



VeevaHub System Overview for Partners

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Preface

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Document History

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1. Purpose of this document

This document is intended to give Veea partners an overview of the VeeaHub platform, along with information to help them start developing edge applications for VeeaHubs and meshes. It should also be useful to intending customers who are evaluating the VeeaHub for their needs.

There is a range of other documentation available from Veea Support, including detailed documentation for the VeeaHub Toolkit, guides for VeeaHub Manager and Enterprise Center and technical and application notes on various topics. Some are listed in Appendix A.

2. Introduction

The VeeaHub combines an advanced computing platform for both business and home applications with connectivity including Wi-Fi, Ethernet, Bluetooth, Zigbee and optionally 4G (later 5G) and LoRaWAN. It is offered in a range of models, with different hardware, connectivity options and form factors.

Multiple VeeaHubs, when connected together, automatically form a mesh. A mesh is a self-organizing, resilient network in which the data between individual hubs (the nodes of the network) is automatically routed to take the optimal route between the nodes. Veea's proprietary mesh technology is called vMesh.

Each VeeaHub is a server, and the mesh can provide distributed computing and data storage close to the users, avoiding uploading and downloading of data to and from the cloud. This minimizes data congestion, data traffic costs and latency, and enables the mesh to continue delivering services even when the Internet connection is disrupted.

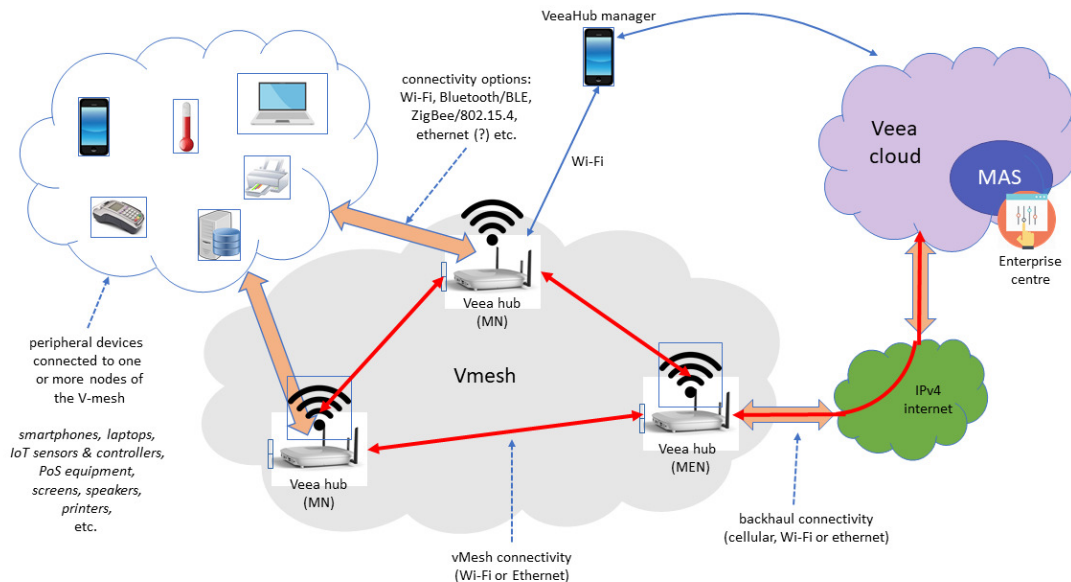
An application on a VeeaHub mesh runs in a container, a form of virtualization. This offers security and convenience of deployment.

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3. System architecture overview

An overview of the overall Veea system architecture is shown in Figure 1.

Figure 1: Veea system architecture overview



A VeeaHub contains a processor, operating system, storage and a number of connectivity options.

A single mesh comprises one or more VeeaHubs. The mesh between VeeaHubs can be formed over Wi-Fi or using Ethernet cable, or using a mixture of the two. One hub is singled out by being the communication link of the mesh to the WAN, and is referred to as the gateway hub (also called the Mesh Edge Node, or MEN). The gateway hub is also required to do management tasks for the network. Future developments are expected to enable the mesh to contain more than one gateway node.

The mesh supports a wide range of end-user devices, such as phones, tablets, PCs, Point of Sale (PoS) devices, printers, sensors and controllers. These devices receive IP addresses through the mesh and access services running on the mesh and on the WAN beyond the mesh.

The VeeaHub platform is designed to permit third-party applications to run on hubs. Developers can create functionality for specific uses or adapt existing applications.

The VeeaHubs and peripherals of the vMesh are connected to the wider Internet via the gateway hub. The backhaul can be Ethernet or cellular. The VeeaHubs are also connected to the Veea Cloud. This cloud comprises all the servers and services required to deploy, authenticate and manage a vMesh and its VeeaHubs.

The functions provided by the Veea Cloud include registration of user accounts, VeeaHubs and meshes, bootstrapping VeeaHubs, updating the platform software and downloading packages of applications to run on the mesh. Most of the functions of the Veea Cloud are not visible to the user, but when it is necessary for the user to interact with it, this is done through the user interfaces of Control Center, Enterprise Center and VeeaHub Manager.

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4. User Interfaces

4.1. Veeahub Manager (VHM)

Veeahub Manager is an app for both Apple and Android mobile devices. It enables a user to monitor Veeahubs and meshes. It is also used to add a new Veeahub to the Veeahub Cloud and to the user's Veeahub account. If the user does not already have an account, a new one can be created at the time of registering the first Veeahub on the Cloud. All users need to use Veeahub Manager for this purpose, but it also enables setting of user-configurable options on a Veeahub or its mesh at any time.

A user document, called Veeahub Manager Guide, describes the functionality of VHM in detail.

4.2. Control Center

Control Center is the user portal to the owner's Veeahubs and vMeshes. This provides the ability to monitor meshes and devices and download application packages, paid or free, but does not provide all the node and mesh configuration options. A Veeahub appears in Control Center once it has been added to the user's account.

Control Center is planned to be merged with Enterprise Center in a future version.

4.3. Enterprise Center and Node Manager

Enterprise Center is the fleet-management interface for enterprise customers. This interface allows enterprise customers and resellers to manage their Veeahub assets and associated applications across multiple deployments. From Enterprise Center the user can make configuration changes to and determine the status of meshes, devices or applications in different locations, as well as managing Veeahub upgrades and viewing or exporting Veeahub analytics. The Node Manager component of Enterprise Center provides a similar range of options to Veeahub Manager.

Enterprise Center can be used to display site management details, showing vMesh deployments on maps and floorplans, along with a display of the vMesh topological and status information.

Enterprise Center is a view into the Management and Authentication Server (MAS) in the Veeahub Cloud. MAS is Veeahub's backend system for managing and controlling all the Veeahubs, meshes and groups of meshes under the ownership of a customer.

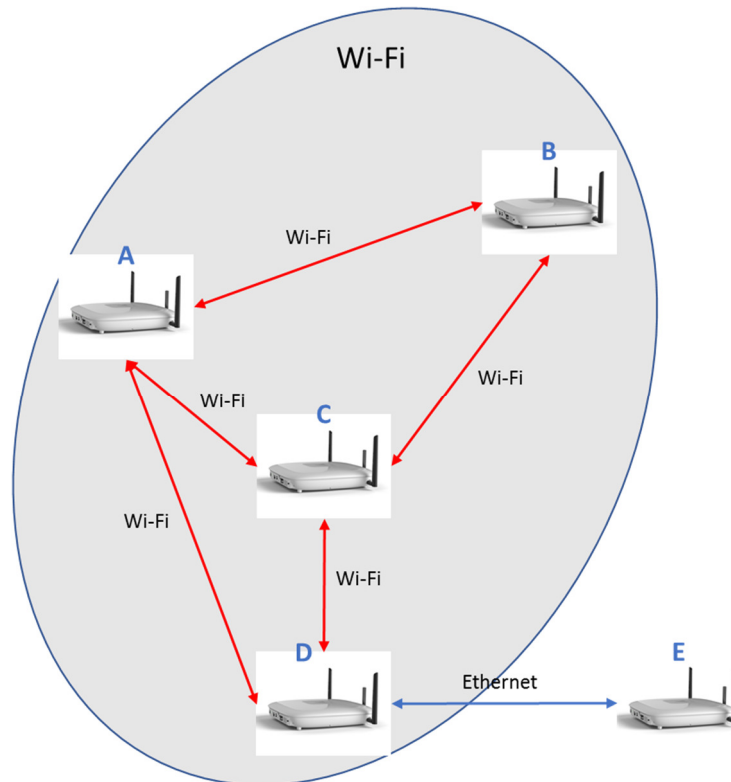
Enterprise Center consists of all the functions that can be carried out by a regular user in a company.

5. vMesh

The mesh is a collection of Veeahubs that are connected together through Veeahub's vMesh technology to form a private network. The mesh employs a layer 3 routing protocol allowing each Veeahub to be individually IP addressable. Using VHM or Node Manager, different configurations can be set up, including up to four separate LANs, each of which can be bridged to the WAN or connected to it through network address translation (NAT).

The datalink and physical layer connections of the vMesh are a Wi-Fi ad hoc network or a cabled Ethernet. A single vMesh can comprise both wireless and cabled links. 802.11ac functionality at 5GHz is employed by default for the Wi-Fi network. An example vMesh is shown in Figure 2, where Veeahubs A-D are connected together as part of a Wi-Fi network, whilst Veeahub E is connected to the vMesh using Ethernet.

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Figure 2: Example vMesh

The routing within the vMesh is adaptable and dynamically selects the best path through the mesh for the current mesh topology based upon a route metric algorithm. If a Veeahub goes out of service for some reason or is moved, new routes are formed within the mesh avoiding the now obsolete links through this Veeahub.

6. The Veeahub

6.1. Veeahub architecture

The Veeahub platform is Linux-based and is split into isolated user spaces, or containers, through the use of a secure Docker environment. The environment used in the Veeahub is a refinement of the standard Docker model enabling improved security and efficiency. The Veeahub enhancements are discussed in section 11.2.

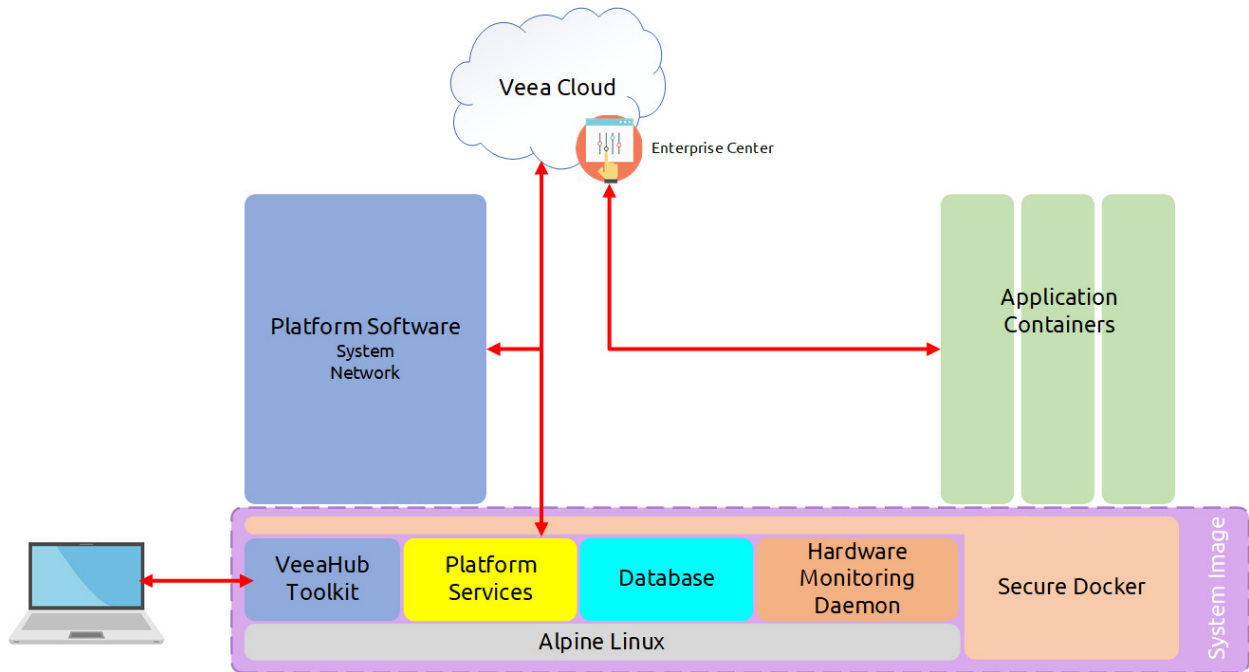
Development and deployment of user containers is described in the Veeahub Toolkit documentation. Once deployed, users install the applications they need from the options in Enterprise Center. Application containers can run services on single nodes or across multiple Veeahub nodes.

Container applications or services may be written by Veeahub, one of its partners, or third-party developers. They may be made freely available or licensed to other Veeahub users and operators as the developer requires. The secure Docker runtime environment means that all container images have to be signed by Veeahub, and all hardware capabilities employed by the application have to be properly licensed, to ensure the integrity of the platform and the vMesh deployments.

A high-level diagram of the Veeahub software architecture is provided in Figure 3, where the application containers are shown in green.

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Figure 3: Veeahub software architecture



6.2. Veeahub connectivity

In addition to the Wi-Fi and Ethernet interfaces employed for vMesh, a Veeahub has 802.11 Wi-Fi basic service set (BSS) at 2.4GHz and 5GHz, used for enabling Wi-Fi access for end devices, and Bluetooth classic and Bluetooth low energy (BLE). The Bluetooth beacon is used to aid establishing the initial connection between a mobile phone running VHM and a Veeahub. Veeahubs may be supplied with optional modules including 4G cellular, IEEE 802.15.4 / ZigBee or LoRa radio. Besides the Ethernet ports, the USB ports can be used with suitable adaptors to provide additional Ethernet connections. Not all Veeahubs have all connectivity options.

The VHE10 has three Wi-Fi interfaces which, depending upon the regulatory domain, spectrum availability and use case, can be employed simultaneously to provide vMesh Wi-Fi connectivity and Wi-Fi access points (APs) at both 2.4GHz and 5GHz. The VHE09 has two Wi-Fi interfaces and the 5GHz AP and mesh are time-multiplexed on a single interface. The basic connectivity options for each Veeahub model are shown in Table 1 below.

Table 1: Veeahub model connectivity options

| | VHC05 | VHE09 | VHE10 | VHH10 (outdoor) |
|--------------------------|---------------------|----------------------------------|-----------------------------|-----------------------------|
| 2.4GHz Wi-Fi | single | single | single | single |
| 5GHz Wi-Fi | single (AP or mesh) | single (AP, mesh or multiplexed) | dual (AP and mesh) | dual (AP and mesh) |
| dedicated Ethernet ports | 1 | 2 | 2 | 2 |
| external USB ports | 2 | 3 | 3 | 0 |
| Ethernet via USB adapter | 2 | 3 | 3 | 0 |
| Bluetooth / BLE | yes | yes | yes | yes |
| ZigBee | yes (optional) | yes (optional) | yes (optional) | yes (optional) |
| LoRa | no | yes (optional) | no | yes (optional) |
| cellular | yes (optional) | yes (optional) | yes (optional) | yes (optional) |
| hardware SKUs | ZigBee and cellular | all optional simultaneously | all optional simultaneously | ZigBee and cellular or LoRa |

6.3. Gateway and Network hubs

A gateway hub or gateway node, also called a Mesh Edge Node (MEN), is the Veeahub that has a direct backhaul connection to the WAN. The backhaul connectivity may be Ethernet or cellular.

The gateway hub also has a number of unique functions in the mesh. It is the first hub in the mesh (unless the role of MEN is reassigned subsequently) and is therefore responsible for the processes that initially establish the mesh. Software that is downloaded from the Veeah Cloud goes to the MEN, which then distributes it to the other nodes as required.

The gateway can be configured as a bridge to the WAN, or to provide NAT between the mesh and the WAN, which is the default. When used in NAT mode, the gateway has a DHCP server that is typically activated to provide IP addresses to the network. For further information see section 10.2.

Currently there can only be one gateway hub per vMesh.

A network hub or network node, also called a Mesh Node (MN), is a Veeahub that does not have a direct backhaul connection to the WAN. These hubs obtain Internet connectivity via the mesh interface using an IPv4 private address assigned to the network hub.

7. Veeah cloud

The Veeah cloud is a collection of software and server functionality that is provided to enable deployment, authentication and management of the vMesh and associated Veeahubs. Enterprise Center (section 4) is the part of the cloud that gives users access to the management functions available to them.

The connection between the Veeahub and the cloud uses WAMP, an open standard websocket subprotocol. The decoupling due to the WAMP router means that there is no direct network path between the Veeahub and the Cloud, which in turn means no ports on the Veeahub need to be opened and the remote attack surface of traditional remote procedure calls is eliminated.

8. Adding and bootstrapping the Veeahub

When the Veeahub leaves the factory, for security and simplicity reasons it is relatively dumb with no concept of ownership and no application software loaded. The enrollment function adds the Veeahub to the cloud database and links the unit to the user's account. This is followed by the bootstrapping of the hub: the location of the Veeahub and its security credentials are provisioned to the Veeahub so that management of the device can be performed and Veeahub system and standard application software can be downloaded to it.

Once the bootstrap has been performed as outlined above, the Veeahub owner can see their device listed on Control Center and select what package they would like configured on the Veeahub. A package comprises a package description, platform software, container software and additional metadata, that is, it includes not only the platform software but also application containers providing different functionality to the Veeahub or vMesh. Alternatively, the Veeahub may have been sold pre-provisioned for a particular purpose, and the necessary software will be downloaded at the first bootstrap. This method is more suitable for large-scale deployments or in enterprise networks.

9. Veeahub flash memory bootstrap, upgrade and recovery

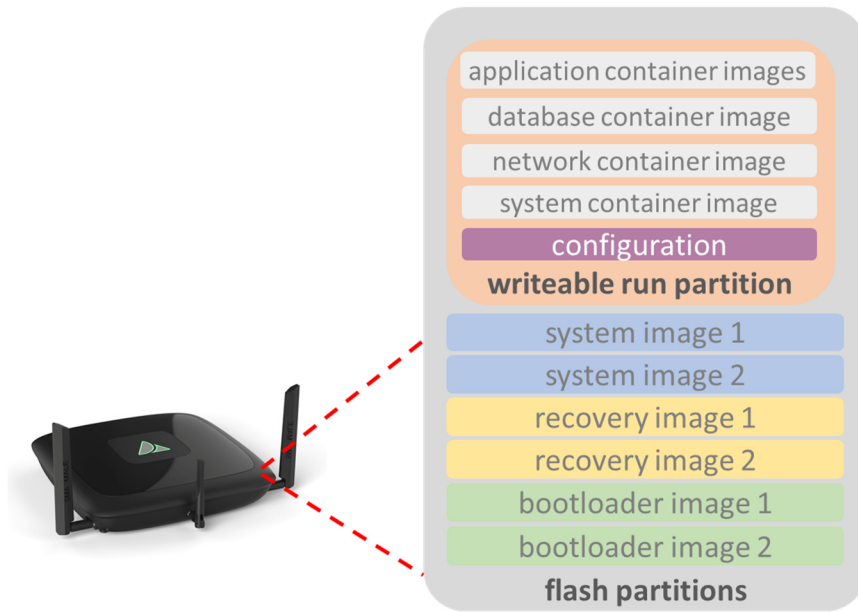
The Veeahub has memory partitioning that is designed to facilitate upgrades whilst also providing redundancy capabilities in case a software image is corrupt, or if part of the memory system fails. The memory is split into a primary and a secondary partition for system software and a single partition, the run partition, for all the container software (Figure 4).

When the Veeahub is bootstrapped for the first time, the bootloader and recovery software are downloaded from the Veeahub, decrypted and authenticated using the credentials supplied, and placed in the primary partitions. The Veeahub is subsequently rebooted and the system image and configuration information are downloaded, decrypted and authenticated. The system image is placed in the primary partition whilst the configuration information, which includes the essential mesh parameters, is put in the run partition.

The Veeahub is then rebooted into the system image, detects that the run partition has no containers and goes into the container bootstrap process. This is essentially the same process, downloading the encrypted images from the image server, decrypting and authenticating them, then loading them into the run partition, updating the Veeahub configuration to include the containers, and configuring the individual containers before starting the container system operation.

Before any system software or containers are downloaded from the image server, the Veeahub checks to ensure for hardware, license and version compatibility.

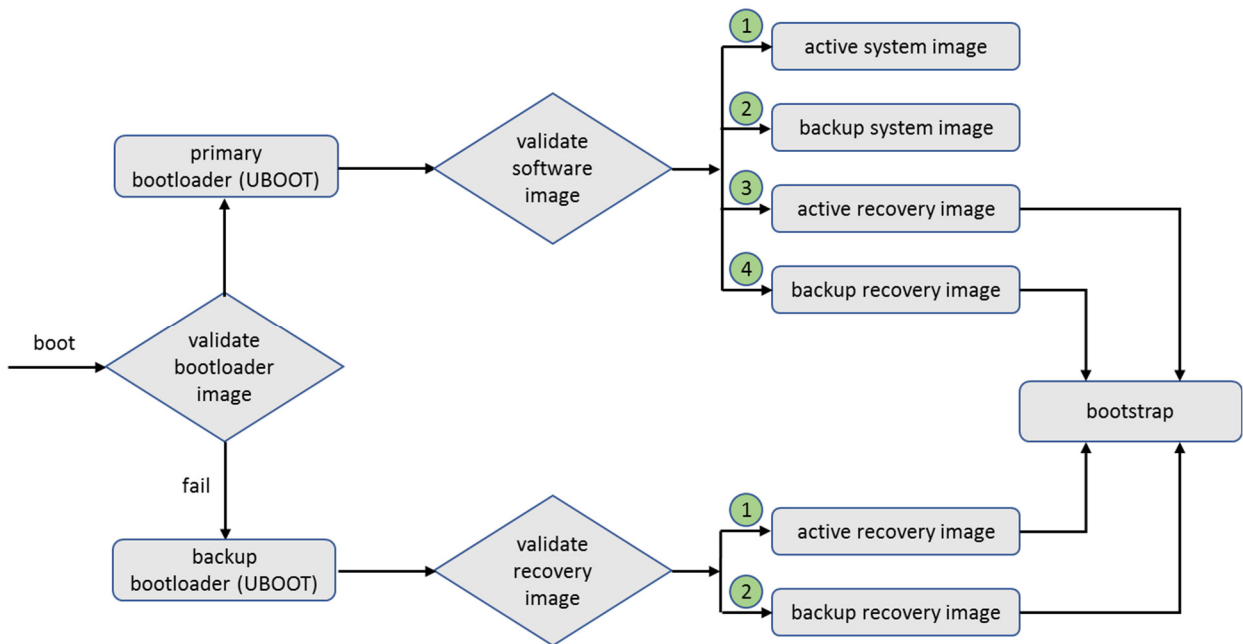
Figure 4 - Veeahub flash partitions



If a software upgrade is performed, then a similar procedure is applied, but with the new software images written into the currently unused partition and the containers overwritten in such a manner that the data is preserved. Once correct operation with the upgraded software has been verified for a suitable period of time, then the new software images are copied across to the other partition as well.

If an issue is found with any of the platform software, either during start up by means of an integrity check, or failure to launch after three attempts, or whilst it is running, the Veeahub software is switched to the other partition and rebooted from there. If this fails, then the bootloader tries the two recovery images. If either of these is launched it successfully initiates the bootstrap procedure, Figure 5.

Figure 5 – Veeahub bootstrap procedure



vMesh upgrade refers to a procedure whereby clients can maintain, upgrade and downgrade their Veeahub software. A new software package is selected by the user, and the package along with any necessary base software upgrade is downloaded to the MEN, which then distributes necessary software updates to the rest of the mesh. A similar process occurs if the user requests an upgrade or unsubscribes from an existing package.

If required, a restart takes place. The MEN reports the mesh upgrade status to the Veeahub Cloud.

10. vMesh networking

This section outlines some of the important aspects of the vMesh that are exposed to users.

10.1. Wi-Fi RSN mesh

A vMesh is typically a Wi-Fi ad hoc network, although some or all the vMesh links can be cabled Ethernet instead. An ad-hoc network is one that does not require an AP to control operations. Any nodes within range of each other can communicate if both agree on some basic parameters. Each node of the mesh uses the same SSID.

Robust secure network (RSN) describes the security enhancements delivered to Wi-Fi in 802.11i, including advanced encryption standard (AES), 802.1x and the extensible authentication protocol (EAP).

10.2. LAN configuration

The MEN is addressed from outside of the vMesh via the IPv4 address of the backhaul interface. This may be a globally routable address or more likely a private IP address from behind a NAT in the backhaul operator's domain.

In the default configuration of the Veeahub mesh, the MEN contains NAT functionality to allow this single IPv4 address to be used by the multiple Veeahubs, and all connected peripherals, within the vMesh. Thus, the MEN is the gateway to the vMesh private network.

The mesh can, alternatively, be configured in bridged mode where all IP addresses are assigned by a DHCP server in the WAN.

There can be up to four LAN subnets (distinct IP address ranges) on a single Veeahub network. A LAN subnet behaves like a separate LAN on the overall network. A LAN can be created in one of two configurations, routed (with NAT to the WAN) or bridged to the WAN, as described above. When a Veeahub network is first set up, it comprises a single LAN in the NAT configuration.

The LANs are configured using Veeahub Manager or the Node Manager in Enterprise Center. For more information about LAN configurations on a Veeahub mesh, see documentation available from Veeahub Support.

10.3. Mesh routing and maintenance

vMesh employs a proprietary routing algorithm. This is based on a distance-vector algorithm, where a Veeahub can only see its immediate neighbors, but knows the distance or cost to any particular Veeahub within the network and also which neighboring Veeahub to send the data to get to that destination. This approach avoids the high overhead of maintaining link-state information for the entire network.

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A link metric between two Veeahubs can be calculated based upon not just the estimated number of transmissions (ETX) but the estimated transmission time (ETT). This approach is superior when links are present that can employ a wide variety of rates as is typical in 802.11n or 802.11ac.

The link costs are calculated in each direction for a neighboring link between two Veeahubs and exchanged between them. The overall route metric between any two, not necessarily neighboring, Veeahubs within a vMesh is the sum of the individual link costs which make up that route.

The link cost for each link is information available to the user, and is displayed on the Site page of Enterprise Center (section 4.3). The vMesh link costs, and hence routing metrics, are recalculated on a regular basis. This ensures that as the vMesh evolves or changes the current routing metrics are dynamically kept up to date.

If it is detected that the interface between two Veeahubs is wired instead of wireless, the same functionality still operates except that a fixed low cost is applied to the link and no regular sounding procedure for the link is performed.

11. Veeahub Applications

11.1. Edge applications and application development

Application packages are selected by users from Enterprise Center. Different packages may be offered to users depending on the Veeahub models and capabilities on the mesh. Applications are offered in this way only when they have been prepared as secure containers that have been verified and signed by Veeva.

An application is downloaded from the Veeva Cloud to the gateway hub. If it is an application that needs to be installed on each node in the mesh, it is downloaded once to the gateway hub and the application image is trickled through the mesh until each Veeahub has obtained it. In this manner, the traffic through the backhaul and mesh is minimized in the process of downloading the application image.

The method of development supported by Veeva is through use of the downloadable Veeahub Toolkit. This comes with a number of template applications that can be used as the starting point for applications of different types.

For development purposes, applications can be sideloaded on to a Veeahub and development, testing and debugging done there. It is also possible to temporarily add SSHD to the application for debugging purposes. These actions circumvent the security requirements and should only be done in a secure environment.

Applications may be written in any language, Python, C, Golang, Node.js etc., but must be compiled to run on ARM 32-bit or 64-bit processors. The VHC05 has a 64-bit processor running in 32-bit mode, while the other models have 64-bit processors.

vBus is a communication bus designed by Veeva to simplify the design of services using hardware devices. It supplies a library of modules for different types of hardware: Wi-Fi, Bluetooth, LoRa, Zigbee, audio, camera and so on. This enables any application running anywhere on the vMesh to communicate with hardware elsewhere on the mesh. Libraries are available in a range of languages, initially Golang, Python, C, Java and JavaScript. vBus includes a dashboard that allows you to access devices and data on different Veeahubs in the network.

11.2. Security and efficiency advantages

The Veeahub container model makes some proprietary enhancements to Docker, particularly for advantages of security and of efficient use of resources.

Because Veeahub is intended as a platform for third parties to develop and sell their own ideas, the design assumes that containers running on the Veeahub may have security vulnerabilities that could allow an attacker access to the container. Once an attacker has gained access to a container, the platform restricts the attacker to just that container and does not allow them access to the rest of the system. All containers are run as normal users with minimum permissions unless essential.

For containers that need to run with elevated permissions for access to hardware devices or specific features, a system of control is applied through licensing. A developer applies for a license for each hardware type or specific feature. This enables Veeahub to keep track of and minimize the number of containers that are running with these elevated permissions and so to keep the whole system secure.

The partner simply adds a license to the relevant Docker container as a label. The Veeahub detects the label and applies the license automatically as the container is started. The labels tell us what hardware the container needs, so these can be used to see if the container would collide with another container that also needs the same hardware, and which Veeahubs the container can be run on.

A container must request the use of a device and receive access only to the hardware devices requested, minimizing use of resources and again reducing security risks.

Another way in which the Veeahub enhances Docker security is that the Veeahub uses checksums for container image metadata as well as for the images themselves. The metadata controls how an image can be started, what resources it should have, etc. Validation of the metadata increases the ability of the platform to know if an image has been modified.

The Veeahub enables signing of the image metadata, in a way that is compatible with the standard Docker container definitions. The author of a container can sign both the images and the metadata. The signed metadata includes the author, version, platform compatibility, hardware requirements, licenses, image checksums, etc. If the image is validated and any part of the image or metadata is changed by a single byte the signature will fail.

This allows the Veeahub to perform an integrity check on any container that it is asked to run and also re-check the integrity of its container images and metadata at any time.

The difference in code size resulting from these security and efficiency enhancements, compared with standard Docker, is small.

11.3. Edge applications offered by Veeahub

Veeahub offers a range of hardware support and packages around which you can build your application or service. For the current set, see Veeahub's commercial datasheets or contact Veeahub Support.

11.4. Developing edge applications

Veeahub supports the third-party development of edge applications through its downloadable Veeahub Toolkit, supported by comprehensive documentation.

The Toolkit runs on Ubuntu Linux version 18.04.3 and later. Veeahub can provide a separate document describing how to set up Ubuntu as an Oracle Virtualbox virtual machine on Windows 10.

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VHT provides the following components:

- Veeahub Client (VHC): a command-line utility designed to help developers easily create, build, and deploy user applications for Veeahub. Veeahub Client is the primary way that developers interact with the toolkit.
- Custom installations of OpenSC and PKCS11 used for signing applications and Transport Layer Security (TLS).
- Python scripts for securely signing and verifying applications.
- Veea root certificate authority as well as license authority and server certificates.
- 32- and 64-bit Qemu ARM tools for cross-compiling applications for the Veeahub.
- A suite of demonstration applications known as C3 Templates.

12. The SD WAN container

The SD WAN container provides management of multiple WAN backhaul connections. When a cellular module is fitted to a Veeahub, it provides 4G cellular failover functionality. Later releases of the application will provide additional features on top of this.

Each WAN interface is assigned a priority metric and in the absence of a failure, the highest priority WAN interface is used to determine the default route. Regular pings are performed on interfaces of a higher priority than the current one (this avoids excessive traffic on a lower-priority interface such as cellular). If connectivity is lost, the default route is moved to the next highest priority WAN interface. Once failover has occurred, pings on the higher-priority interface determine when failback to that interface is possible.

13. Technical Support

Before contacting Technical Support, please consult the documentation, tutorials, and community topics available on the support web site www.veea.com/support/. Please sign up, if you don't already have an account, and sign in.

For unresolved queries, click on the Submit a request link.

Please complete the form with an appropriate subject, and as much detail as possible in the description field. Please include any relevant information such as Veea hardware serial numbers, logs, screenshots, etc.

An email will automatically be sent to your email address to confirm the request has been received.

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Appendix A Veeahub documentation

Veeahub documentation available includes:

- Veeahub Manager Guide (separate editions for Apple and Android mobile devices)
- Enterprise Center Guide
- LAN configuration on a Veeahub network
- Veeahub LAN configuration procedure
- Veeahub Toolkit documentation

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