

2.4 VoLTE

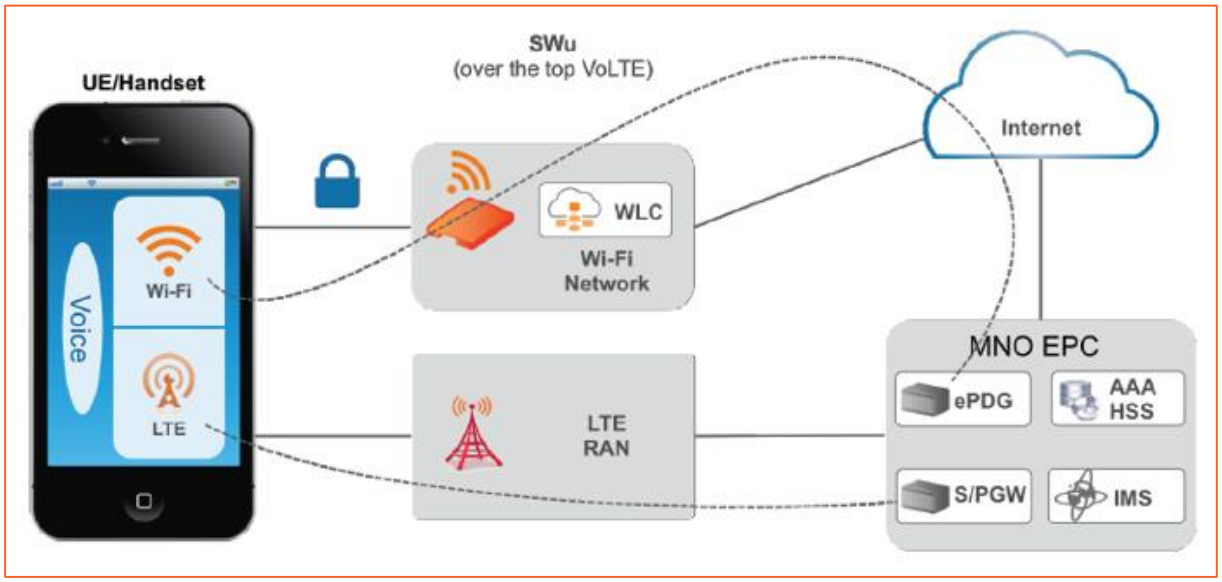
VoLTE is a technique whereby a telephone call is set up within an IPsec tunnel to the provider's core network via the 4G connection. In this core network the translation between telephone number and IP address takes place. In short, VoLTE is exactly the same as VoIP, which has been used for much longer in enterprise Wi-Fi networks. The VoIP server is the core of the provider. The biggest difference from traditional VOIP implementations is the use is made of the "native dialler".

2.5 VoWi-Fi

Wi-Fi calling or VoWiFi is an addition to the VoLTE service. With Wi-Fi calling, only an available Wi-Fi network is used to set up communication with the provider's core network. Wi-Fi calling costs nothing extra and is charged in the same way as calling via 2G / 3G / 4G (it is also not free of charge).
The difference with, for example, calling via WhatsApp and other VoIP applications lies mainly in the fact that Wi-Fi calling simply uses the "native dialler", or in other words the device can still be reached on its normal mobile number.

3 Components

A number of components are required for Wi-Fi calling. All these elements also have their own influence on the functioning of Wi-Fi calling and / or VoLTE.



3.1 Mobile operator

In the first place, a mobile operator is needed that supports VoLTE and / or Wi-Fi calling. The mobile operator can also determine which of the two technologies is available for which devices and / or user groups.
For example, KPN can determine for an iPhone 6 that it cannot use VoLTE, but an iPhone 7 can, while either device supports both VoLTE and VoWi-Fi. Vodafone could allow the use of an iPhone 6. Mobile operators can also make a distinction between VoLTE and VoWi-Fi. On the mobile operator's website, you can find more information about which devices are supported. A few examples of Dutch mobile operators are displayed below.

https://forum.vodafone.nl/netwerkvragen-4/bellen-over-wifi-en-4g-volte-vowifi-274646

https://www.kpn.com/beleef/mobiel/mobiel-bellen-via-wifi-van-kpn.htm

https://www.tele2.nl/klantenservice/mobiel/wifi-bellen-en-volte

3.2 3G and 4G coverage

For a correct integration between Wi-Fi calling and VoLTE it is important that there is a certain amount of overlap between Wi-Fi and mobile communication techniques to make a conversation possible at all locations. Hereby it is possible to switch seamlessly between VoLTE and VoWiFi. Because the technologies of 3G and VoLTE / VoWiFi are not compatible with each other, roaming between 3G and VoLTE / VoWiFi is not possible. Ongoing phone calls will be terminated when moving out of the coverage area.

3.3 Wi-Fi network

The Wi-Fi network is the component used by the client device to build an IPsec tunnel to the 3gpp core. If all ports are set correct, or no traffic is excluded all Wi-Fi networks can be used for Wi-Fi calling. However, quality of the connection will differ based on the difference on quality of the Wi-Fi network. If clients are not able to roam within reasonable amount of time, calls will falter or in the worst case even be disconnected. If QoS is not implemented correctly Wi-Fi calling traffic will not be prioritized correctly which might cause issues. Beside some specific Wi-Fi calling settings, as a rule of thumb it can be assumed that if a Wi-Fi network is designed, and therefore suitable for traditional (enterprise)VoIP, it can also be used for Wi-Fi calling.

3.4 LAN network

The Wi-Fi network is connected to a wired network via a switch or directly to the router. The switch is then connected to a router or firewall, and all of these components can cause Wi-Fi calling to malfunction. Ports or destinations can be blocked, or roaming from one access point to another can cause the data stream to be interrupted because the data stream in the switch is not restored to the new access point fast enough or simply if the user enters a different subnet which breaks the IPsec tunnel. All the components of the internal network need to be configured and impact to the quality of the call must be analysed.

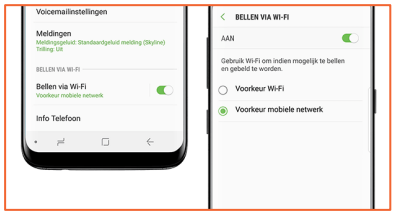
3.5 Client device

Different client devices are capable of using the Wi-Fi calling feature.

3.5.1 iOS devices

All iOS devices starting with Iphone5C, when using a minimum of IOS 10.2 support VoLTE and Wi-Fi calling. If your provider allows to use one or both of the feature's configuration options will be available. When using IOS devices for Wi-Fi calling there are no options to prefer Wi-Fi network for call handling. The green diamond of the device will decide whether Wi-Fi or mobile network is used, and which thresholds apply. With current IOS version this will mostly mean the mobile network (3G or better) will always be used even when there is a poor connection. When only 3G and Wi-Fi is available the call will be started using 3G connection. Once 3G signal is lost the call will be broken, due to the fact roaming between 3G and Wi-Fi is not possible. Then the call needs to be manually started again.

3.5.2 Android



When using android devices, support for Wi-Fi calling is much harder to distinguish. As an example, there are "stock android" software versions on Google Pixel devices and for Samsung devices there are different types of user interfaces such as TouchWiz and Samsung Experience. There are even software developers that release software version based on Android stock ROM's such as OxygenOS, Cyanogen or LineageOS. Even if these versions will support Wi-Fi calling, the question is if providers will allow these versions to make use of the Wi-Fi calling feature.
To make it even more complicated there is a difference in country where the device is purchased or distributed from. As an example, Samsung has different version for US, Europe, country or even specific for the mobile provider. If your reseller purchased the device as "grey import" even if the GUI is Dutch, the actual ROM version can be polish and needs to be flashed to a specific version to make Wi-Fi calling available.
The only way to make sure to use a supported client device is use the list of supported hardware provided by the provider and then also purchase the device with your provider. Your provider will make sure supported ROM is loaded into the device.

3.5.3 Windows Phone

As of the writing of this document no Windows (or windows mobile) device are available that support Wi-Fi calling. Since there are no new devices or software that will be developed most likely there won't be any supported devices in the future.

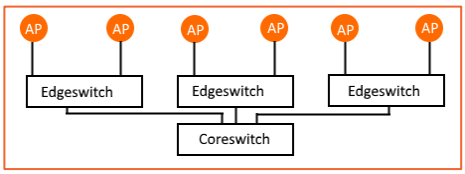
3.6 User

Last but not least, Wi-Fi calling depends on the user. If the Wi-Fi network is configured correctly, the correct device is used and supported by the provider, the user can misconfigure, so Wi-Fi calling is not function as expected. To make sure all company hardware is configured correctly, the use of a mobile device manager is highly recommended.

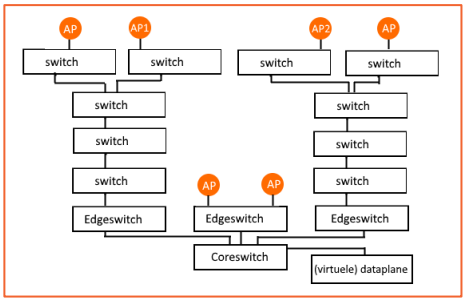
4 Ruckus Wireless and Wi-Fi calling

As you can be read in previous chapters, there are many variables that can determine the correct operation of Wi-Fi calling. Several things such as device and provider settings cannot be improved. Ruckus has a few options that can improve the quality of VoIP call in general, but also specifically for Wi-Fi calling, Ruckus has a few options that can improve its performance.

4.1 Ruckus dataplane



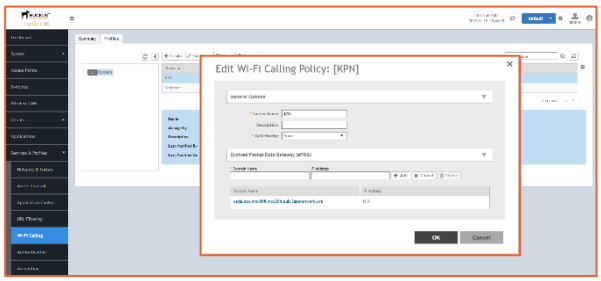
In the best situation when using local breakout, the infrastructure of a company is designed and build for its needs, in example using a core-switch and a couple of access switches and everything is configured correctly based on the specification used for VoIP operation. When a client roams from one access point to another it can be designed in such a way that no interruption is noticed by the user. If so, only a WLAN controller such as Ruckus SmartZone is sufficient for operation of a time sensitive application such as VoIP and Wi-Fi calling.



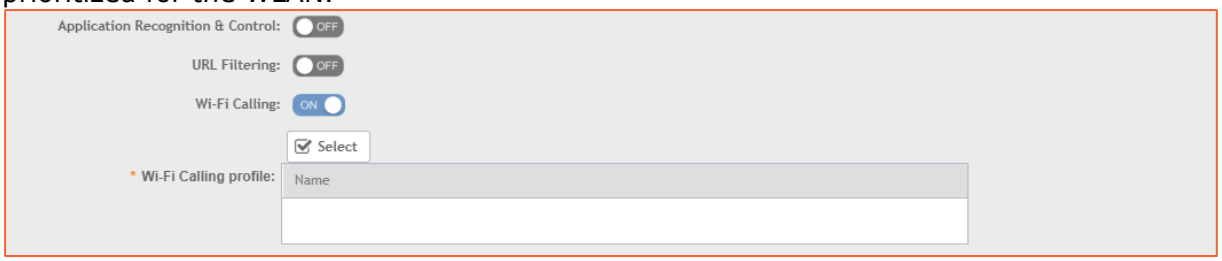
Unfortunately, this is not always the case and especially in industrial environments evolution of the network over time makes a simple chained network, as example in the picture left. If a device is connected to AP1 and roams to AP2 all L2 devices in the network needs to update their MAC tables before traffic to the specific client is restored. If this process scan takes too much time it will result in a big delay and results in an interruption of the conversation, or even worse the call is dropped. If that is the case, we recommend using a Ruckus dataplane in combination with the Ruckus SmartZone.
It works straight forward, the accesspoint builds a tunnel to the dataplane and all data from a specific SSID. The client traffic will be tunnelled to the dataplane and enters the actual L2 domain always on the same location. The advantage is that in between the hardware the MAC tables never need to update when a client's roams from one AP to another. Another advantage is that used client vlan's does not have to be configured on all network elements. In between accesspoint and dataplane.

4.2 Wi-Fi calling policy

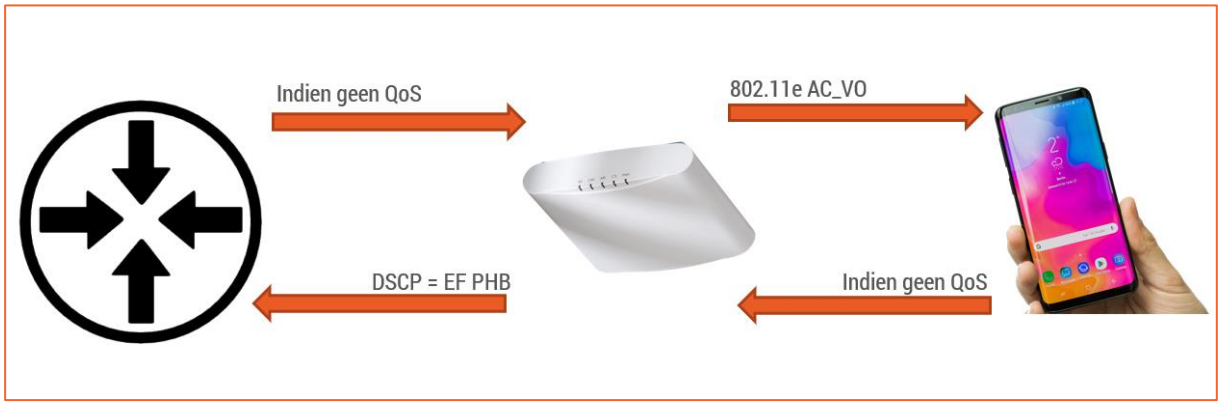
By default, in between provider core and client device no QoS is applied. Traffic is not prioritized and therefore handled same as all other traffic, partly because the data is inside the IPsec tunnel. Especially for the wireless part and contention for the medium, correctly prioritisation makes sense. Also, in a complex and busy switching environment the use of QoS can have its advantages.



Ruckus "Wi-Fi calling support" option is available starting with SmartZone version 5.0 and can recognize Wi-Fi calling traffic and for instance based on destination-address be re-prioritized for best performance of the application. Profiles can be built for different providers and makes it even possible to receive call statistics for a single operator. In the screenshot you can see how Wi-Fi calling policy can be locally configured per provider based on FQDN of the 3gpp core. After configuring the profiles, The Wi-Fi calling option can be enabled for a single WLAN and then you should be able to select the profiles (providers) that must be prioritized for the WLAN.

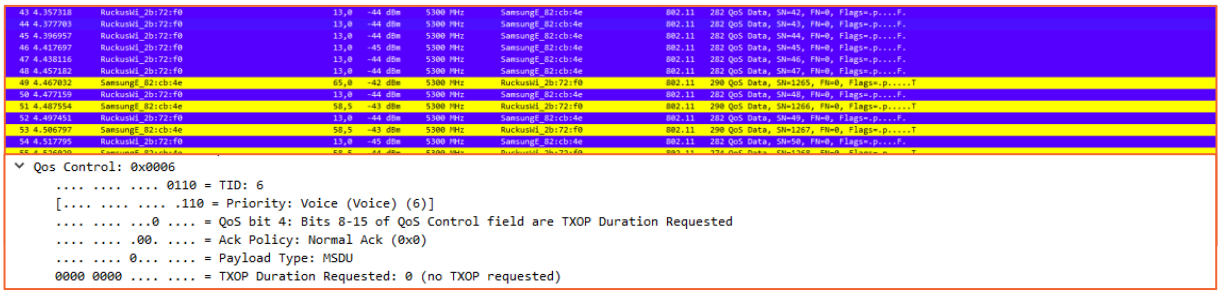


The picture below is a schematic representation of the process of the Wi-Fi calling policy. Make notice of the fact that the policy cannot influence the traffic send by the client device or the network.



QoS never applies to traffic originating from the internet, optional is QoS marking based on source on the firewall. Based on the policy the accesspoint will mark the packets as 802.11e AC_VO. In most cases, traffic from the client device will not have any QoS markings, the accesspoint will set the DSCP marking to EF PHB (low loss, low delay and low jitter services) before forwarding it to the network.

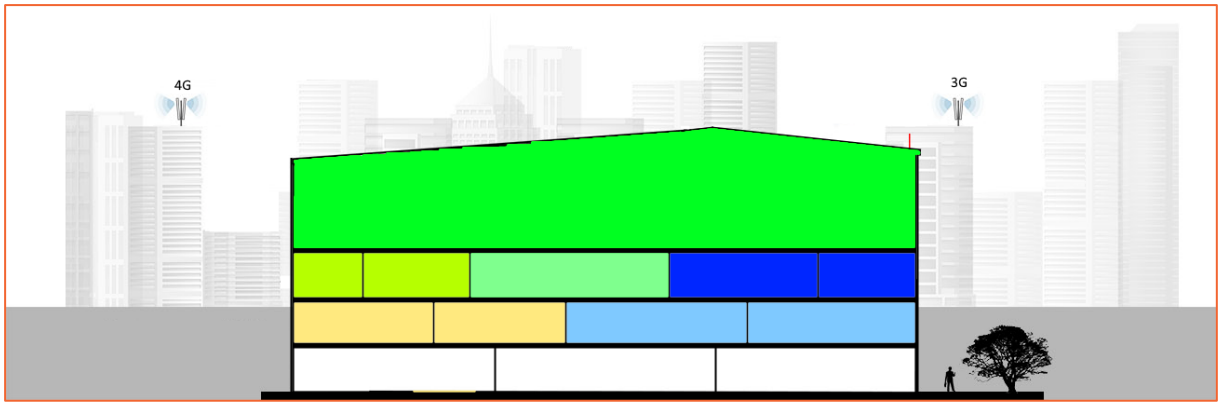
Picture below shows a packet capture after the Wi-Fi calling policy is applied.



5 Roaming

Although 3G, 4G and Wi-Fi calling are all used to make calls using the native dialler of the phone, roaming between different techniques is not always possible. Beside that the operation of different client devices using different 3G/4G coverage area's is different.
Using example below I will try to describe different options. This example is a simplified representation, in reality 3G and 4G signals may come from the same physical location and border areas between 3G / 4G and Wi-Fi are much vaguer.
The starting point in this chapter is that there is enough overlap between the various technologies that are switched between. Exactly how much that overlap should be depends on the device and provider used and the associated (set) threshold values. These values are set in the client device software and cannot be adjusted by the user.

Green = both 3G and 4G coverage
Blue = only 3G coverage
yellow = only 4G coverage
White = no cellular coverage



5.1 VoWiFi

If roaming takes place within the same network and the same subnet, the network is suitable for VoIP, no interruptions need take place. Restoring the data stream to the new location in the network can take place quickly enough to continue the conversation without interruptions being noticed.
This situation can occur if no mobile network is available or if Wi-Fi calling is used as the preferred network and you are moving through a building where a fully covering VoIP ready network is active. When leaving this building 4G coverage will most likely be present outside and when the signal of the Wi-Fi drops roaming to 4G is seamless.

5.2 Between VoLTE and VoWiFi

Because 4G and Wi-Fi calling use the same technique, creating an IPsec tunnel to the core of the operator using the available dataconnection roaming between both will be seamless and not being noticed. This can occur if making a phonecall using 4G and enter a location where no cellular coverage is present, and Wi-Fi is. Provided that the overlap between the two is sufficient, it does not matter whether there is a preference for cellular or Wi-Fi in the client device.

5.3 Between VoLTE and 3G

Switching between 4G and 3G is not possible. Because both use different ways to connect to the provider core, when switching between both connections will be broken. As long as there is no need a device will most likely not switch. This situation will occur when a call using 4G is started and the device moves to a non-4G coverage area where 3G coverage is present.

5.4 Between 3G and VoWiFi

Switching between 3G and VoWi-Fi is not possible. Wi-Fi calling uses the same technique as VoLTE and therefor switching is not possible. Some specific cases where this situation will occur:

- A device is set to prefer cellular (default for iPhone and optional for android). 4G is not available in the building and 3G is only available on the edges of the building. When starting a call 3G will be used, then if the user will move inside the building no 3G coverage is present and the call cannot be transferred to Wi-Fi.
- A device is set to prefer cellular (default for iPhone and optional for android) and VoLTE is disabled on the device. When starting a call 3G will be used, then if the user will move inside the building no 3G coverage is present and the call cannot be transferred to Wi-Fi.
- A device is set to prefer Wi-Fi when making a call, but the Wi-Fi network is unavailable when the call started. Then the user is moving inside a building where Wi-Fi coverage is present but 3G not. Call cannot be transferred and will be disconnected.
- A device is set to prefer Wi-Fi when making a call, and after starting the call it will leave the coverage area of the Wi-Fi network and only 3G coverage is present (or 4G support is switched off).

5.5 Live tests

In addition to how thing work on paper, tests will give more in-depth knowledge in the behaviour. Tests were performed to proof how smooth roaming was, if the switch was noticed and at what signal levels roaming would occur. For the test only one accesspoint is used, placed in the corner of the building to make a roaming boundary (see figure 5).

The tests are performed using a Galaxy note9. This device is a high model from Samsung and is supported by both KPN and Vodafone for Wi-Fi calling. Since iPhone always prefer cellular, and 3G or 4G is present everywhere in the building testing with iPhone was not possible. The Samsung device is configured with preference for Wi-Fi.

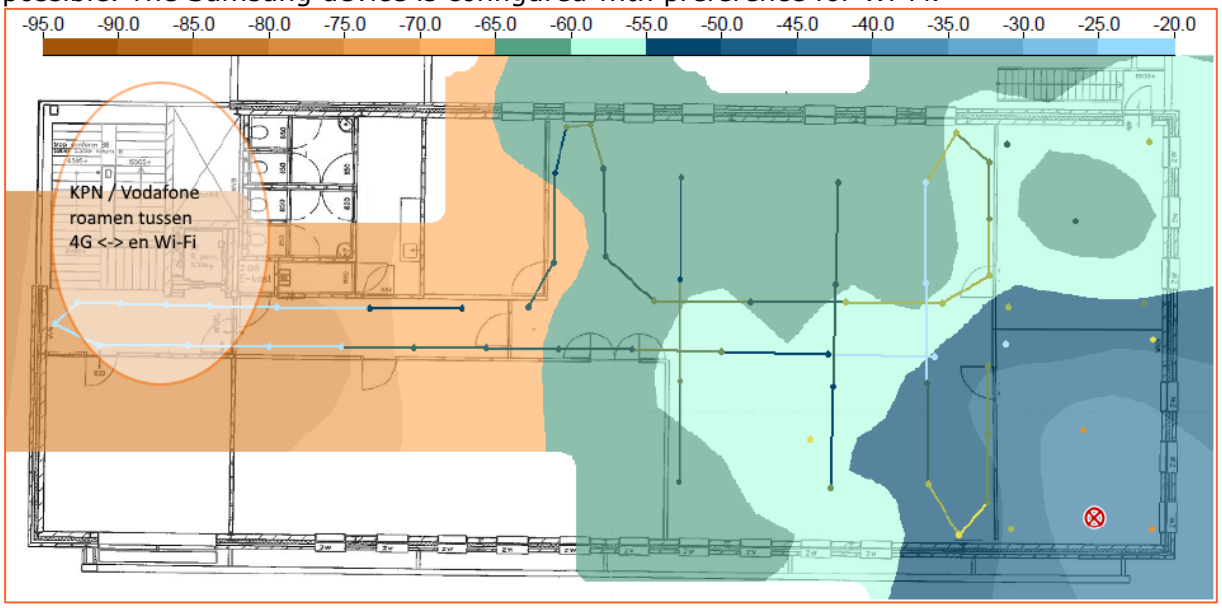


Figure 1 - 2,4 GHz coverage (dBm)

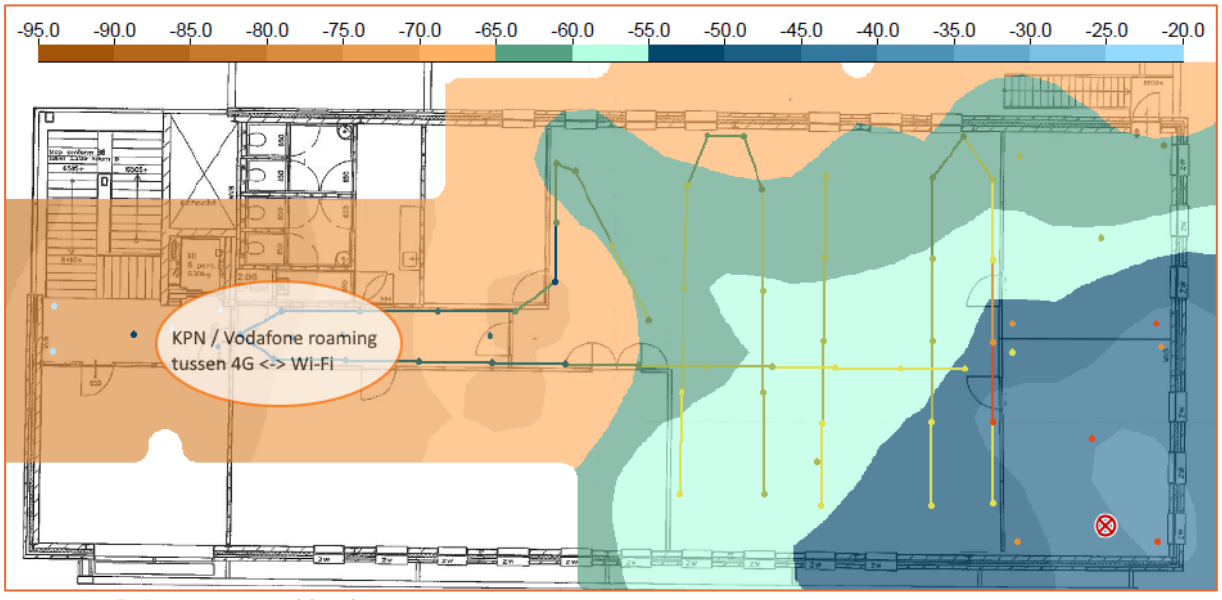


Figure 2 - 5 GHz coverage (dBm)

In table below you will find the result of the tests. In the test's distinction is made if a call is active or not. The signal strength is an indication and provided by the used client device.

Vodafone

NAAR ->	3G	4G	Wi-Fi	Gesprek 3G	Gesprek 4G	Gesprek Wi-Fi	Vliegtuigstand
3G ->			-73 dBm				
4G ->			-73 dBm				
Wi-Fi ->	-76 dBm	-76 dBm					
Gesprek 3G ->						blijft op 3G	
Gesprek 4G ->						-73 dBm	
Gesprek Wi-Fi ->				-76 dBm gesprek weg	-76 dBm		Tot Wi-Fi wegvalt

KPN

NAAR ->	3G	4G	Wi-Fi	Gesprek 3G	Gesprek 4G	Gesprek Wi-Fi	Vliegtuigstand
3G ->							
4G ->			-76 dBm				
Wi-Fi ->		-79 dBm					
Gesprek 3G ->							
Gesprek 4G ->							
Gesprek Wi-Fi ->							

Figure 3 - results roam tests Samsung Galaxy Note9

5.6 Other test results

5.6.1 Galaxy Note9

- When switching from Wi-Fi to 4G (with Wi-Fi preferred) without an active call a timer of 120 seconds is started. If user will return to the Wi-Fi coverage area the device will not switch back before timer is passed.
- Sometimes when switching from Wi-Fi to 4G or vice versa, a short interruption can occur that may not even be noticed by the user.
- If the user will move up and down the roaming boundaries it will most likely switch between both (for instance when walking back and forth). This issue can be solved by providing Wi-Fi coverage at all locations.

5.6.2 iPhone

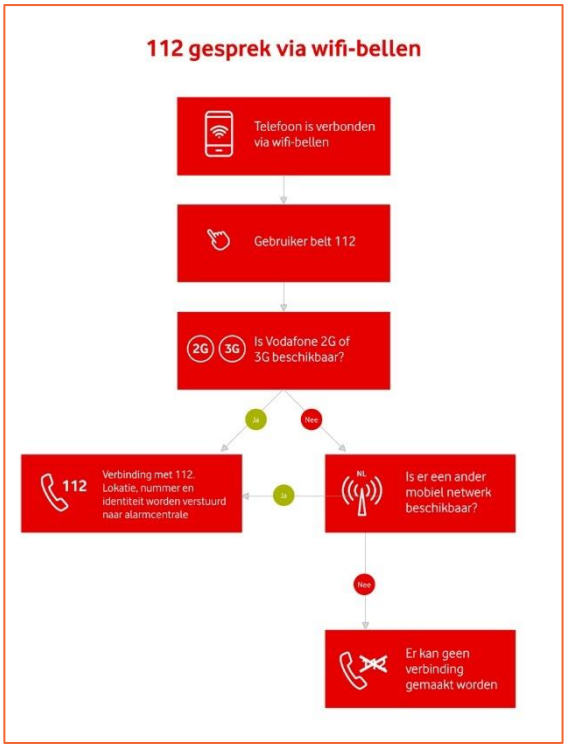
- iPhone cannot be set to prefer Wi-Fi for making calls. It is not possible to repeat the same tests as Note9.
- iPhone is sticky when it comes to 4G. Call quality can decrease before the iPhone decides to switch to Wi-Fi
- If the call is started using Wi-Fi calling it will maintain the connection using Wi-Fi until the Wi-Fi network is unavailable.

6 Others

6.1 Summary

- When compared to 2G and 3G call quality will increase when Wi-Fi calling is used (HD-Voice quality)
- Short time for the device to setup a call,
- Longer battery life,
- Wi-Fi calling will take over when 4G signal is to weak, user will not suffer from bad or dropped calls.
- No extra is charged, calls are billed exactly the same as 2G/3G/4G call.
- When using Wi-Fi calling user can be reached using the default cellular number.
- If device is in power save mode it will be waked when a call arrives.
- A call is handled as high priority when compared to other applications. Other applications will move to background en the dialler is displayed.

6.2 Emergency 112



At the moment of writing making emergency calls is not supported when using Wi-Fi calling only. This is among other things related to regulations which demands actual location is added to the call information. Based on the architecture calls can be routed to other countries before leaving the company network and GPS can be unavailable.
The picture left show how emergency calls will be handled. The own cellular network or from other providers can be used, otherwise emergency call are not possible and other alternatives must be found for contacting emergency services.