Overview

Ayla Product Architecture Comparison

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Ayla Networks

Referenced Documents

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1 Introduction

Ayla Networks provides a cloud-based application enablement platform making it easy and cost-effective for OEMs to connect any device to the Internet. Ayla's software creates a flexible fabric to accelerate the development and support of smart, interactive product solutions, across devices to cloud to applications.

Using Ayla software device makers, service providers, and large retailers to quickly integrate secure connectivity and data intelligence into products without substantial design modifications or changes to existing business models.

This document discusses device design options and development approach for interacting with Ayla Embedded Agents that run on IoT devices and IoT device gateways.

2 Product Architecture

2.1 Ayla Platform

Ayla designed its IoT platform to be generic, meaning it can work with virtually any kind of product. For Ayla, it is important that its platform supports an air conditioner just as easily as a thermostat, a medical device, a coffee maker or an oilrig.

Manufacturers are experts in their domains, but rarely are they also experts in making IoT connected versions of their products. The Ayla architecture is built to take care of the IoT connectivity portion of the equation for manufacturers, no matter what kinds of products they make.

The Ayla IoT platform architecture takes an end-to-end approach, offering software that spans all the elements of the IoT itself: device, cloud, and mobile app.
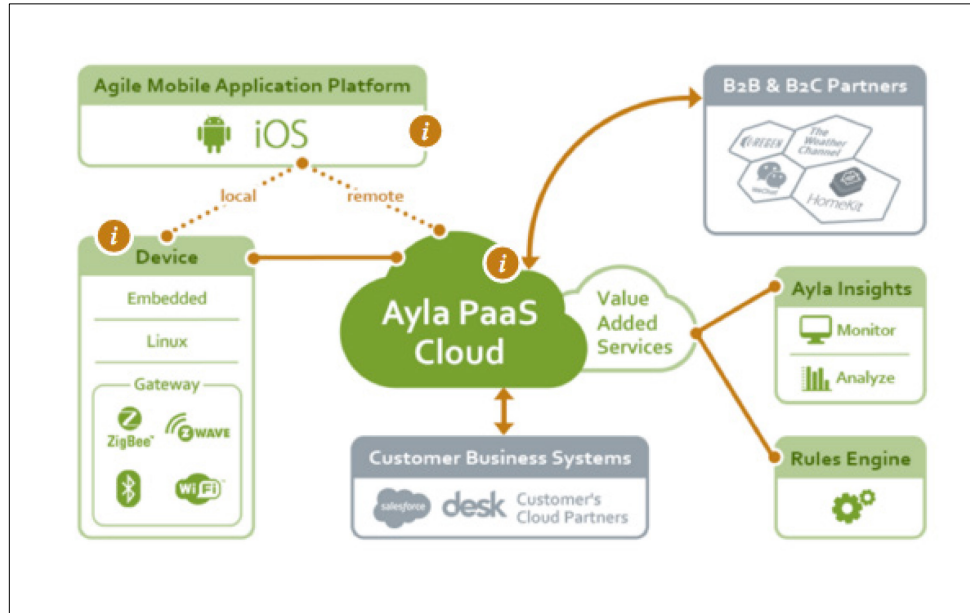
Figure 1. Ayla Platform Architecture Diagram

Across this full spectrum, Ayla handles security, performance, network latency and communications handoffs everywhere. It also takes care of keeping the software, firmware and security of connected products updated and current.

3   Ayla Device Support

Traditionally for manufacturers, any software embedded into their products was either designed or connected by others. Complex software engineering has not been part of manufacturing engineers' experience. Manufacturers also are not generally accustomed to handling the software distribution and management issues surrounding manufacturing embedded products.

If manufacturers want to build their IoT platforms, they must consider several things like how to bring these new areas of expertise into their workforce. Do they hire new people, embark on a lengthy process to train their existing staff or utilize a ready-made IoT platform instead?

3.1   Ayla Embedded Agents

Ayla Embedded Agents run on IoT devices or IoT device gateways. They incorporate a fully optimized networking stack along with additional protocols to connect devices to Ayla Cloud Services.

Developers using nearly any microcontroller can choose to use Ayla-enabled connectivity modules, which provide cloud connectivity while shortening the arduous software quality-assurance and hardware verification cycles typically required for designs based on standard off-the-shelf connectivity modules.
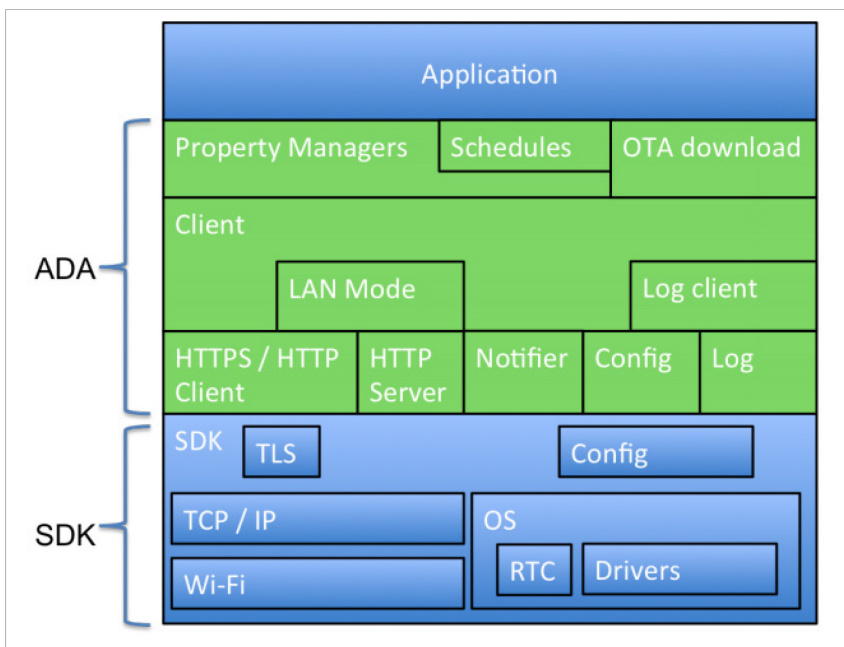
Figure 2. Ayla Embedded Agent

Developers using Linux or other operating systems can integrate Ayla Embedded Agents into their designs to enable cloud capabilities over any networking media.

3.2   Device Offerings Options

The following end device solutions are currently available from Ayla Networks.

- Ayla-enabled Wi-Fi Module – Black Box

- Ayla Embedded Software Agent – Embedded White Box

- Ayla Linux Software Agent – White Box

- Ayla Generic Gateway Agent – White Box

3.2.1   Ayla-enabled Wi-Fi Modules – Black Box

The "Black Box" Ayla-enabled Wi-Fi module is a Wi-Fi communications module pre-loaded with software that enables a device to connect to the Ayla cloud service. An external processor running the customer application can connect to the module via SPI or UART. The Black Box Ayla Module includes: production-ready Ayla Cloud Agent, Networking and Security software, and offers the following benefits:

- Available for Embedded Solutions

- Provides fastest time to market

- No smart gateway required

- No custom software or QA, regardless of the type of End-Device

- No need to hire Embedded engineers

- Any Microcontroller-Based System

  o Simple Connection Through SPI or UART

  o Port Only a Small Driver – Less than 20KB of Code

NOTE	OEMs are only responsible for the host application.

3.2.2 Ayla Embedded Software Agent – Embedded White Box

The "White Box" Ayla Embedded Software Agent is a software module that can be integrated with embedded networking and OS software, to run on a Wi-Fi communications module. The customer application code runs on the module with the Ayla Software Agent, and has access to all the features and services of the OS and networking stack on the module. The Ayla Embedded Software Agent provides the following benefits:

- Targeted for specific Wi-Fi manufacturers and their supported SDKs.

- Secure, reliable connectivity to the Ayla Cloud Service

- LAN Mode Support – Direct Mobile-To-Device Communications

- Support for OTA Image Management and Distribution

- On-Device Schedules for Automated Control

- Wi-Fi setup for specific Wi-Fi modules, and example application code

- The Ayla Embedded Agent is available as Source

- This solution is well suited for applications with existing RTOS and networking

- APIs and data representation are similar to Black Box

- Cloud Agent's Modular Design allows code for additional functions to be included as needed

NOTE	OEMs are responsible for all device side applications including:
	- Host Application implementation
	- OS features, such as tasks, timers, memory management
	- Networking stack, including TLS
	- Security routines for authentication and encryption
	- Integration of Ayla Embedded Agent into OS and network stack
	- Upgrade of the module software, using images received via Ayla's OTA service
	- Loading of Ayla Device credentials during device manufacture

3.2.3   Ayla Linux Software Agent – White Box

The "White Box" Ayla Linux Agent is a software package that can be integrated into an embedded Linux environment. The customer application code links against a library provided as part of the Ayla software package. The customer application shares the Linux environment with the Ayla Software Agent, and has access to all the Linux features and services. The Ayla Linux Software Agent provides the following benefits:

- Secure, reliable connectivity to the Ayla Cloud Service

- LAN Mode Support – Direct Mobile-To-Device Communications

- Support for OTA Image Management and Distribution

- On-Device Schedules for Automated Control

- Wi-Fi setup framework, with example implementations

- The Ayla Linux Agent available as Source

- This solution is well suited for existing Linux-based customer applications

- APIs and data representation are similar to Black Box

- Cloud Agent's Modular Design allows code for additional functions to be included as needed

NOTE   OEMs are responsible for all device side applications including:
- Host Application implementation
- Linux configuration and system management
- Networking stack, including TLS
- Security routines for authentication and encryption
- Installation and integration of Ayla Embedded Agent into the Linux distribution
- Integration of Ayla's Wi-Fi setup framework into the platform's W-i-Fi driver
- Linux image management, using images received via Ayla's OTA service
- Loading of Ayla Device credentials during device manufacture

3.2.4   Ayla Generic Gateway Agent – White Box

The "White Box" Ayla Generic Agent is a software package that can be integrated into a Linux-based gateway product, enabling nodes on a connected network to be represented as devices in the Ayla Cloud Service, and managed remotely. The customer gateway application links against a library provided as part of the Ayla software package. The Ayla Generic Gateway Agent provides the following benefits:

- Available for Gateway Solutions

- Flexible definition of node data to handle any type of networked device

- Support for multiple attached networks of different media types

- Secure, reliable connectivity to the Ayla Cloud Service

- LAN Mode Support – Direct Mobile-To-Gateway Communications

- Support for OTA Image Management and Distribution for Gateway and Nodes

- On-Device Schedules for Automated Control of Gateway and Nodes

- Wi-Fi setup framework, with example implementations

- The Ayla Generic Gateway Agent available as Source

- This solution is well suited for existing Linux-based gateway applications

- Cloud Agent's Modular Design allows code for additional functions to be included as needed

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NOTE   OEMs are responsible for all device side applications including:
- Gateway Application, include node management and communication
- Networking
- Security
- Per Device Authentication
- LAN Mode – Direct Mobile-To-Device Communications
- Support for OTA Image Management and Distribution
- On-Device Schedules for Automated Control

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4   Black Box Model

The Black Box model integrates Wi-Fi modules from various vendors like Broadcom, Marvell, Qualcomm, etc. with the Ayla Embedded Agent firmware. The Ayla Embedded Agent firmware implements all the required SW applications, networking and security protocol stacks to get a device communicating with the Ayla Cloud service.

OEMs integrate the Wi-Fi module into their product and interface with the host microcontroller on the device logic board using a serial interface like SPI or UART. This provides flexibility in the type of host MCU that is used in the device. The Wi-Fi module has been integrated with host MCUs from various vendors (for example: Microchip PIC18, PIC32, Atmel ATmega, Renesas RL78, Freescale, STMicro STM32F2, F3, F4).
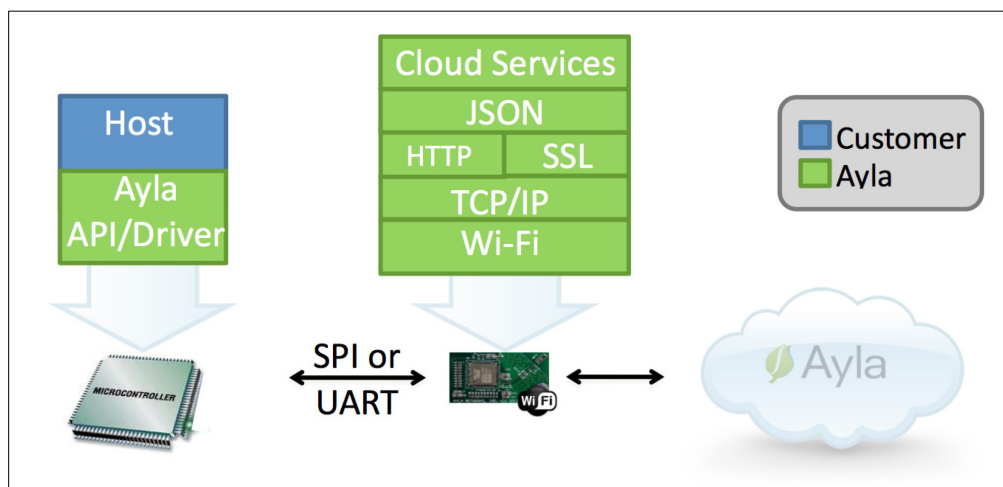
Figure 3. Ayla Black Box Model

4.1   Solutions Statement

The Black box model is the most scalable, easy to use, and fastest Time-To-Market solution. This solution offers a simple connection through SPI or UART with only a small a driver in most configurations. Properties can be defined to match whatever the host application currently uses and do not need to re-architect the host application around the cloud service.

4.2   Advantages

The Black Box model provides OEMs or device developers the following benefits:

- Production ready Wi-Fi connectivity module from various HW vendors (Broadcom, Marvell, Qualcomm, etc.)

- Modules available from the largest module manufacturers, USI, and Murata

- Small form-factor modules and can be easily integrated into existing designs

- Connectivity modules are available with FCC certification

- Supports full 802.11 b/g/n standards

- Support for Wi-Fi security modes: WPA/WPA2-Personal and WEP

- Ayla CloudConnect stacks provide all the networking software to enable device connectivity; no additional networking software is required in the device

- Minimal impact on host microcontroller software. Requires the porting of a simple serial driver to enable connectivity on the host microcontroller board

- Ayla CloudConnect stacks include all the application software for 2-way communication with the Ayla Cloud service

- Built-in capability to easily join secure Wi-Fi networks and to register applications

- All data communication is secured with TLS and AES 128-bit encryption

- Out of the box support for over-the-air software updates to Wi-Fi module; design support for over-the-air software updates to device host microcontroller application

4.3   Development Expertise

The embedded Black Box solution offers the easiest and quickest path from device design to production-ready modules including end-to-end testing. The design efforts are handled by Ayla, which allows customers to focus their efforts and expertise on developing the host application. Embedded design efforts including cloud services, security management along with quality control activities are handled by Ayla Networks.

4.4   Support

OEMs are responsible for providing a minimum of five (5) hours a week of application engineering support. Ayla supplies all other engineering support.

4.5   Case Study

A global leader in water treatment products (OEM) sells their connected devices through dealers. A dealer's responsibilities include installing a unit at a customer's premise, performing routine maintenance, and responding to alerts generated by the device. OEMs have varying requirements on whether dealers have access to a device post-installation, and if so, what the level of access should be.

4.5.1   Key Challenges

- OEM has different needs on retail vs. dealer-installer channels

- Common platform needs to extend across all product lines

- Multiple divisions each trying to create their connectivity and cloud solution

- Large Enterprise-class operational scale projects

4.5.2   Resolution

The Ayla Platform using the Black Box model was selected because it can provide one solution meeting needs of all divisions. The Ayla Platform provides the following functionality:

- Data access control policy manager
- Operations Center portal for field visibility
- No need to supply or dedicated additional engineering or QA support. One product/development for multiple channels
- Saved $1M+ in hiring/building out cloud operations
- OEM can rely on single vendor (Ayla) for complete solution

5   Embedded White Box Model

The Ayla Embedded Agent software is used in embedded microprocessor systems. Ayla Embedded Agents run on IoT devices or gateways and incorporate a fully optimized networking stack, along with the additional protocols needed, to connect devices to the Ayla Cloud. Developers using nearly any microcontroller or operating system can use Ayla-enabled connectivity modules to enable cloud capabilities over any type of networking protocol.
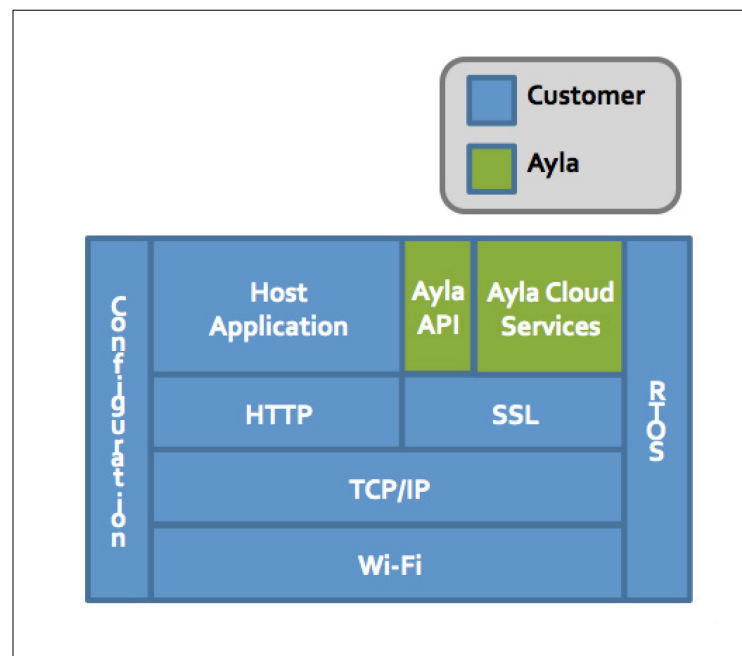

Figure 4. Ayla Embedded White Model

Customers can use the embedded white box model to develop an embedded system with connectivity to the Ayla Device Service and mobile applications.

5.1   Ayla Device Service – Cloud

The Embedded White Box Model integrates with Ayla Cloud Services. Part of the Ayla Cloud services is the Ayla Devices Service. The Ayla Device Service provides a way to deliver control and status information between any device and the web or a mobile application. This information is transferred in data items called properties. The communication may take place either over the Internet from the device to the Ayla Device Service (ADS) and then to the mobile application, or directly from the device to the mobile application over the local-area network (LAN).

5.2   Solutions Statement

The Embedded White Box model is one of the most challenging solutions available. This solution requires a large amount of engineering resources and a sufficient amount of time for development and testing before moving to production. While this solution provides more flexibility and development control for manufacturers, it also comes with fewer design protections that are available with the Black-box solution.

5.3   Advantages

The embedded white box solution is similar to the Black Box solution. The Embedded White Box solution also allows the customer to build-in their host application. The Embedded White Box solution requires the user to be able to handle all commissioning, radio control, and security blocks issues.

Additional advantages include:

- Fully tested and production ready
- Wi-Fi and Ethernet options
- Already programmed with unique id and security keys
- FCC and SIP versions available
- Global distribution

5.4   Development Expertise

Ayla recommends 3-6 senior engineers to develop the application (appd) and essential components required to create a production ready product.

New hardware will require new testing and manufacturing scripts at a minimum, there may be additional code required as well.

The product manufacturer resources must provide the following platform functionality.

- C library functions
- RTOS functions

- TCP/IP network

- Connection monitor: indicate to ADA when the network is available and not.

- If Wi-Fi is used, the platform must provide for Wi-Fi setup and monitoring.

- TLS / SSL client

- HTTP client

- HTTP server

- A configuration system to persist configuration information over power cycles.

- Console output for debug logging

- A CLI or other method to configure the device during manufacture

- Firmware update methods (OTA)

- Real-time clock

5.5 Support

Support for the White Box solution involves hiring engineering resources with a high level of programming in Linux or C and have experience with networked products. OEMs will be responsible for working with Ayla API and example code, creating config files for devd and device end-to-end testing. Additional support activities include transitioning devices to the field after development and managing over-the-air-updates (OTA).

Another support issue to consider is the Embedded White Box model, when compared to the Black Box model, requires a longer design and development lead time, large amounts of engineering resources. The Embedded White Box Model solution takes longer to go market.

5.6 Case Study

Product manufacturer wants to create user controllable products using internal engineering resources. Manufacturer also wishes to take advance of existing relationships they have with chip and board vendors and suppliers. Embedded product design and development has been done by this team before, but has not brought to market a cloud controllable product where they were responsible for the complete solution including end-to-end design and testing.

5.6.1 Key challenges

- Incomplete manufacturing process testing and comprehension – Products must be tested, validated and perfected for Whitebox development

- Development team not sufficiently experienced – Identify this issue early. Build a team with the resources or skill set required to succeed.

- Unrealistic Timeline – Manufacturer should understand issues early and be flexible with adding additional resources if needed.

5.6.2   Resolution

The Ayla Embedded White Box (embedded) model was selected because it provides some of the same features and functionality of the Ayla platform, while allowing the OEM more control over host application, scheduling and time-to-market activity. OEM has multiple products releasing at various times, and the White Box solution provides the necessary functionality required.

The Ayla White Box (embedded) model provides the following functionality:

• Data access control policy manager.

• Operations Center portal for field visibility.

• OEM can manage the hiring of any additional engineering or QA support required.

• OEM can manage moving embedded devices from development to the field.

6   White Box Model

The White Box model is predicated on an open or partially open, customizable offering. The White Box model allows Linux-based devices to connect directly to the Ayla cloud. Ayla also provides a Device Client daemon (devd), and a library implementing Ayla APIs that customers application links against.

The platform manufacturer is responsible for hardware and Linux distribution. The Ayla Linux agent is distributed as a source package, with example customer application (appd). The White Box – Linux model requires a Source License Agreement (SLA).
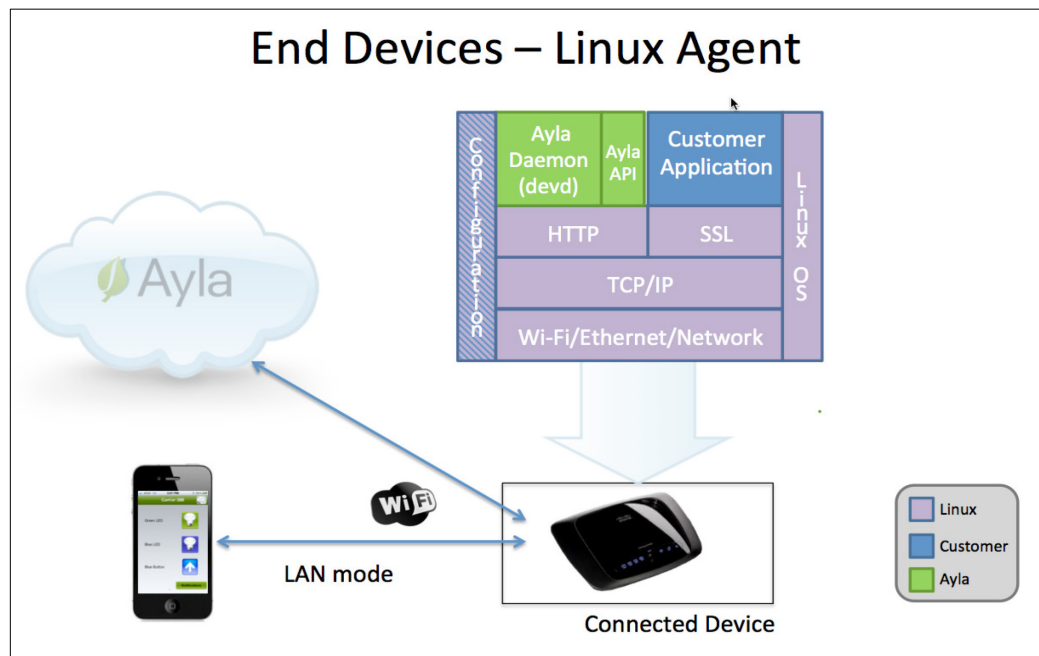

Figure 5. Ayla White Box Model

6.1 Advantages

The white box solution is similar to the Black Box solution. The White Box solution also allows the customer to build-in their host application. However, the White Box solution requires the user to be able to handle all commissioning, radio control, and security blocks issues.

Another disadvantage of the White Box model, when compared to the Black Box model, is it requires a longer design and development lead time and, therefore, a longer time market.

Additional advantages include:

- Fully tested and production ready
- Wi-Fi and Ethernet options
- Already programmed with unique id and security keys
- FCC and SIP versions available
- Global distribution

6.2 Development Expertise

Development efforts for implementing the embedded Linux generic gateway solution requires OEMs to be highly Linux capable and handle all of all the device side applications including, connection, transport, commissioning and security blocks.

OEMs' are responsible for supplying the following engineering resources:

- Host Application
- Networking
- Security
- Device Provisioning (Wi-Fi Setup)
- Per Device Authentication
- LAN Mode – Direct Mobile-To-Device Communications
- Support for OTA Image Management and Distribution
- On-Device Schedules for Automated Control

6.3 Support

Support for the White Box solution involves hiring engineering resources with a high level of programming in Linux or C and have experience with networked products. OEMs will be responsible for working with Ayla API and example code, creating config files for devd and device end-to-end testing. Additional support activities include transitioning devices to the field after development and managing over-the-air-updates (OTA).

6.4 Case Study

Large HVAC equipment manufacturer producing 100K+ units each month would like to use an embedded technology solution for controlling units. The manufacturer has various engineering resources and would design, develop and manage their own host application. The manufacturer is willing to provide expert Linux, end-to-end device testing and is capable of moving devices from testing to fields.

6.4.1 Key Challenges

- OEM has different needs on retail vs. dealer-installer channels
- Common platform needs to extend across all product lines
- Experience in designing embedded Linux devices

6.4.2 Resolution

The Ayla White Box model was selected because it provides some of the same features and functionality of the Ayla platform, while allowing the OEM more control over host application, scheduling and time-to-market activity. OEM has multiple products releasing at various times, and the White Box solution provides the necessary functionality required.

The Ayla White Box (embedded) model provides the following functionality:

- Data access control policy manager.
- Operations Center portal for field visibility.
- OEM can manage the hiring of any additional engineering or QA support required.
- OEM can manage moving embedded devices from development to the field.

7   Generic Gateway

The generic gateway solution is a software framework suitable for connecting one or more networks of devices to the Ayla cloud. The generic gateway does not require a specific network type. End devices have their own DSNs and properties.

Ayla provides a device client daemon (devd), and a library implementing Ayla Generic Gateway API. Also included is the Ayla Linux agent distributed as a source package, with example customer application (appd). This solution requires the platform manufacturers to supply or hire the engineering resources to add this solution to the network stack. OEMs are responsible for all hardware and Linux distribution.
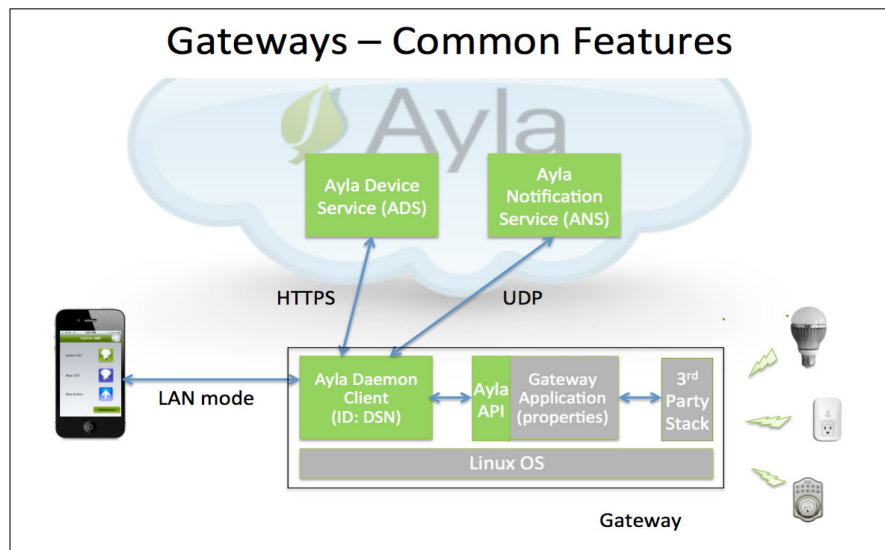

Figure 6. Ayla Generic Gateway

7.1   Solutions Statement

The Ayla Generic Gateway enables devices on existing network to be controlled remotely via Ayla cloud and converts device data into properties. Devices can be added and removed dynamically with no changes to existing networked devices.

7.2   Advantages

Using the Generic Gateway solution, OEMs can expect the following benefits:

- Generic Gateway solution allows OEMs to enable devices on existing networks to be controlled remotely via Ayla cloud

- Gateway provides connectivity to Ayla cloud, and converts device data into properties

- No changes to existing networked devices

- Devices can be added and removed dynamically

- Ayla provides a Device Client daemon (devd), and a library implementing Ayla API, which gateway application links interacts

7.3 Development Expertise

Development efforts for implementing the Linux generic gateway solution requires OEMs to be highly Linux capable, and handle all of all the device side applications including, connection, transport, commissioning and security blocks.

OEMs' are responsible for supplying the following engineering resources:

- Host Application
- Networking
- Security
- Device Provisioning (Wi-Fi Setup)
- Per Device Authentication
- LAN Mode – Direct Mobile-To-Device Communications
- Support for OTA Image Management and Distribution
- On-Device Schedules for Automated Control

7.4 Support

As noted earlier, there is a significant work to adapt to the network stack. Ayla supplies a Generic Gateway API and example gateway application. OEMs need to understand details about template matching for nodes, requirements for configuration and how to move devices from developer service to field service, or between services. Overall engineering support is needed for porting to a Linux environment.

7.5 Case Study

Large retail home appliance and equipment manufacturer would like to control existing and new devices using Ayla's Cloud. The OEM has several retail and dealer channels and wants to use an embedded technology solution for controlling units. The manufacturer is willing to provide expert Linux, end-to-end device testing through a 3rd party and is capable of moving devices from testing to fields.

7.5.1 Key Challenges

- OEM has different needs on retail vs. dealer-installer channels
- Common platform needs to extend across all product lines
- End-to-end testing
- Experience in designing embedded Linux devices

7.5.2 Resolution

The Ayla Generic Gateway model was selected because it provided some of the functionality of the Ayla Platform, while allowing the OEM more flexibility in their approach to device designing and manufacturing activity because there's no major impact on existing network devices. New devices created can be added dynamically and using Ayla's Device Client daemon and API's OEMs can remotely control existing devices using Ayla's Cloud.

8 Comparison Chart

The following chart compares device characteristics for the different product architecture device design solutions.

Table 1 – Comparison of Ayla Solutions

Characteristic	Black Box	White Box	Generic Gateway
Ayla Cloud Support	Yes	Yes	Yes
Ayla Mobile Library Support for iOS and Android	Yes	Yes	Yes
Production Ready Ayla Cloud Agent	Yes	Yes	Yes
Gateway Support	No	No	Yes
Production Ready, Pre-Certified FCC/ETSI Hardware	Yes	No	No
Out-of-the-Box Production Networking	Yes	No	No
Out-of-the-Box Security	Yes	No	No
Out-of-the-Box Transport	Yes	No	No
Out-of-the-Box Device Provisioning	Yes	No	No
Out-of-the-Box Device Registration	Yes	Yes	Yes
Out-of-the-Box On-Device Schedules	Yes	No	No
Out-of-the-Box Module OTA Support	Yes	No	No
Out-of-the-Box Support for secure LAN Connect	Yes	No	No
Manufacturing Production Scripts	Yes	Yes	Yes
Reduced Time to Market	Yes	No	No
Customer Device Side Engineering Effort	LOW	HIGH	HIGH

As you can see from the chart, the Black Box solution provides the most features and Out-of-the-Box services with the least amount of customer device side engineering efforts of all the available options.

9   Summary

Ayla Networks offers three different device options for manufacturers wanting to create, configure and control embedded devices.

- Ayla-Enabled Wi-Fi modules – Black Box
- Ayla Embedded Software Agent – Embedded White Box
- Ayla Linux Agent – Linux White Box

The single largest difference between the three options is the Black Box solution has the OEM package application method all worked out including details on how to integrate it into a manufacturing environment. The Black box solution is the most scalable, easy to use, and fastest time-to-market solution available from Ayla. The other two options, Embedded White Box, and Linux White Box require highly skilled Linux engineering resources and have a longer time market associated with it.

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