IOT BZH

AGL - Application Framework Documentation

Developer Documentation

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Abstract

The Application Framework is one of the key components of the AGL platform. It allows to install/uninstall applications securely on a target device and handles applications life cycle. The Application Framework is also responsible for setting up the secure contexts used to run applications as well as enabling privilege checks at various levels. It finally defines a necessary isolation between non-trusted high level applications run by end users and low level BSP trusted services running at lower level.

This document is the developer documentation.

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1. AGL framework, IoT.bzh proposal overview

1.1. Foreword

This document describes what we intend to do. It may happen that our current implementation and the content of this document differ.

In case of differences, it is assumed that this document is right and the implementation is wrong.

1.2. Introduction

During the first works in having the security model of Tizen integrated in AGL (Automotive Grade Linux) distribution, it became quickly obvious that the count of components specific to Tizen to integrate was huge.

Here is a minimal list of what was needed:

- platform/appfw/app-installers
- platform/core/security/cert-svc
- platform/core/appfw/ail
- platform/core/appfw/aul-1
- platform/core/appfw/libslp-db-util
- platform/core/appfw/pkgmgr-info
- platform/core/appfw/slp-pkgmgr

But this list isn't complete because many dependencies are hidden. Those hidden dependencies are including some common libraries but also many tizen specific sub-components (iniparser, bundle, dlog, libtzplatform-config, db-util, vconf-buxton, ...).

This is an issue because AGL is not expected to be Tizen. Taking it would either need to patch it for removing unwanted components or to take all of them.

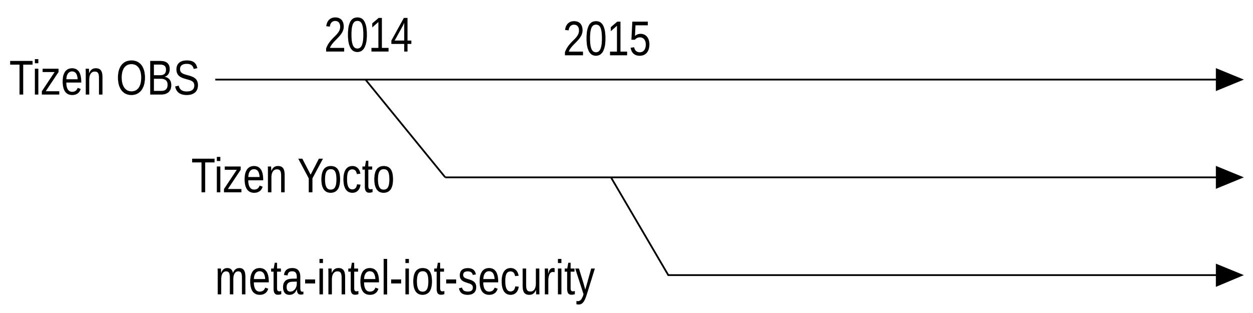
However, a careful study of the core components of the security framework of Tizen showed that their dependencies to Tizen are light (and since some of our work, there is no more dependency to tizen). Those components are **cynara**, **security-manager**, **D-Bus aware of cynara**.

Luckily, these core security components of Tizen are provided by meta-intel-iot-security, a set of yocto layers. These layers were created by Intel to isolate Tizen specific security components from the initial port of Tizen to Yocto. The 3 layers are providing components for:

- Implementing Smack LSM

- Implementing Integrity Measurement Architecture
- Implementing Tizen Security Framework

The figure below shows the history of these layers.



Security_model_history

We took the decision to use these security layers that provide the basis of the Tizen security, the security framework.

For the components of the application framework, built top of the security framework, instead of pulling the huge set of packages from Tizen, we decided to refit it by developing a tiny set of components that would implement the same behaviour but without all the dependencies and with minor architectural improvements for AGL.

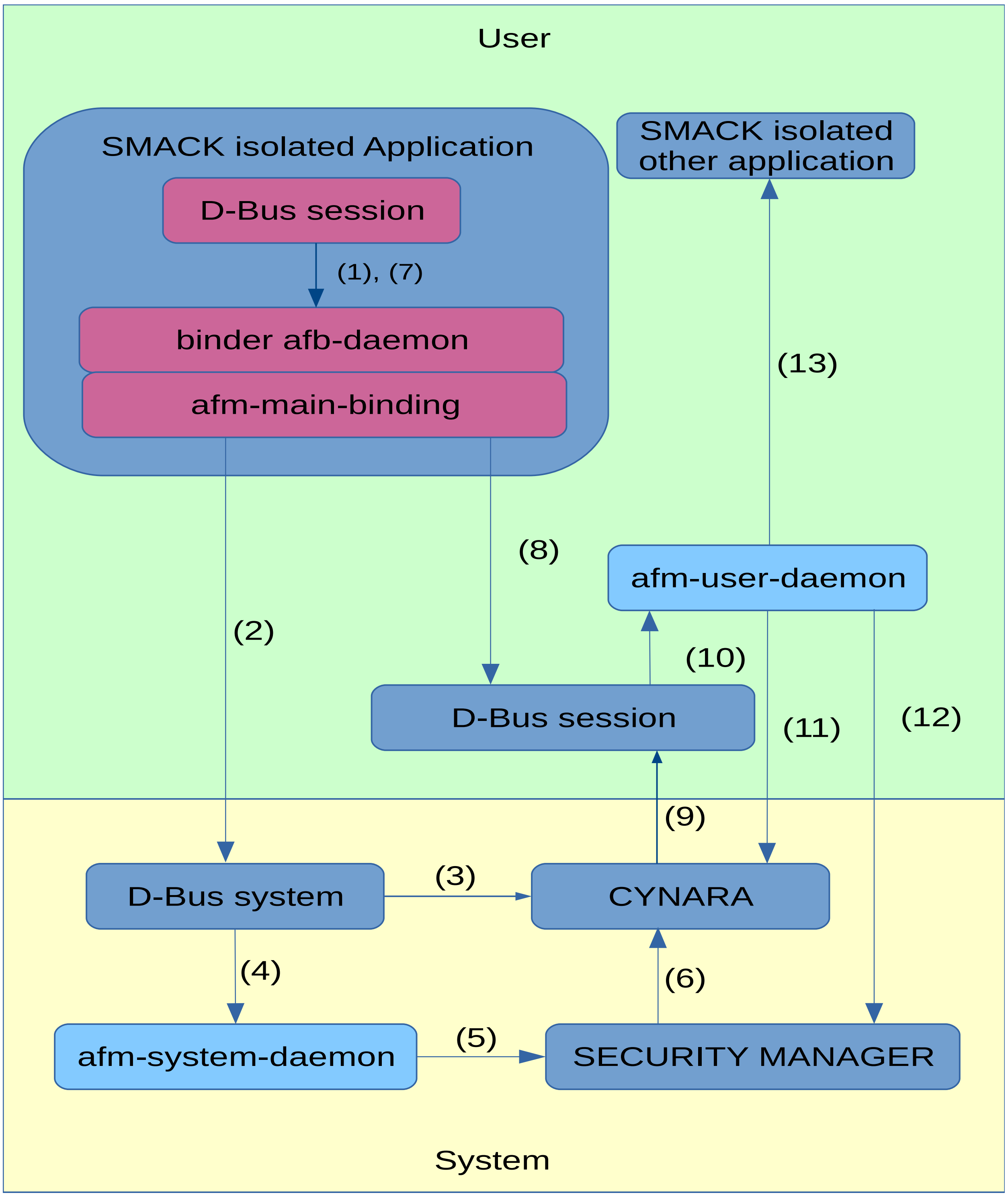
These components are **afm-system-daemon** and **afm-user-daemon**. They provides infrastructure for installing, uninstalling, launching, terminating, pausing and resuming applications in a multi user secure environment.

A third component exists in the framework, the binder **afb-daemon**. The binder provides the easiest way to provide secured API for any tier. Currently, the use of the binder is not absolutely mandatory.

This documentation explains the framework created by IoT.bzh by rewriting the Tizen Application Framework. Be aware of the previous foreword.

1.3. Overview

The figure below shows the major components of the framework and their interactions going through the following scenario: APPLICATION installs an other application and then launch it.



AppFW-APP_install_sequences

Let follow the sequence of calls:

1. APPLICATION calls its **binder** to install the OTHER application.
2. The binding **afm-main-binding** of the **binder** calls, through **D-Bus** system, the system daemon to install the OTHER application.

3. The system **D-Bus** checks wether APPLICATION has the permission or not to install applications by calling **CYNARA**.
4. The system **D-Bus** transmits the request to **afm-system-daemon**.

afm-system-daemon checks the application to install, its signatures and rights and install it.

5. **afm-system-daemon** calls **SECURITY-MANAGER** for fulfilling security context of the installed application.
6. **SECURITY-MANAGER** calls **CYNARA** to install initial permissions for the application.
7. APPLICATION call its binder to start the nearly installed OTHER application.
8. The binding **afm-main-binding** of the **binder** calls, through **D-Bus** session, the user daemon to launch the OTHER application.
9. The session **D-Bus** checks wether APPLICATION has the permission or not to start an application by calling **CYNARA**.
10. The session **D-Bus** transmits the request to **afm-user-daemon**.
11. **afm-user-daemon** checks wether APPLICATION has the permission or not to start the OTHER application **CYNARA**.
12. **afm-user-daemon** uses **SECURITY-MANAGER** features to set the security context for the OTHER application.
13. **afm-user-daemon** launches the OTHER application.

This scenario does not cover all the features of the frameworks. Shortly because details will be revealed in the next chapters, the components are:

- ***SECURITY-MANAGER***: in charge of setting Smack contexts and rules, of setting groups, and, of creating initial content of *CYNARA* rules for applications.
- ***CYNARA***: in charge of handling API access permissions by users and by applications.
- ***D-Bus***: in charge of checking security of messaging. The usual D-Bus security rules are enhanced by *CYNARA* checking rules.
- ***afm-system-daemon***: in charge of installing and uninstalling applications.
- ***afm-user-daemon***: in charge of listing applications, querying application details, starting, terminating, pausing, resuming applications and their instances for a given user context.
- ***afb-binder***: in charge of serving resources and features through an HTTP interface.

- ***afm-main-binding***: This binding allows applications to use the API of the AGL framework.

1.4. Links between the "Security framework" and the "Application framework"

The security framework refers to the security model used to ensure security and to the tools that are provided for implementing that model.

The security model refers to how DAC (Discretionary Access Control), MAC (Mandatory Access Control) and Capabilities are used by the system to ensure security and privacy. It also includes features of reporting using audit features and by managing logs and alerts.

The application framework manages the applications: installing, uninstalling, starting, pausing, listing ...

The application framework uses the security model/framework to ensure the security and the privacy of the applications that it manages.

The application framework must be compliant with the underlying security model/framework. But it should hide it to the applications.

1.5. The security framework

The implemented security model is the security model of Tizen 3. This model is described here.

The security framework then comes from Tizen 3 but through the meta-intel. It includes: **Security-Manager**, **Cynara** and **D-Bus** compliant to Cynara.

Two patches are applied to the security-manager. The goal of these patches is to remove specific dependencies with Tizen packages that are not needed by AGL. None of these patches adds or removes any behaviour.

In theory, the security framework/model is an implementation details that should not impact the layers above the application framework.

The security framework of Tizen provides "nice lad" a valuable component to scan log files and analyse auditing. This component is still in development.

1.6. The application framework

The application framework on top of the security framework provides the components to install and uninstall applications and to run it in a secured environment.

The goal is to manage applications and to hide the details of the security framework to the applications.

For the reasons explained in introduction, we did not used the application framework of Tizen as is but used an adaptation of it.

The basis is kept identical: the applications are distributed in a digitally signed container that must match the specifications of widgets (web applications). This is described by the technical recommendations widgets and widgets-digsig of the W3 consortium.

This model allows the distribution of HTML, QML and binary applications.

The management of signatures of the widget packages. This basis is not meant as being rigid and it can be extended in the future to include for example incremental delivery.

2. The application framework daemons

2.1. Foreword

This document describes application framework daemons FCF (Fully Conform to Specification) implementation is still under development. It may happen that current implementation somehow diverges with specifications.

2.2. Introduction

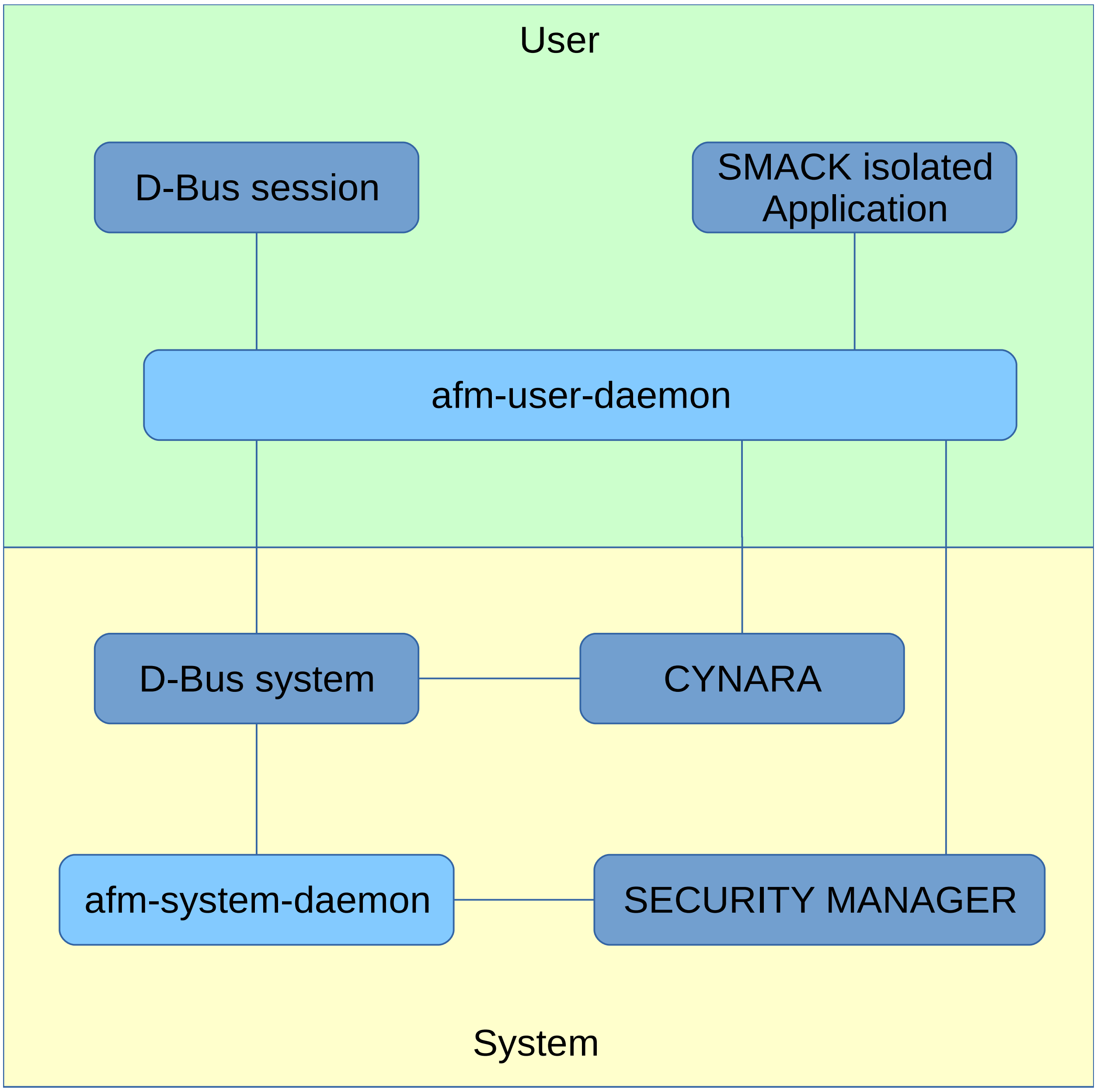
Daemons ***afm-user-daemon*** and ***afm-system-daemon*** handle applications life. Understand that they will manage operations like:

- ***installation***
- ***uninstallation***
- ***running***
- ***suspend***
- ***inventory***
- ...

In addition, they ensure that operations use the security framework as needed and that applications are executed in the correct context.

D-Bus is in charge of transmitting orders to the appropriate daemon depending upon ***D-Bus*** destination.

The figure below summarizes the situation of both **afm-system-daemon** and **afm-user-daemon** in the system.


User
D-Bus session
SMACK isolated Application
afm-user-daemon
D-Bus system
CYNARA
afm-system-daemon
SECURITY MANAGER
System

afm-daemons

2.3. The D-Bus interface

2.3.1. Overview of the dbus interface

The ***afm daemons*** takes theirs orders from the session instance of D-Bus. The use of D-Bus is great because it allows to implement discovery and signaling.

The dbus session is by default addressed by environment variable *DBUS_SESSION_BUS_ADDRESS*. Using **systemd** variable *DBUS_SESSION_BUS_ADDRESS* is automatically set for user sessions.

They are listening with the destination name ***org.AGL.afm.[user|system]*** at the object of path ***/org/AGL/afm/[user|system]*** on the interface ***org.AGL.afm.[user|system]*** for the below detailed members for the ***afm-system-daemon***:

- ***install***
- ***uninstall***

And for ***afm-user-daemon***:

- ***runnables***
- ***detail***
- ***start***
- ***once***
- ***terminate***
- ***pause***
- ***resume***
- ***runners***
- ***state***
- ***install***
- ***uninstall***

D-Bus is mainly used for signaling and discovery. Its optimized typed protocol is not used except for transmitting only one string in both directions.

The client and the service are using JSON serialization to exchange data. Signature of any member of the D-Bus interface is ***string -> string*** for ***JSON -> JSON***. This is the normal case, if there is an error, current implementation returns a dbus error that is a string.

Here are examples using *dbus-send*, here to install an application from a widget file:

```
dbus-send --session --print-reply \
    --dest=org.AGL.afm.system \
    /org/AGL/afm/system \
    org.AGL.afm.system.install 'string:"/tmp/appli.wgt"
```

And here, to query data on installed applications that can be run:

```
dbus-send --session --print-reply \
    --dest=org.AGL.afm.user \
    /org/AGL/afm/user \
    org.AGL.afm.user.runnables string:true
```

2.3.2. The protocol over D-Bus

On all following sub-chapters we assume that we talk about either ***afm-system-daemon*** or ***afm-user-daemon***. Method and D-Bus parameters are considered as self-explanatory.

The D-Bus interface is defined by:

- **DESTINATION**: org.AGL.afm.[user|system]
- **PATH**: /org/AGL/afm/[user|system]
- **INTERFACE**: org.AGL.afm.[user|system]

Method org.AGL.afm.system.install

Description: Install an application from a widget file.

When an application with the same *id* and *version* already exists. Outside of using *force=true* the application is not reinstalled.

Applications are installed the subdirectories of applications common directory. If *root* is specified, the application is installed under the sub-directories of the *root* defined.

Note that this methods is a simple accessor method of ***org.AGL.afm.system.install*** from ***afm-system-daemon***.

After the installation and before returning to the sender, ***afm-system-daemon*** sends a signal ***org.AGL.afm.system.changed***.

Input: The *path* of the widget file to install and, optionally, a flag to *force* reinstallation, and, optionally, a *root* directory.

Either just a string being the absolute path of the widget file:

```
"/a/path/driving/to/the/widget"
```

Or an object:

```
{
  "wgt": "/a/path/to/the/widget",
  "force": false,
  "root": "/a/path/to/the/root"
}
```

"wgt" and "root" must be absolute paths.

output: An object with the field "added" being the string for the id of the added application.

```
{"added":"appli@x.y"}
```

Method org.AGL.afm.system.uninstall

Description: Uninstall an application from its id.

Note that this methods is a simple method accessor of ***org.AGL.afm.system.uninstall*** from ***afm-system-daemon***.

After the uninstallation and before returning to the sender, ***afm-system-daemon*** sends a signal ***org.AGL.afm.system.changed***.

Input: the *id* of the application and optionally the application *root* path.

Either a string:

```
"appli@x.y"
```

Or an object:

```
{
  "id": "appli@x.y",
  "root": "/a/path/to/the/root"
}
```

output: the value 'true'.

Method org.AGL.afm.user.detail

Description: Get details about an application from its id.

Input: the id of the application as below.

Either just a string:

```
"appli@x.y"
```

Or an object having the field "id" of type string:

```
{"id":"appli@x.y"}
```

Output: A JSON object describing the application containing the fields described below.

```
{
  "id":          string, the application id (id@version)
  "version":     string, the version of the application
  "width":       integer, requested width of the application
  "height":      integer, resquested height of the application
  "name":        string, the name of the application
  "description": string, the description of the application
  "shortname":   string, the short name of the application
  "author":      string, the author of the application
}
```

Method org.AGL.afm.user.runnables

Description: Get the list of applications that can be run.

Input: any valid json entry, can be anything except null.

output: An array of description of the runnable applications. Each item of the array contains an object containing the detail of an application as described above for the method *org.AGL.afm.user.detail*.

Method org.AGL.afm.user.install

Description: Install an application from its widget file.

If an application of the same *id* and *version* exists, it is not reinstalled except when *force=true*.

Applications are installed in the subdirectories of the common directory reserved for applications. If *root* is specified, the application is installed under sub-directories of defined *root*.

Note that this methods is a simple accessor to the method ***org.AGL.afm.system.install*** of ***afm-system-daemon***.

After the installation and before returning to the sender, ***afm-user-daemon*** sends the signal ***org.AGL.afm.user.changed***.

Input: The *path* of widget file to be installed. Optionally, a flag to *force* reinstallation and/or a *root* directory.

Simple form a simple string containing the absolute widget path:

```
"/a/path/driving/to/the/widget"
```

Or an object:

```
{
  "wgt": "/a/path/to/the/widget",
  "force": false,
  "root": "/a/path/to/the/root"
}
```

wgt and ***root*** MUST be absolute paths.

output: An object containing field "added" to use as application ID.

```
{"added":"appli@x.y"}
```

Method org.AGL.afm.user.uninstall

Description: Uninstall an application from its id.

Note that this methods is a simple accessor to ***org.AGL.afm.system.uninstall*** method from ***afm-system-daemon***.

After the uninstallation and before returning to the sender, ***afm-user-daemon*** sends the signal ***org.AGL.afm.user.changed***.

Input: the *id* of the application and, optionally, the path to application *root*.

Either a string:

```
"appli@x.y"
```

Or an object:

```
{
  "id": "appli@x.y",
  "root": "/a/path/to/the/root"
}
```

output: the value 'true'.

Method org.AGL.afm.user.start

Description:

Input: the *id* of the application and, optionally, the start *mode* as below.

Either just a string:

```
"appli@x.y"
```

Or an object containing field "id" of type string and optionally a field mode:

```
{"id":"appli@x.y","mode":"local"}
```

The field "mode" is a string equal to either "local" or "remote".

[Currently the mode is not available in the systemd version]

output: The *runid* of the application launched. *runid* is an integer.

Method org.AGL.afm.user.once

Description:

Input: the *id* of the application

Either just a string:

```
"appli@x.y"
```

Or an object containing field "id" of type string.

```
{"id":"appli@x.y"}
```

output: The *state* of the application retrieved or launched. See *org.AGL.afm.user.state* to get a description of the returned object.

Method org.AGL.afm.user.terminate

Description: Terminates the application attached to *runid*.

Input: The *runid* (an integer) of running instance to terminate.

output: the value 'true'.

Method org.AGL.afm.user.stop

Obsolete since 8th November 2016 (2016/11/08). Kept for compatibility.

Use **org.AGL.afm.user.pause** instead.

Method org.AGL.afm.user.continue

Obsolete since 8th November 2016 (2016/11/08). Kept for compatibility.

Use **org.AGL.afm.user.resume** instead.

Method org.AGL.afm.user.pause

[Currently not available in the systemd version]

Description: Pauses the application attached to *runid* until terminate or resume.

Input: The *runid* (integer) of the running instance to pause.

output: the value 'true'.

Method org.AGL.afm.user.resume

[Currently not available in the systemd version]

Description: Resumes the application attached to *runid* previously paused.

Input: The *runid* (integer) of the running instance to resume.

output: the value 'true'.

Method org.AGL.afm.user.state

Description: Get informations about a running instance of *runid*.

Input: The *runid* (integer) of the running instance inspected.

output: An object describing instance state. It contains: the runid (integer), the pids of the processes as an array starting with the group leader, the id of the running application (string), the state of the application (string either: "starting", "running", "paused").

Example of returned state:

```
{
  "runid": 2,
  "pids": [ 435, 436 ],
  "state": "running",
  "id": "appli@x.y"
}
```

Method org.AGL.afm.user.runners

Description: Get the list of currently running instances.

Input: anything.

output: An array of states, one per running instance, as returned by the method ***org.AGL.afm.user.state***.

2.4. Starting afm daemons

afm-system-daemon and ***afm-user-daemon*** are launched as systemd services attached to system and user respectively. Normally, service files are locatedat */lib/systemd/system/afm-system-daemon.service* and */lib/systemd/user/afm-user-daemon.service*.

2.4.1. *afm-system-daemon* options

The options for launching **afm-system-daemon** are:

```
-r
--root directory

     Set the root application directory.

     Note that the default root directory is defined
     to be /usr/share/afm/applications (may change).

-d
--daemon

     Daemonizes the process. It is not needed by sytemd.

-q
--quiet

     Reduces the verbosity (can be repeated).
```

```
-v
--verbose

     Increases the verbosity (can be repeated).

-h
--help

     Prints a short help.
```

2.4.2. *afm-user-daemon* options

The options for launching **afm-user-daemon** are:

```
-a
--application directory

     [Currently not available in the systemd version]

     Includes the given application directory to
     the database base of applications.

     Can be repeated.

-r
--root directory

     [Currently not available in the systemd version]

     Includes root application directory or directories when
     passing multiple rootdir to
     applications database.

     Note that default root directory for
     applications is always added. In current version
     /usr/share/afm/applications is used as default.

-m
--mode (local|remote)

     [Currently not available in the systemd version]

     Set the default launch mode.
     The default value is 'local'

-d
--daemon

     Daemonizes the process. It is not needed by sytemd.

-q
--quiet

     Reduces the verbosity (can be repeated).

-v
--verbose
```

```
     Increases the verbosity (can be repeated).

-h
--help

     Prints a short help.
```

2.5. Tasks of afm-user-daemon

2.5.1. Maintaining list of applications

At start **afm-user-daemon** scans the directories containing applications and load in memory a list of avaliable applications accessible by current user.

When **afm-system-daemon** installs or removes an application. On success it sends the signal *org.AGL.afm.system.changed*. When receiving such a signal, **afm-user-daemon** rebuilds its applications list.

afm-user-daemon provides the data it collects about applications to its clients. Clients may either request the full list of avaliable applications or a more specific information about a given application.

2.5.2. Launching application

afm-user-daemon launches application by using systemd. Systemd builds a secure environment for the application before starting it.

Once launched, running instances of application receive a runid that identify them. To make interface with systemd evident, the pid is the runid.

2.5.3. Managing instances of running applications

afm-user-daemon manages the list of applications that it launched.

When owning the right permissions, a client can get the list of running instances and details about a specific running instance. It can also terminate a given application.

2.5.4. Installing and uninstalling applications

If the client own the right permissions, **afm-user-daemon** delegates that task to **afm-system-daemon**.

2.6. Using *afm-util*

The command line tool ***afm-util*** uses dbus-send to send orders to **afm-user-daemon**. This small scripts allows to send command to ***afm-user-daemon*** either interactively at shell prompt or scriptically.

The syntax is simple: it accept a command and when requires attached arguments.

Here is the summary of ***afm-util***:

- **afm-util runnables** :

list the runnable widgets installed

- **afm-util install wgt** :

install the wgt file

- **afm-util uninstall id** :

remove the installed widget of id

- **afm-util detail id** :

print detail about the installed widget of id

- **afm-util runners** :

list the running instance

- **afm-util start id** :

start an instance of the widget of id

- **afm-util once id** :

run once an instance of the widget of id

- **afm-util terminate rid** :

terminate the running instance rid

- **afm-util state rid** :

get status of the running instance rid

Here is how to list applications using ***afm-util***:

```
afm-util runnables
```

3. The widgets

The widgets are described by the W3C's technical recommendations Packaged Web Apps (Widgets) and XML Digital Signatures for Widgets

In summary, **widgets are ZIP files that can be signed and whose content is described by the file** .

3.1. Tools for managing widgets

This project includes tools for managing widgets. These tools are:

- ***wgtpkg-info***: command line tool to display informations about a widget file.
- ***wgtpkg-installer***: command line tool to install a widget file.
- ***wgtpkg-pack***: command line tool to create a widget file from a widget directory.
- ***wgtpkg-sign***: command line tool to add a signature to a widget directory.

For all these commands, a tiny help is available with options **-h** or **--help**.

There is no tool for unpacking a widget. For doing such operation, you can use the command **unzip**.

To list the files of a widget:

```
$ unzip -l WIDGET
```

To extract a widget in some directory:

```
$ unzip WIDGET -d DIRECTORY
```

Note that DIRECTORY will be created if needed.

3.2. Getting data about a widget file

The command **wgtpkg-info** opens a widget file, reads its **config.xml** file and displays its content in a human readable way.

3.3. Signing and packing widget

3.3.1. Signing

To sign a widget, you need a private key and its certificate.

The tool **wgtpkg-sign** creates or replace a signature file in the directory of the widget

BEFORE its packaging.

There are two types of signature files: author and distributor.

Example 1: add an author signature

```
$ wgtpkg-sign -a -k me.key.pem -c me.cert.pem DIRECTORY
```

Example 2: add a distributor signature

```
$ wgtpkg-sign -k authority.key.pem -c authority.cert.pem DIRECTORY
```

3.3.2. Packing

This operation can be done using the command **zip** but we provide the tool **wgtpkg-pack** that may add checking.

Example:

```
$ wgtpkg-pack DIRECTORY -o file.wgt
```

3.4. Writing a widget

3.4.1. The steps for writing a widget

1. make your application
2. create its configuration file **config.xml**
3. sign it
4. pack it

Fairly easy, no?

3.5. Organization of directory of applications

3.5.1. directory where are stored applications

Applications can be installed in different places: the system itself, extension device. On a phone application are typically installed on the sd card.

This translates to:

- /usr/applications: system wide applications
- /opt/applications: removable applications

From here those paths are referenced as: "APPDIR".

The main path for applications is: APPDIR/PKGID/VER.

Where:

- APPDIR is as defined above

- PKGID is a directory whose name is the package identifier
- VER is the version of the package MAJOR.MINOR

This organization has the advantage to allow several versions to leave together. This is needed for some good reasons (rolling back) and also for less good reasons (user habits).

3.5.2. Identity of installed files

All files are installed as user "afm" and group "afm". All files have rw(x) for user and r-(x) for group and others.

This allows every user to read every file.

3.5.3. labeling the directories of applications

The data of a user are in its directory and are labelled by the security-manager using the labels of the application.

4. The configuration file config.xml

The widgets are described by the W3C's technical recommendations Packaged Web Apps (Widgets) and XML Digital Signatures for Widgets that specifies the configuration file **config.xml**.

4.1. Overview

The file **config.xml** describes important data of the application to the framework:

- the unique identifier of the application
- the name of the application
- the type of the application
- the icon of the application
- the permissions linked to the application
- the services and dependancies of the application

The file MUST be at the root of the widget and MUST be case sensitively name ***config.xml***.

The file **config.xml** is a XML file described by the document widgets.

Here is the example of the config file for the QML application SmartHome.

```
<?xml version="1.0" encoding="UTF-8"?>
<widget xmlns="http://www.w3.org/ns/widgets" id="smarthome" version="0.1">
  <name>SmartHome</name>
  <icon src="smarthome.png"/>
  <content src="qml/smarthome/smarthome.qml" type="text/vnd.qt.qml"/>
  <description>This is the Smarthome QML demo application. It shows some user
interfaces for controlling an
automated house. The user interface is completely done with QML.</description>
  <author>Qt team</author>
  <license>GPL</license>
</widget>
```

The most important items are:

- **<widget id="......">**: gives the id of the widget. It must be unique.
- **<widget version="......">**: gives the version of the widget
- **<icon src="...">**: gives a path to the icon of the application (can be repeated with different sizes)
- **<content src="..." type="...">**: this indicates the entry point and its type.

4.2. Standard elements of "config.xml"

4.2.1. The element widget

the attribute id of widget

The attribute *id* is mandatory (for version 2.x, blowfish) and must be unique.

Values for *id* are any non empty string containing only latin letters, arabic digits, and the three characters '.' (dot), '-' (dash) and '_' (underscore).

Authors can use a mnemonic id or can pick a unique id using command **uuid** or **uuidgen**.

4.2.2. the attribute version of widget

The attribute *version* is mandatory (for version 2.x, blowfish).

Values for *version* are any non empty string containing only latin letters, arabic digits, and the three characters '.' (dot), '-' (dash) and '_' (underscore).

Version values are dot separated fields MAJOR.MINOR.REVISION. Such version would preferabily follow guidelines of semantic versionning.

4.2.3. The element content

The element *content* is mandatory (for version 2.x, blowfish) and must designate a file (subject to localisation) with its attribute *src*.

The content designed depends on its type. See below for the known types.

4.2.4. The element icon

The element *icon* is mandatory (for version 2.x, blowfish) and must be unique. It must designate an image file with its attribute *src*.

4.3. AGL features

The AGL framework uses the feature tag for specifying security and binding requirement of the widget.

Since the migration of the framework to leverage systemd power, the features are of important use to:

- declare more than just an application
- declare the expected dependencies
- declare the expected permissions
- declare the exported apis

The specification of widgets is intentded to describe only one application. In the present case, we expect to describe more than just an application. For example, a publisher could provide a widget containing a service, an application for tuning that service, an application that leverage the service. Here, the term of service means a background application that runs without IHM and whose public api can be accessed by other applications.

So the features are used to describe each of the possible units of widgets. The "standard" unit in the meaning of widgets is called the "main" unit.

4.3.1. feature name="urn:AGL:widget:required-api"

List of the api required by the widget.

Each required api must be explicited using a entry.

Example:

```
<feature name="urn:AGL:widget:required-api">
  <param name="#target" value="main" />>
  <param name="gps" value="auto" />
  <param name="afm-main" value="link" />
</feature>
```

This will be *virtually* translated for mustaches to the JSON

```
"required-api": [
   { "name": "gps", "value": "auto" },
   { "name": "afm-main", "value": "link" }
 ]
```

param name="#target"

OPTIONAL

Declares the name of the unit requiring the listed apis. Only one instance of the param "#target" is allowed. When there is not instance of this param, it behave as if the target main was specified.

param name=[required api name]

The name is the name of the required API.

The value describes how to connect to the required api. It is either:

- local:

The binding is a local shared object. In that case, the name is the relative path of the shared object to be loaded.

- auto:

The framework set automatically the kind of the connection to the API

- ws:

The framework connect using internal websockets

- dbus:

The framework connect using internal dbus

- link:

The framework connect in memory by dinamically linking

- cloud: [PROPOSAL - NOT IMPLEMENTED]

The framework connect externally using websock. In that case, the name includes data to access the service. Example: `<param name="log:https://oic@agl.iot.bzh/cloud/log" value="cloud" />`

4.3.2. feature name="urn:AGL:widget:required-permission"

List of the permissions required by the unit.

Each required permission must be explicited using a entry.

Example:

```
  <feature name="urn:AGL:widget:required-permission">
    <param name="#target" value="geoloc" />
    <param name="urn:AGL:permission:real-time" value="required" />
    <param name="urn:AGL:permission:syscall:*" value="required" />
  </feature>
```

This will be *virtually* translated for mustaches to the JSON

```
"required-permission":{
  "urn:AGL:permission:real-time":{
    "name":"urn:AGL:permission:real-time",
    "value":"required"
  },
  "urn:AGL:permission:syscall:*":{
    "name":"urn:AGL:permission:syscall:*",
    "value":"required"
  }
}
```

param name="#target"

OPTIONAL

Declares the name of the unit requiring the listed permissions. Only one instance of the param "#target" is allowed. When there is not instance of this param, it behave as if the target main was specified.

param name=[required permission name]

The value is either:

- required: the permission is mandatorily needed except if the feature isn't required (required="false") and in that case it is optional.
- optional: the permission is optional

4.3.3. feature name="urn:AGL:widget:provided-unit"

This feature is made for declaring new units for the widget. Using this feature, a software publisher can provide more than one application in the same widget.

Example:

```
<feature name="urn:AGL:widget:provided-unit">
  <param name="#target" value="geoloc" />
  <param name="description" value="binding of name geoloc" />
  <param name="content.src" value="index.html" />
  <param name="content.type" value="application/vnd.agl.service" />
</feature>
```

This will be *virtually* translated for mustaches to the JSON

```
  {
    "#target":"geoloc",
    "description":"binding of name geoloc",
    "content":{
      "src":"index.html",
      "type":"application\/vnd.agl.service"
    },
    ...
  }
```

param name="#target"

REQUIRED

Declares the name of the unit. The default unit, the unit of the main of the widget, has the name "main". The value given here must be unique within the widget file. It will be used in other places of the widget config.xml file to designate the unit.

Only one instance of the param "#target" is allowed. The value can't be "main".

param name="content.type"

REQUIRED

The mimetype of the provided unit.

param name="content.src"

A path to the

other parameters

The items that can be set for the main unit can also be set using the params if needed.

- description
- name.content
- name.short
- ...

4.3.4. feature name="urn:AGL:widget:provided-api"

Use this feature for exporting one or more API of a unit to other widgets of the platform.

This feature is an important feature of the framework.

Example:

```
  <feature name="urn:AGL:widget:provided-api">
    <param name="#target" value="geoloc" />
    <param name="geoloc" value="auto" />
    <param name="moonloc" value="auto" />
  </feature>
```

This will be *virtually* translated for mustaches to the JSON

```
      "provided-api":[
        {
          "name":"geoloc",
          "value":"auto"
        },
        {
          "name":"moonloc",
          "value":"auto"
        }
      ],
```

param name="#target"

OPTIONAL

Declares the name of the unit exporting the listed apis. Only one instance of the param "#target" is allowed. When there is not instance of this param, it behave as if the target main was specified.

param name=[name of exported api]

The name give the name of the api that is exported.

The value is one of the following values:

- ws:

export the api using UNIX websocket

- dbus:

export the API using dbus

- auto:

export the api using the default method(s).

4.4. Known content types

The configuration file ***/etc/afm/afm-unit.conf*** defines how to create systemd units for widgets.

Known types for the type of content are:

- ***text/html***: HTML application, content.src designates the home page of the application
- ***application/x-executable***: Native application, content.src designates the relative path of the binary
- ***application/vnd.agl.service***: AGL service, content.src is not used.

Adding more types is easy, it just need to edit the configuration file ***afm-unit.conf***.

4.4.1. Older content type currently not supported at the moment.

This types were defined previously when the framework was not leveraging systemd. The transition to systemd let these types out at the moment.

- ***application/vnd.agl.url***
- ***application/vnd.agl.native***
- ***text/vnd.qt.qml***, ***application/vnd.agl.qml***
- ***application/vnd.agl.qml.hybrid***
- ***application/vnd.agl.html.hybrid***

5. The configuration file afm-unit.conf

The integration of the framework with systemd mainly consists of creating the systemd unit files corresponding to the need and requirements of the installed widgets.

This configuration file named `afm-unit.conf` installed on the system wiht the path `/etc/afm/afm-unit.conf` describes how to generate all units from the *config.xml* configuration files of widgets. The description uses an extended version of the templating formalism of mustache to describes all the units.

Let present how it works using the following diagram that describes graphically the workflow of creating the unit files for systemd `afm-unit.conf` from the configuration file of the widget `config.xml`:

make-units

In a first step, and because mustache is intended to work on JSON representations, the configuration file is translated to an internal JSON representation. This representation is shown along the examples of the documentation of the config files of widgets.

In a second step, the mustache template `afm-unit.conf` is instanciated using the C library mustach that follows the rules of mustache and with all its available extensions:

- use of colon (:) for explicit substitution
- test of values with = or =!

In a third step, the result of instanciating `afm-unit.conf` for the widget is splited in units. To achieve that goal, the lines containing specific directives are searched. Any directive occupy one full line. The directives are:

- %nl

  Produce an empty line at the end

- %begin systemd-unit
- %end systemd-unit

  Delimit the produced unit, its begin and its end

- %systemd-unit user
- %systemd-unit system

  Tells the kind of unit (user/system)

- %systemd-unit service NAME
- %systemd-unit socket NAME

  Gives the name and type (service or socket) of the unit. The extension is automatically computed from the type and must not be set in the name.

- %systemd-unit wanted-by NAME

  Tells to install a link to the unit in the wants of NAME

Then the computed units are then written to the filesystem and inserted in systemd.

The generated unit files will contain variables for internal use of the framework. These variables are starting with `X-AFM-`. The variables starting with `X-AFM-` but not with `X-AFM--` are the public variables. These variables will be returned by the framework as the details of an application (see **afm-util detail ...**).

Variables starting with `X-AFM--` are private to the framework. By example, the variable `X-AFM--http-port` is used to record the allocated port for applications.

6. The permissions

6.1. Permission's names

The proposal here is to specify a naming scheme for permissions that allows the system to be as stateless as possible. The current specification includes in the naming of permissions either the name of the bound binding when existing and the level of the permission itself. Doing this, there is no real need for the framework to keep installed permissions in a database.

The permission names are URN of the form:

```
urn:AGL:permission:<api>:<level>:<hierarchical-name>
```

where "AGL" is the NID (the namespace identifier) dedicated to AGL (note: a RFC should be produced to standardize this name space).

The permission names are made of NSS (the namespace specific string) starting with "permission:" and followed by colon separated fields. The 2 first fields are `<api>` and `<level>` and the remaining fields are grouped to form the `<hierarchical-name>`.

```
<api> ::= [ <pname> ]

<pname> ::= 1*<pchars>

<pchars> ::= <upper> | <lower> | <number> | <extra>

<extra> ::= "-" | "." | "_" | "@"
```

The field `<api>` can be made of any valid character for NSS except the characters colon and star (:*). This field designates the api providing the permission. This scheme is used to deduce binding requirements from permission requirements. The field `<api>` can be the empty string when the permission is defined by the AGL system itself.

[PROPOSAL 1] The field `<api>` if starting with the character "@" represents a transversal/cross permission not bound to any binding.

[PROPOSAL 2]The field `<api>` if starting with the 2 characters "@@" in addition to a permission not bound to any binding, represents a permission that must be set at installation and that can not be revoked later.

```
<level> ::= 1*<lower>
```

The field `<level>` is made only of letters in lower case. The field `<level>` can only take some predefined values:

- system

- platform
- partner
- tiers
- owner
- public

The field `<hierarchical-name>` is made of `<pname>` separated by colons.

```
<hierarchical-name> ::= <pname> 0*(":" <pname>)
```

The names at left are hierarchically grouping the names at right. This hierarchical behaviour is intended to be used to request permissions using hierarchical grouping.

6.2. Permission value

In some case, it could be worth to add a value to a permission.

Currently, the framework allows it for permissions linked to systemd. But this not currently used.

Conversely, permissions linked to cynara can't carry data except in their name.

Thus to have a simple and cleaner model, it is better to forbid attachement of value to permission.

6.3. Example of permissions

Here is a list of some possible permissions. These permissions are available the 17th of March 2017.

- urn:AGL:permission::platform:no-oom

Set OOMScoreAdjust=-500 to keep the out-of-memory killer away.

- urn:AGL:permission::partner:real-time

Set IOSchedulingClass=realtime to give to the process realtime scheduling.

Conversely, not having this permission set RestrictRealtime=on to forbid realtime features.

- urn:AGL:permission::public:display

Adds the group "display" to the list of supplementary groups of the process.

- urn:AGL:permission::public:syscall:clock

Without this permission SystemCallFilter=~@clock is set to forfid call to clock.

- urn:AGL:permission::public:no-htdocs

The http directory served is not "htdocs" but "."

- urn:AGL:permission::public:applications:read

Allows to read data of installed applications (and to access icons).

- urn:AGL:permission::partner:service:no-ws

Forbids services to provide its API through websocket.

- urn:AGL:permission::partner:service:no-dbus

Forbids services to provide its API through D-Bus.

- urn:AGL:permission::system:run-by-default

Starts automatically the application. Example: home-screen.

- http://tizen.org/privilege/internal/dbus

Permission to use D-Bus.

7. AGL Application Framework: A Quick Tutorial

7.1. Introduction

This document proposes a quick tutorial to demonstrate the major functionalities of the AGL Application Framework. For more complete information, please refer to the inline documentation available in the main git repository:

https://gerrit.automotivelinux.org/gerrit/#/admin/projects/src/app-framework-main

For more information on AGL, please visit: https://www.automotivelinux.org/

7.2. Sample applications

4 sample applications (.wgt files) are prebuilt and available at the following address: https://github.com/iotbzh/afm-widget-examples

You can get them by cloning this git repository on your desktop (will be useful later in this tutorial):

```
$ git clone https://github.com/iotbzh/afm-widget-examples
```

7.3. Using the CLI tool

7.3.1. Setup Environment

Connect your AGL target board to the network and copy some sample widgets on it through SSH (set BOARDIP with your board IP address) :

```
$ cd afm-widget-examples
$ BOARDIP=1.2.3.4
$ scp *.wgt root@$BOARDIP:~/
```

Connect through SSH on the target board and check for Application Framework daemons:

```
$ ssh root@$BOARDIP
root@porter:~# ps -ef|grep bin/afm
afm        409     1  0 13:00 ?        00:00:00 /usr/bin/afm-system-daemon
root       505   499  0 13:01 ?        00:00:00 /usr/bin/afm-user-daemon
root       596   550  0 13:22 pts/0    00:00:00 grep afm
```

We can see that there are two daemons running: * **afm-system-daemon** runs with a system user 'afm' and is responsible for installing/uninstalling packages * **afm-user-daemon** runs as a user daemon (currently as root because it's the only real user on the target board) and is responsible for the whole lifecycle of the applications running inside the user session.

The application framework has a tool running on the Command Line Interface (CLI). Using the **afm-util** command, you can install, uninstall, list, run, pause ... applications.

To begin, run '**afm-util help**' to get a quick help on commands:

```
root@porter:~# afm-util help
usage: afm-util command [arg]

The commands are:

  list
  runnables       list the runnable widgets installed

  add wgt
  install wgt     install the wgt file

  remove id
  uninstall id    remove the installed widget of id

  info id
  detail id       print detail about the installed widget of id

  ps
  runners         list the running instance

  run id
  start id        start an instance of the widget of id

  kill rid
  terminate rid   terminate the running instance rid

  status rid
  state rid       get status of the running instance rid
```

7.3.2. Install an application

You can then install your first application:

```
root@porter:~# afm-util install /home/root/annex.wgt
{ "added": "webapps-annex@0.0" }
```

Let's install a second application:

```
root@porter:~# afm-util install /home/root/memory-match.wgt
{ "added": "webapps-memory-match@1.1" }
```

Note that usually, **afm-util** will return a **JSON result**, which is the common format for messages returned by the Application Framework daemons.

7.3.3. List installed applications

You can then list all installed applications:

```
root@porter:~# afm-util list
[ { "id": "webapps-annex@0.0", "version": "0.0.10", "width": 0, "height": 0,
"name": "Annex", "description": "Reversi\/Othello", "shortname": "", "author":
"Todd Brandt <todd.e.brandt@intel.com>" },
 { "id": "webapps-memory-match@1.1", "version": "1.1.7", "width": 0, "height":
0, "name": "MemoryMatch", "description": "Memory match", "shortname": "",
"author": "Todd Brandt <todd.e.brandt@intel.com>" } ]
```

Here, we can see the two previously installed applications.

7.3.4. Get information about an application

Let's get some details about the first application:

```
root@porter:~# afm-util info webapps-annex@0.0
{ "id": "webapps-annex@0.0", "version": "0.0.10", "width": 0, "height": 0,
"name": "Annex", "description": "Reversi\/Othello", "shortname": "", "author":
"Todd Brandt <todd.e.brandt@intel.com>" }
```

Note that AGL applications are mostly handled by afm-util through their IDs. In our example, the application ID is 'webapps-annex@0.0'.

7.3.5. Start application

Let's start the first application Annex:

```
root@porter:~# afm-util start webapps-annex@0.0
1
```

As the application is a HTML5 game, you should then get a webview running with QML on the board display.

7.3.6. Security Context

The application has been started in the user session, with a dedicated security context, enforced by SMACK. To illustrate this, we can take a look at the running processes and their respective SMACK labels:

```
root@porter:~# ps -efZ |grep webapps-annex | grep -v grep
User::App::webapps-annex        root        716   491  0 13:19 ?        00:00:00
/usr/bin/afb-daemon --mode=local --readyfd=8 --alias=/icons
/usr/share/afm/icons --port=12348
--rootdir=/usr/share/afm/applications/webapps-annex/0.0 --token=7D6D2F16
--sessiondir=/home/root/app-data/webapps-annex/.afb-daemon
User::App::webapps-annex        root        717   491  0 13:19 ?        00:00:00
/usr/bin/qt5/qmlscene http://localhost:12348/index.html?token=7D6D2F16
/usr/bin/web-runtime-webkit.qml
```

In the previous result, we see that the application is composed of two processes: * the application binder (afb-daemon) * the application UI (qmlscene ...)

While most system processes run with the label 'System', we see that the application runs with a specific SMACK label 'User::App::webapps-annex': this label is used to force the application to follow a Mandatory Access Control (MAC) scheme. This means that those processes run in their own security context, isolated from the rest of the system (and other applications). Global security rules can then be applied to restrict access to all other user or system resources.

7.3.7. Check running applications

To check for running applications, just run:

```
root@porter:~# afm-util ps
[ { "runid": 1, "state": "running", "id": "webapps-annex@0.0" } ]
```

The 'runid' is the application instance ID and is used as an argument for the subcommands controlling the application runtime state (kill/pause/resume/status)

7.3.8. Uninstall application

To uninstall an application, simply use its ID:

```
root@porter:~# afm-util uninstall webapps-annex@0.0
true
```

Then list the installed apps to confirm the removal:

```
root@porter:~# afm-util list
[ { "id": "webapps-memory-match@1.1", "version": "1.1.7", "width": 0, "height":
0, "name": "MemoryMatch", "description": "Memory match", "shortname": "",
"author": "Todd Brandt <todd.e.brandt@intel.com>" } ]
```

7.4. afm-client: a sample HTML5 'Homescreen'

afm-client is a HTML5 UI that allows to install/uninstall applications as well as starting/pausing them as already demonstrated with afm-util.

The HTML5 UI is accessible remotely through this URL: http://[board_ip]:1234/opa?token=132456789

7.4.1. Installing an application

By clicking on the '**Upload**' button on the right, you can send an application package (WGT file) and install it. Select for example the file '**rabbit.wgt**' that was cloned initially from the git repository afm-widget-examples.

Then a popup requester ask for a confirmation: 'Upload Application rabbit.wgt ?'. Click on the '**Install**' button.

You should then see some changes in the toolbar: a new icon appeared, representing the freshly installed application.

7.4.2. Running an application

In the toolbar, click on the button representing the Rabbit application. You'll get a popup asking to: * start the application * or get some info about it * or uninstall it

Click on the 'start' item: the application starts and should be visible as a webview on the target board display. Note that at this point, we could also run the application remotely, that is in the same browser as the Homescreen app. By default, the application framework is configured to run applications 'locally' on the board display.

7.4.3. Uninstalling an application

From the same popup menu, you can select 'uninstall' to remove the application from the system. As a consequence, the application icon should disappear from the toolbar.

7.5. afb-client: a template for Angular Applications

Another package '**afb-client**' is also available for testing. This is a sample HTML5 application demonstrating various basic capabilities of the Binder daemon. It can be used by developers as a template to start writing real AGL Applications.

This application is not available as WGT file yet and it should be started manually without any specific security context:

```
root@porter:~# /usr/bin/afb-daemon --port=1235 --token=''
--sessiondir=/home/root/.afm-daemon --rootdir=/usr/share/agl/afb-client
--alias=/icons:/usr/share/afm/icons
```

Then you can access it from a browser: http://[board_ip]:1235/opa/?token=132456789

afb-client is a simple application to demonstrate the built-in capabilities of the binder daemon (handling sessions and security tokens, testing POSTs uploads...) and was used during the application framework development to validate the proposed features.

8. Overview of AFB-DAEMON

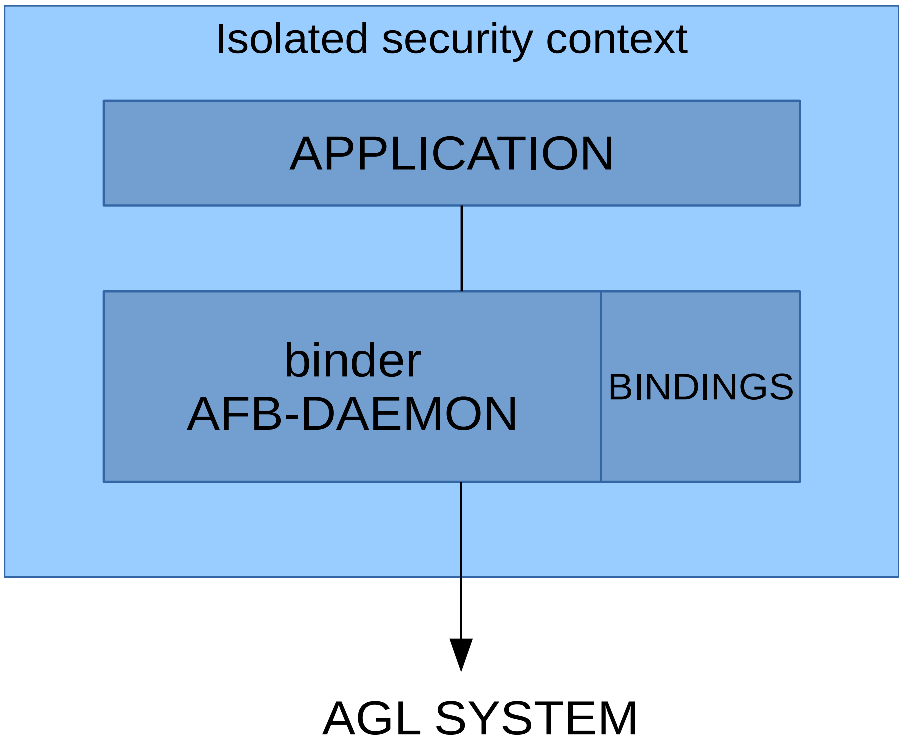
8.1. Roles of afb-daemon

The name **afb-daemon** stands for *Application Framework Binder Daemon*. That is why afb-daemon is also named ***the binder***.

Afb-daemon is in charge to bind one instance of an application to the AGL framework and AGL system.

On the following figure, you can use a typical use of afb-daemon:

Figure: binder afb-daemon, basis



binder-basis

The application and its companion binder run in secured and isolated environment set for them. Applications are intended to access to AGL system through the binder.

The binder afb-daemon serves multiple purposes:

1. It acts as a gateway for the application to access the system;
2. It acts as an HTTP server for serving files to HTML5 applications;
3. It allows HTML5 applications to have native extensions subject to security enforcement for accessing hardware resources or for speeding parts of

algorithm.

8.2. Use cases of the binder afb-daemon

This section tries to give a better understanding of the binder usage through several use cases.

8.2.1. Remotely running application

One of the most interesting aspect of using the binder afb-daemon is the ability to run applications remotely. This feature is possible because the binder afb-daemon implements native web protocols.

So the figure binder, basis would become when the application is run remotely:

Figure: binder afb-daemon and remotely running application

8.2.2. Adding native features to HTML5/QML applications

Applications can provide with their packaged delivery a binding. That binding will be instantiated for each application instance. The methods of the binding will be accessible by applications and will be executed within the security context.

8.2.3. Offering services to the system

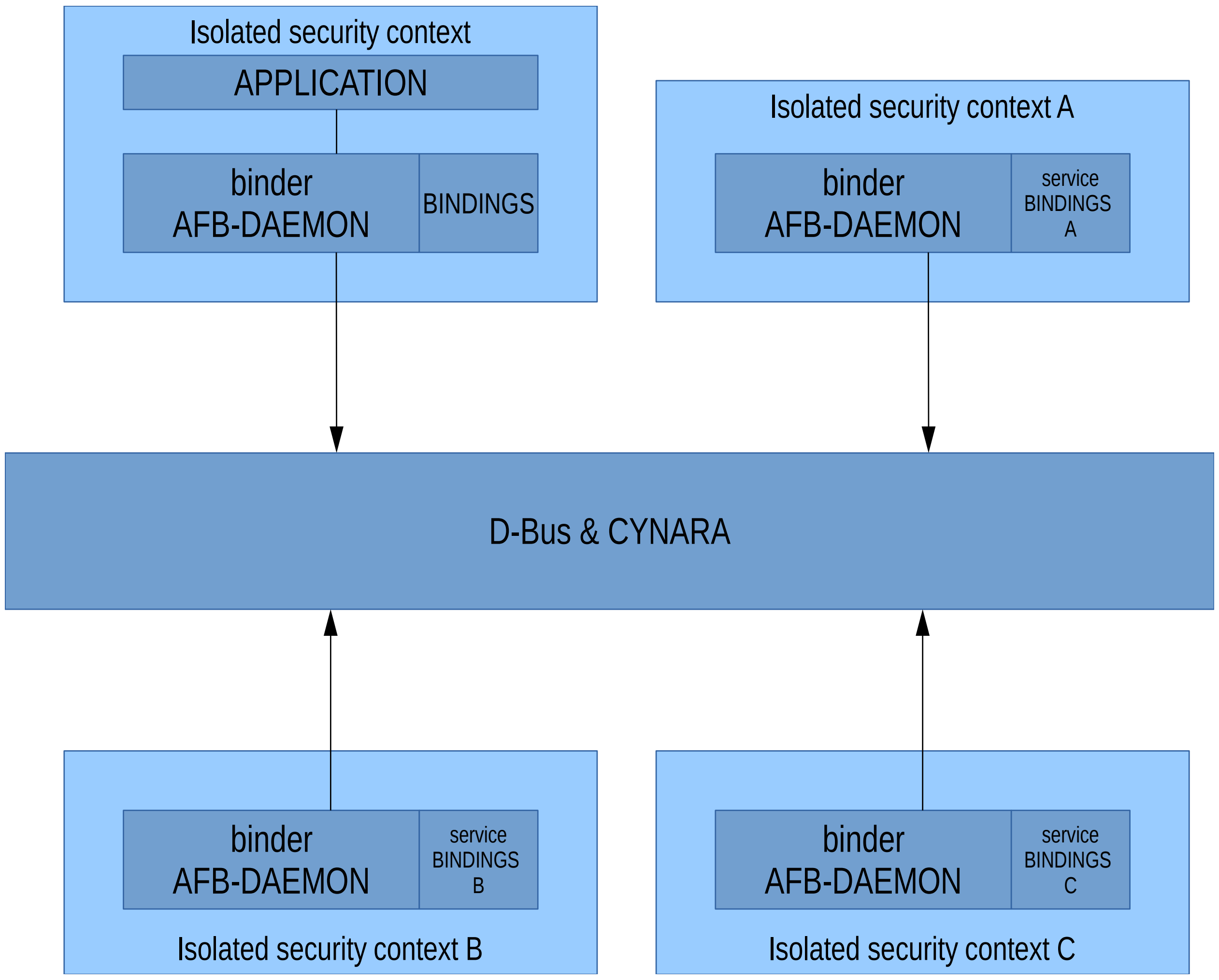
It is possible to run the binder afb-daemon as a daemon that provides the API of its bindings.

This will be used for:

1. offering common APIs
2. provide application's services (services provided as application)

In that case, the figure showing the whole aspects is

Figure: binder afb-daemon for services



afb-for-services

For this case, the binder afb-daemon takes care to attribute one single session context to each client instance. It allows bindings to store and retrieve data associated to each of its client.

8.3. The bindings of the binder afb-daemon

The binder can instantiate bindings. The primary use of bindings is to add native methods that can be accessed by applications written with any language through web technologies ala JSON RPC.

This simple idea is declined to serves multiple purposes:

1. add native feature to applications
2. add common API available by any applications
3. provide customers services

A specific document explains how to write an afb-daemon binder binding: HOWTO WRITE a BINDING for AFB-DAEMON

8.4. Launching the binder afb-daemon

The launch options for binder **afb-daemon** are:

```
--help

  Prints help with available options

--version

  Display version and copyright

--verbose

  Increases the verbosity, can be repeated

--quiet

  Decreases the verbosity, can be repeated

--port=xxxx

  HTTP listening TCP port  [default 1234]

--workdir=xxxx

  Directory where the daemon must run [default: $PWD if defined
  or the current working directory]

--uploaddir=xxxx

  Directory where uploaded files are temporarily stored [default: workdir]

--rootdir=xxxx

  Root directory of the application to serve [default: workdir]

--roothttp=xxxx

  Directory of HTTP served files. If not set, files are not served
  but apis are still accessibles.

--rootbase=xxxx

  Angular Base Root URL [default /opa]

  This is used for any application of kind OPA (one page application).
  When set, any missing document whose url has the form /opa/zzz
  is translated to /opa/#!zzz

--rootapi=xxxx

  HTML Root API URL [default /api]

  The bindings are available within that url.

--alias=xxxx
```

```
  Maps a path located anywhere in the file system to the
  a subdirectory. The syntax for mapping a PATH to the
  subdirectory NAME is: --alias=/NAME:PATH.

  Example: --alias=/icons:/usr/share/icons maps the
  content of /usr/share/icons within the subpath /icons.

  This option can be repeated.

--no-httpd

  Tells to not start the HTTP server.

--apitimeout=xxxx

  binding API timeout in seconds [default 20]

  Defines how many seconds maximum a method is allowed to run.
  0 means no limit.

--cntxtimeout=xxxx

  Client Session Timeout in seconds [default 3600]

--cache-eol=xxxx

  Client cache end of live [default 100000 that is 27,7 hours]

--session-max=xxxx

  Maximum count of simultaneous sessions [default 10]

--ldpaths=xxxx

  Load bindings from given paths separated by colons
  as for dir1:dir2:binding1.so:... [default = $libdir/afb]

  You can mix path to directories and to bindings.
  The sub-directories of the given directories are searched
  recursively.

  The bindings are the files terminated by '.so' (the extension
  so denotes shared object) that contain the public entry symbol.

--binding=xxxx

  Load the binding of given path.

--token=xxxx

  Initial Secret token to authenticate.

  If not set, no client can authenticate.

  If set to the empty string, then any initial token is accepted.

--random-token

  Generate a random starting token. See option --exec.
  --mode=xxxx

    Set the mode: either local, remote or global.

    The mode indicate if the application is run locally on the host
    or remotely through network.

  --readyfd=xxxx

    Set the #fd to signal when ready

    If set, the binder afb-daemon will write "READY=1\n" on the file
    descriptor whose number if given (/proc/self/fd/xxx).

  --dbus-client=xxxx

    Transparent binding to a binder afb-daemon service through dbus.

    It creates an API of name xxxx that is implemented remotely
    and queried via DBUS.

  --dbus-server=xxxx

    Provides a binder afb-daemon service through dbus.

    The name xxxx must be the name of an API defined by a binding.
    This API is exported through DBUS.

  --ws-client=xxxx

    Transparent binding to a binder afb-daemon service through a WebSocket.

    The value of xxxx is either a unix naming socket, of the form
"unix:path/api",
    or an internet socket, of the form "host:port/api".

  --ws-server=xxxx

    Provides a binder afb-daemon service through WebSocket.

    The value of xxxx is either a unix naming socket, of the form
"unix:path/api",
    or an internet socket, of the form "host:port/api".

  --foreground

    Get all in foreground mode (default)

  --daemon

    Get all in background mode

  --no-httpd

    Forbids HTTP serve

  --exec
```

```
    Must be the last option for afb-daemon. The remaining
    arguments define a command that afb-daemon will launch.
    The sequences @p, @t and @@ of the arguments are replaced
    with the port, the token and @.

  --tracereq=xxxx

    Trace the processing of requests in the log file.

    Valid values are 'no' (default), 'common', 'extra' or 'all'.
```

8.5. Future development of afb-daemon

- The binder afb-daemon would launch the applications directly.
- The current setting of mode (local/remote/global) might be reworked to a mechanism for querying configuration variables.
- Implements "one-shot" initial token. It means that after its first authenticated use, the initial token is removed and no client can connect anymore.
- Creates some intrinsic APIs.
- Make the service connection using WebSocket not DBUS.
- Management of targeted events.
- Securing LOA.
- Integration of the protocol JSON-RPC for the websockets.

9. How to write an application on top of AGL FRAMEWORK

9.1. Programming Languages for Applications

9.1.1. Writing an HTML5 application

Developers of HTML5 applications (client side) can easily create applications for AGL framework using their preferred HTML5 framework.

Developers may also take advantage of powerful server side bindings to improve application behavior. Server side bindings return an application/json mine-type and can be accessed though either HTTP or Websockets.

In a near future, JSON-RPC protocol should be added to complete the current x-afb-json1 protocol.

Two examples of HTML5 applications are given:

- afb-client a simple "hello world" application template
- afm-client a simple "Home screen" application template

9.1.2. Writing a Qt application

Writing Qt applications is also supported. Qt offers standard API to send request through HTTP or WebSockets.

It is also possible to write QML applications. A sample QML application [token-websock] is available:

- token-websock a simple "hello world" application in QML

9.1.3. Writing a "C" application

C applications can use afb-daemon binder through a websocket connection.

The library **libafbwsc** is provided for C clients that need to connect with an afb-daemon binder.

The program **afb-client-demo** is the C example that use **libafbwsc** library. Source code is available here src/afb-client-demo.c.

Current implementation relies on libsystemd and file descriptors. This model might be review in the future to support secure sockets and get rid of libsystemd dependency.

9.2. Handling sessions within applications

Applications should understand sessions and token management when interacting with afb-daemon binder.

Applications communicate with their private binder(afb-daemon) using a network connection or potentially any other connection channel. While the current version does not yet implement Unix socket, this feature might be added in the near future. Developers need to be warn that HTTP protocol is a none connected protocol and that using HTTP socket connection to authenticate clients is not supported.

For this reason, the binder should authenticate the application by using a shared secret. The secret is named "token" and the identification of client is named "session".

The examples **token-websock.qml** and **afb-client** are demonstrating how authentication and sessions are managed.

9.2.1. Handling sessions

Bindings and other binder features need to keep track of client instances. This is especially important for bindings running as services as they may typically have to keep each client's data separated.

For HTML5 applications, the web runtime handles the cookie of session that the binder afb-daemon automatically sets.

Session identifier can be set using the parameter **uuid** or **x-afb-uuid** in URI requests. Within current version of the framework session UUID is supported by both HTTP requests and websocket negotiation.

9.2.2. Exchanging tokens

At application start, AGL framework communicates a shared secret to both binder and client application. This initial secret is called the "**initial token**".

For each of its client application, the binder manages a current active token for session management. This authentication token can be use to restrict the access to some binding's methods.

The token must be included in URI request on HTTP or during websockets connection using parameter **token** or **x-afb-token**.

To ensure security, tokens must be refreshed periodically.

9.2.3. Example of session management

In following examples, we suppose that **afb-daemon** is launched with something equivalent to:

```
$ afb-daemon --port=1234 --token=123456 [...]
```

making the expectation that **AuthLogin** binding is requested as default.

Using curl

First, connects with the initial token, 123456:

```
$ curl http://localhost:1234/api/auth/connect?token=123456
{
  "jtype": "afb-reply",
  "request": {
     "status": "success",
     "token": "0aef6841-2ddd-436d-b961-ae78da3b5c5f",
     "uuid": "850c4594-1be1-4e9b-9fcc-38cc3e6ff015"
  },
  "response": {"token": "A New Token and Session Context Was Created"}
}
```

It returns an answer containing session UUID, 850c4594-1be1-4e9b-9fcc-38cc3e6ff015, and a refreshed token, 850c4594-1be1-4e9b-9fcc-38cc3e6ff015.

Check if session and token is valid:

```
$ curl http://localhost:1234/api/auth/check?token=0aef6841-2ddd-436d-b961-
ae78da3b5c5f\&uuid=850c4594-1be1-4e9b-9fcc-38cc3e6ff015
{
  "jtype": "afb-reply",
  "request": {"status":"success"},
  "response": {"isvalid":true}
}
```

Refresh the token:

```
$ curl http://localhost:1234/api/auth/refresh?token=0aef6841-2ddd-436d-b961-
ae78da3b5c5f\&uuid=850c4594-1be1-4e9b-9fcc-38cc3e6ff015
{
  "jtype": "afb-reply",
  "request": {
     "status":"success",
     "token":"b8ec3ec3-6ffe-448c-9a6c-efda69ad7bd9"
  },
  "response": {"token":"Token was refreshed"}
}
```

Close the session:

```
curl http://localhost:1234/api/auth/logout?token=b8ec3ec3-6ffe-448c-9a6c-
efda69ad7bd9\&uuid=850c4594-1be1-4e9b-9fcc-38cc3e6ff015
{
  "jtype": "afb-reply",
  "request": {"status": "success"},
  "response": {"info":"Token and all resources are released"}
}
```

Checking on closed session for uuid should be refused:

```
curl http://localhost:1234/api/auth/check?token=b8ec3ec3-6ffe-448c-9a6c-
efda69ad7bd9\&uuid=850c4594-1be1-4e9b-9fcc-38cc3e6ff015
{
  "jtype": "afb-reply",
  "request": {
     "status": "failed",
     "info": "invalid token's identity"
  }
}
```

Using afb-client-demo

The program is packaged within AGL in the rpm **libafbwsc-dev**

Here is an example of exchange using **afb-client-demo**:

```
$ afb-client-demo ws://localhost:1234/api?token=123456
auth connect
ON-REPLY 1:auth/connect: {"jtype":"afb-reply","request":{"status":"success",
   "token":"63f71a29-8b52-4f9b-829f-b3028ba46b68","uuid":"5fcc3f3d-4b84-4fc7-
ba66-2d8bd34ae7d1"},
   "response":{"token":"A New Token and Session Context Was Created"}}
auth check
ON-REPLY 2:auth/check: {"jtype":"afb-reply","request":
{"status":"success"},"response":{"isvalid":true}}
auth refresh
ON-REPLY 4:auth/refresh: {"jtype":"afb-reply","request":{"status":"success",
   "token":"8b8ba8f4-1b0c-48fa-962d-4a00a8c9157e"},"response":{"token":"Token
was refreshed"}}
auth check
ON-REPLY 5:auth/check: {"jtype":"afb-reply","request":
{"status":"success"},"response":{"isvalid":true}}
auth refresh
ON-REPLY 6:auth/refresh: {"jtype":"afb-reply","request":{"status":"success",
   "token":"e83b36f8-d945-463d-b983-5d8ed73ba529"},"response":{"token":"Token
was refreshed"}}
```

After closing connection, reconnect as here after:

```
$ afb-client-demo ws://localhost:1234/api?token=e83b36f8-d945-463d-b983-
5d8ed73ba529\&uuid=5fcc3f3d-4b84-4fc7-ba66-2d8bd34ae7d1 auth check
ON-REPLY 1:auth/check: {"jtype":"afb-reply","request":
{"status":"success"},"response":{"isvalid":true}}
```

Same connection check using **curl**:

```
$ curl http://localhost:1234/api/auth/check?token=e83b36f8-d945-463d-b983-
5d8ed73ba529\&uuid=5fcc3f3d-4b84-4fc7-ba66-2d8bd34ae7d1
{"jtype":"afb-reply","request":{"status":"success"},"response":
{"isvalid":true}}
```

9.3. Format of replies

Replies use javascript object returned as serialized JSON.

This object contains at least 2 mandatory fields of name **jtype** and **request** and one optional field of name **response**.

9.3.1. Template

This is a template of replies:

```
{
   "jtype": "afb-reply",
   "request": {
      "status": "success",
      "info": "informationnal text",
      "token": "e83b36f8-d945-463d-b983-5d8ed73ba52",
      "uuid": "5fcc3f3d-4b84-4fc7-ba66-2d8bd34ae7d1",
      "reqid": "application-generated-id-23456"
   },
   "response": ....any response object....
}
```

9.3.2. Field jtype

The field **jtype** must have a value of type string equal to **"afb-reply"**.

9.3.3. Field request

The field **request** must have a value of type object. This request object has at least one field named **status** and four optional fields named **info**, **token**, **uuid**, **reqid**.

Subfield request.status

status must have a value of type string. This string is equal to **"success"** only in case of success.

Subfield request.info

info is of type string and represent optional information added to the reply.

Subfield request.token

token is of type string. It is sent either at session creation or when the token is refreshed.

Subfield request.uuid

uuid is of type string. It is sent at session creation.

Subfield request.reqid

reqid is of type string. It is sent in response to HTTP requests that added a parameter of name **reqid** or **x-afb-reqid** at request time. Value returns in the reply has the exact same value as the one received in the request.

9.3.4. Field response

This field response optionally contains an object returned when request succeeded.

9.4. Format of events

Events are javascript object serialized as JSON.

This object contains at least 2 mandatory fields of name **jtype** and **event** and one optional field of name **data**.

9.4.1. Template

Here is a template of event:

```
{
   "jtype": "afb-event",
   "event": "sample_api_name/sample_event_name",
   "data": ...any event data...
}
```

9.4.2. Field jtype

The field **jtype** must have a value of type string equal to **"afb-event"**.

9.4.3. Field event

The field **event** carries the event's name.

The name of the event is made of two parts separated by a slash: the name of the name of the API that generated the event and the name of event within the API.

9.4.4. Field data

This field data if present holds the data carried by the event.

10. Overview of bindings shipped with AFB-Daemon

10.1. List of bindings

Here are the bindings shipped in the source tree:

- Hello World
- Authentication
- Tic Tac Toe
- Audio *(2 backends: ALSA/PulseAudio)*
- Radio *(1 backend: RTLSDR RTL2832U)*
- Media *(1 backend: Rygel UPnP)*

All bindings may not be built, depending on the development libraries present on the system at build time.

10.2. Detail of bindings

10.2.1. Hello World

A sample Hello World binding for demonstration and learning purposes.

This binding provides a few unauthenticated requests, all beginning with "ping", to demonstrate basic binder capabilities.

Verbs:

- *ping:* returns a success response
- *pingfail:* returns a failure response
- *pingnull:* returns a success response, with an empty JSON response field
- *pingbug:* does a memory violation (intercepted by the binder)
- *pingJson:* returns a success response, with a complex JSON response field
- *pingevent:* broadcasts a global event

10.2.2. Authentication

A sample Authentication binding for demonstration purposes.

This binding provides a few requests to demonstrate the binder's token-based security mechanism.

Calling "*connect*" with a security token will initiate a session, calling "*refresh*" will issue a new token and invalidate the previous one, calling "*logout*" will invalidate all tokens and close the session.

Verbs:

- *ping:* returns a success response
- *connect:* creates a session and returns a new token
- *refresh:* returns a new token
- *check:* verifies the passed token is valid
- *logout:* closes the session

10.2.3. Tic Tac Toe

A sample Tic Tac Toe game binding.

This binding provides an interactive Tic Tac Toe game where the binder returns the grid as a JSON response.

Verbs:

- *new:* starts a new game
- *play:* asks the server to play
- *move:* gives a client move
- *board:* gets the current board state, as a JSON structure
- *level*: sets the server level
- *join*: joins an existing board
- *undo*: undo the last move
- *wait*: wait for a move

10.2.4. Audio

A sample Audio binding with 2 backends:

- ALSA (mandatory)
- PulseAudio (optional)

This binding is able to initialize a specific soundcard, define volume levels, channels (mono/stereo...), mute sound, and play a 22,050 Hz PCM stream.

Verbs:

- *ping:* returns a success response
- *init:* initializes backend, on the "default" sound card
- *volume:* gets or sets volume, in % (0-100)
- *channels:* gets or sets channels count (1-8)
- *mute:* gets or sets the mute status (on-off)
- *play*: gets or sets the playing status (on-off)

(if PulseAudio development libraries are not found at build time, only ALSA will be available)

(if a PulseAudio server is not found at runtime, the binding will dynamically fall back to ALSA)

_(a specifc backend can be forced by using this syntax before running afb-daemon

$ export AFB_AUDIO_OUTPUT=Alsa)_

10.2.5. Radio

A sample AM/FM Radio binding with 1 backend:

- RTLSDR - Realtek RTL2832U dongles (mandatory)

This binding is able to initialize specific RTL2832U dongles, switch between AM/FM modes, define frequency, mute sound, and play sound (if combining with the **audio** binding).

Verbs:

- *ping:* returns a success response
- *init:* initializes backend, looking for plugged-in devices
- *power:* sets device power status (on-off)
- *mode:* sets device reception mode (AM-FM)
- *freq:* sets device frequency (in Hz)
- *mute*: sets device mute status (on-off)
- *play*: sets device playing status (on-off)

(if rtlsdr development libraries are not found at build time, this binding will not be built)

10.2.6. Media

A sample Media Server binding with 1 backend:

- Rygel

This binding is able to detect a local Rygel UPnP media server, list audio files, select an audio file for playback, play/pause/seek in this file, upload an audio file to the server.

Verbs:

- *ping:* returns a success response
- *init:* initializes backend, looking for an active local UPnP server
- *list:* returns list of audio files, as a JSON structure
- *select:* select an audio files, by index number (001-...)
- *play:* plays the currently selected audio file
- *stop:* stops the currently selected audio file
- *pause:* pauses the currently selected audio file
- *seek:* seeks in the currently selected audio file, in seconds

- *upload:* uploads an audio file, with a POST request

(if GUPnP/GSSDP development libraries are not found at build time, this binding will not be built)

Sample command-line applications: *afb-client-demo* (built by default)

Sample HTML5 applications: **test/*.html, afb-client, afb-radio**

Sample Qt/QML applications: *test/token-websock.qml*

11. How to write a binding for AFB-DAEMON

11.1. Summary

The afb-daemon binders serve files through HTTP protocol and offers to developers the capability to offer application API methods through HTTP or WebSocket protocol.

The bindings are used to add API to ***afb-daemon***. This part describes how to write a binding for***afb-daemon***.

Excepting this summary, this document target developers.

Before moving further through an example, here after a short overview of binder bindings fundamentals.

11.1.1. Nature of a binding

A binding is an independent piece of software. A binding is self contain and exposes application logic as sharable library. A binding is intended to be dynamically loaded by ***afb-daemon*** to expose application API.

Technically, a binder binding does not reference and is not linked with any ***afb-daemon*** library.

11.1.2. Class of bindings

Application binder supports two kinds of bindings: application bindings and service bindings. Technically both class of binding are equivalent and use the same coding convention. Only sharing mode and security context diverge.

Application-bindings

Application-bindings implements the glue in between application's UI and services. Every AGL application has a corresponding binder that typically activates one or many bindings to interface the application logic with lower platform services. When an application is started by the AGL application framework, a dedicate binder is started that loads/activates application binding(s). API expose by application-binding are executed within corresponding application security context.

Application bindings generally handle a unique context for a unique client. As the application framework start a dedicated instance of afb_daemon for each AGL application, if a given binding is used within multiple application each of those application get a new and private instance of eventually "shared" binding.

Service-bindings

Service-bindings enable API activation within corresponding service security context and not within calling application context. Service-bindings are intended to run as a unique instance. Service-bindings can be shared in between multiple clients.

Service-bindings can either be stateless or manage client context. When managing context each client get a private context. Sharing may either be global to the platform (ie: GPS service) or dedicated to a given user (ie: user preferences)

11.1.3. Live cycle of bindings within *afb-daemon*

Application and service bindings are loaded and activated each time a new ***afb-daemon*** is started.

At launch time, every loaded binding initialise itself. If a single binding initialisation fails the corresponding instance of ***afb-daemon*** aborts.

Conversely, when a binding initialisation succeeds, it should register its unique name as well as the list of verbs (methods name from binder point of view) attached to the methods it exposes.

When initialised, on request from application clients to the right API/verbs binding methods are activated by the ***afb-daemon*** attached to the application or service.

At exit time, no special action is enforced by ***afb-daemon***. When a specific actions is required at afb-daemon stop, developers should use 'atexit/on_exit' during binding initialisation sequence to register a custom exit function.

11.1.4. Binding Content

Afb-daemon's bindings register two classes of objects: names and functions.

Bindings declare categories of names: - A unique binding name to access all API exposed by this binding, - One name for each methods/verbs provided by this binding.

Bindings declare two categories of functions: - function used for initialisation - functions implementing the exposed API methods

Afb-daemon parses URI requests to extract the API(binding name) and the VERB(method to activate). As an example, URI **foo/bar** translates to binding named **foo** and method named **bar**. To serve such a request, ***afb-daemon*** looks for an active binding named **foo** and then within this binding for a method named **bar**. When found ***afb-daemon*** calls the corresponding method with an attached parameter if any.

Afb-daemon is case-insensitive when parsing URI. Thus **TicTacToe/Board** and **tictactoe/board** are equivalent.

The name of the binding

The name of a given binding is also known as the name of the API prefix that defines the binding.

The name of a binding SHOULD be unique within a given ***afb-daemon*** instance.

For example, when a client of ***afb-daemon*** calls a URI named **foo/bar**. Afb-daemon extracts the prefix **foo** and the suffix **bar**. **foo** must match a binding name and **bar** has to match a VERB attached to some method.

Names of methods

Each binding exposes a set of methods that can be called by the clients of a given ***afb-daemon***.

VERB's name attached to a given binding (API) MUST be unique within a binding.

Bindings static declaration link VERBS to the corresponding methods. When clients emit requests on a given API/VERB corresponding method is called by ***afb-daemon***.

Initialisation function

Binding's initialisation function serves several purposes.

1. It allows ***afb-daemon*** to control the binding version depending on the initialisation of function name. As today, the only supported initialisation function is **afbBindingV1Register**. This identifies version "one" of bindings.
2. It allows bindings to initialise itself.
3. It enables names declarations: descriptions, requirements and implementations of exposed API/VERB.

Functions instantiation of API/VERBs

When an API/VERB is called, ***afb-daemon*** constructs a request object. Then it passes this request object to the implementation function corresponding to requested method, this within attached API binding.

An implementation function receives a request object used to: get the arguments of the request, send an answer, store session data.

A binding MUST set an answer to every received requests.

Nevertheless, there are two implementations, *synchronous* and *asynchronous*. API/VERB implementation that set an answer before returning are called *synchronous implementations*. Those that do not systematically set an answer before returning are called *asynchronous implementations*.

Asynchronous implementations typically launch asynchronous actions. They record some context at request time and provide an answer to the request only at completion of asynchronous actions.

11.2. The Tic-Tac-Toe example

This part explains how to write an afb-binding. For the sake of being practical it uses many examples based on tic-tac-toe. This binding example is in *bindings/samples/tic-tac-toe.c*.

This binding is named ***tictactoe***.

11.3. Dependencies when compiling

Afb-daemon provides a configuration file for *pkg-config*. Typing the command

```
pkg-config --cflags afb-daemon
```

Print flags use for compilation:

```
$ pkg-config --cflags afb-daemon
-I/opt/local/include -I/usr/include/json-c
```

For linking, you should use

```
$ pkg-config --libs afb-daemon
-ljson-c
```

Afb-daemon automatically includes the dependency to json-c. This is activated through **Requires** keyword in pkg-config. While almost every binding replies on **json-c** this is not a must have dependency.

Internally, ***afb-daemon*** relies on **libsystemd** for its event loop, as well as for its binding to D-Bus. Bindings developers are encouraged to leverage **libsystemd** when possible. Nevertheless there is no hard dependency to **libsystemd** if you do not want to use it, feel free to do so.

> Afb-daemon bindings are fully self contained. They do not enforce dependency on any libraries from the application framework. Afb-daemon dependencies requirer to run AGL bindings are given at runtime through pointers leveraging read-only memory feature.

11.4. Header files to include

Binding *tictactoe* has following includes:

```
#define _GNU_SOURCE
#include <stdio.h>
#include <string.h>
#include <json-c/json.h>
#include <afb/afb-binding.h>
```

Header *afb/afb-binding.h* is the only hard dependency, it includes all features that a binding MUST HAVE. Outside of includes used to support application logic, common external headers used within bindings are:

- *json-c/json.h*: should be include to handle json objects;
- *systemd/sd-event.h*: should be include to access event main loop;
- *systemd/sd-bus.h*: should be include for dbus connections.

The *tictactoe* binding does not leverage systemd features, also only json.h is used on top of mandatory afb/afb-binding.h.

When including *afb/afb-binding.h*, the macro **_GNU_SOURCE** MUST be defined.

11.5. Choosing names

Designers of bindings should define a unique name for every API binding as well as for methods VERBs. They should also define names for request arguments passed as name/value pair in URI.

While forging names, designers should respect few rules to ensure that created names are valid and easy to use across platforms.

All names and strings are UTF-8 encoded.

11.5.1. Names for API (binding)

Binding API name are checked. All characters are authorised except:

- the control characters (000 .. 01f)
- the characters of the set { ' ', '"', '#', '%', '&', ''', '/', '?', '`', '7f' }

In other words the set of forbidden characters is { 000..020, 022, 023, 025..027, 02f, 03f, 060, 07f }.

Afb-daemon makes no distinction between lower case and upper case when searching for API/VERB.

11.5.2. Names for methods

The names of methods VERBs are totally free and not checked.

However, the validity rules for method's VERB name are the same as for Binding API name except that the dot(.) character is forbidden.

Afb-daemon makes no case distinction when searching for an API by name.

11.5.3. Names for arguments

Argument's name are not restricted and can be everything you wish.

> Warning arguments search is case sensitive and "index" and "Index" are not two different arguments.

11.5.4. Forging names widely available

The key names of javascript object can be almost anything using the arrayed notation:

```
object[key] = value
```

Nevertheless this is not the case with javascript dot notation:

```
object.key = value
```

Using the dot notation, the key must be a valid javascript identifier and dash(-) as well as few other reserved characters cannot be used.

For this reason, we advise developers to chose name compatible with both javascript and HTML notation.

It is a good practice, even for arguments not to rely on case sensitivity. This may reduce headache strength at debug time, especially with interpreted language like javascript that may not warn you that a variable was not defined.

11.6. Declaration of methods and initialisation of the bindings

11.6.1. Declaration of methods

To be active, binding's methods should be declared to ***afb-daemon***. Furthermore, the binding itself must be recorded.

The registration mechanism is very basic: when ***afb-daemon*** starts, it loads all bindings listed in: command line or configuration file.

Loading a binding follows the following steps:

1. Afb-daemon loads the binding with *dlopen*.
2. Afb-daemon searches for a symbol named **afbBindingV1Register** using *dlsym*. This symbol is assumed to be the exported initialisation function of the binding.
3. Afb-daemon builds an interface object for the binding.
4. Afb-daemon calls the found function **afbBindingV1Register** with interface pointer as parameter.
5. Function **afbBindingV1Register** setups the binding and initialises it.
6. Function **afbBindingV1Register** returns the pointer to a structure describing the binding: version, name (prefix or API name), and list of methods.
7. Afb-daemon checks that the returned version and name can be managed. If so, binding and its methods are register to become usable as soon as ***afb-daemon***

initialisation is finished.

11.6.2. Initialisation of bindings

The bindings initialisation is the final step made at the end of declaration of methods. This will initialize the binding and make its ***afb-daemon***'s interface fully functional.

So, afb-daemon binder call **afbBindingV1ServiceInit** as final step to a binding. This will allows the binding to call features in its name and as saw in Binder events guide you can create an event only at this moment and not before. Before that it will fail because afb-daemon doesn't know the binding name.

afbBindingV1ServiceInit is defined as below:

```
/*
 * When a binding have an exported implementation of the
 * function 'afbBindingV1ServiceInit', defined below,
 * the framework calls it for initialising the service after
 * registration of all bindings.
 *
 * The object 'service' should be recorded. It has functions that
 * allows the binding to call features with its own personality.
 *
 * The function should return 0 in case of success or, else, should return
 * a negative value.
 */
extern int afbBindingV1ServiceInit(struct afb_service service);
```

11.6.3. Application binding example: tic-tac-toe

If we continue our tic-tac-toe example, here after the code used for **afbBindingV1Register** implementation from binding *tic-tac-toe*:

```
/*
 * activation function for registering the binding called by afb-daemon
 */
const struct afb_binding *afbBindingV1Register(const struct
afb_binding_interface *itf)
{
   afbitf = itf;         // records the interface for accessing afb-daemon
   return &binding_description;  // returns the description of the binding
}
```

It is a very minimal initialisation function because *tic-tac-toe* binding doesn't have any application related initialisation step. It merely record daemon's interface and returns its description.

The variable **afbitf** is a binding global variable. It keeps the interface to ***afb-daemon*** that should be used for logging and pushing events. Here is its declaration:

```
/*
 * the interface to afb-daemon
 */
const struct afb_binding_interface *afbitf;
```

The description of the binding is defined here after.

```
/*
 * array of the methods exported to afb-daemon
 */
static const struct afb_verb_desc_v1 binding_methods[] = {
   /* VERB'S NAME     SESSION MANAGEMENT          FUNCTION TO CALL  SHORT
DESCRIPTION */
   { .name= "new",   .session= AFB_SESSION_NONE, .callback= new,   .info=
"Starts a new game" },
   { .name= "play",  .session= AFB_SESSION_NONE, .callback= play,  .info= "Asks
the server to play" },
   { .name= "move",  .session= AFB_SESSION_NONE, .callback= move,  .info=
"Tells the client move" },
   { .name= "board", .session= AFB_SESSION_NONE, .callback= board, .info= "Get
the current board" },
   { .name= "level", .session= AFB_SESSION_NONE, .callback= level, .info= "Set
the server level" },
   { .name= "join",  .session= AFB_SESSION_CHECK,.callback= join,  .info= "Join
a board" },
   { .name= "undo",  .session= AFB_SESSION_NONE, .callback= undo,  .info= "Undo
the last move" },
   { .name= "wait",  .session= AFB_SESSION_NONE, .callback= wait,  .info= "Wait
for a change" },
   { .name= NULL } /* marker for end of the array */
};

/*
 * description of the binding for afb-daemon
 */
static const struct afb_binding binding_description =
{
   /* description conforms to VERSION 1 */
   .type= AFB_BINDING_VERSION_1,
   .v1= {              /* fills the v1 field of the union when
AFB_BINDING_VERSION_1 */
      .prefix= "tictactoe",     /* the API name (or binding name or prefix) */
      .info= "Sample tac-tac-toe game", /* short description of of the binding
*/
      .methods = binding_methods        /* the array describing the methods of
the API */
   }
};
```

The structure **binding_description** describes the binding. It declares the type and version of the binding, its name, a short description and its methods list.

The list of methods is an array of structures describing the methods and terminated by a NULL marker.

In version one of afb-damon binding, a method description contains 4 fields:

- the name of the method,
- the session management flags,
- the implementation function to be call for the method,
- a short description.

The structure describing methods is defined as follows:

```
/*
 * Description of one method of the API provided by the binding
 * This enumeration is valid for bindings of type 1
 */
struct afb_verb_desc_v1
{
       const char *name;                        /* name of the method */
       enum AFB_session_v1 session;             /* authorisation and session 
requirements of the method */
       void (*callback)(struct afb_req req);    /* callback function 
implementing the method */
       const char *info;                        /* textual description of the 
method */
};
```

For technical reasons, the enumeration **enum AFB_session_v1** is not exactly an enumeration but the wrapper of constant definitions that can be mixed using bitwise or (the C operator |).

The constants that can bit mixed are:

Constant name	Meaning
AFB_SESSION_CREATE	Equals to AFB_SESSION_LOA_EQ_0
AFB_SESSION_CLOSE	Closes the session after the reply and set the LOA to 0
AFB_SESSION_RENEW	Refreshes the token of authentification
AFB_SESSION_CHECK	Just requires the token authentification
AFB_SESSION_LOA_LE_0	Requires the current LOA to be lesser then or equal to 0
AFB_SESSION_LOA_LE_1	Requires the current LOA to be lesser then or equal to 1
AFB_SESSION_LOA_LE_2	Requires the current LOA to be lesser then or equal to 2
AFB_SESSION_LOA_LE_3	Requires the current LOA to be lesser then or equal to 3
AFB_SESSION_LOA_GE_0	Requires the current LOA to be greater then or equal to 0
AFB_SESSION_LOA_GE_1	Requires the current LOA to be greater then or equal to 1
AFB_SESSION_LOA_GE_2	Requires the current LOA to be greater then or equal to 2
AFB_SESSION_LOA_GE_3	Requires the current LOA to be greater then or equal to 3
AFB_SESSION_LOA_EQ_0	Requires the current LOA to be equal to 0
AFB_SESSION_LOA_EQ_1	Requires the current LOA to be equal to 1
AFB_SESSION_LOA_EQ_2	Requires the current LOA to be equal to 2
AFB_SESSION_LOA_EQ_3	Requires the current LOA to be equal to 3

If any of this flag is set, ***afb-daemon*** requires an authentication token as if **AFB_SESSION_CHECK** flag was also set.

The special value **AFB_SESSION_NONE** is zero and can be used to bypass token check.

Note that **AFB_SESSION_CREATE** and **AFB_SESSION_CLOSE** might be removed in later versions.

11.7. Sending messages to the log system

Afb-daemon provides 4 levels of verbosity and 5 methods for logging messages.

The verbosity is managed. Options allow the change the verbosity of ***afb-daemon*** and the verbosity of the bindings can be set binding by binding.

The methods for logging messages are defined as macros that test the verbosity level and that call the real logging function only if the message must be output. This avoid evaluation of arguments of the formatting messages if the message must not be output.

11.7.1. Verbs for logging messages

The 5 logging methods are:

Macro	Verbosity	Meaning	syslog level
ERROR	0	Error conditions	3
WARNING	1	Warning conditions	4
NOTICE	1	Normal but significant condition	5
INFO	2	Informational	6
DEBUG	3	Debug-level messages	7

You can note that the 2 methods **WARNING** and **NOTICE** have the same level of verbosity. But they don't have the same *syslog level*. It means that they are output with a different level on the logging system.

All of these methods have the same signature:

```
void ERROR(const struct afb_binding_interface *afbitf, const char
*message, ...);
```

The first argument **afbitf** is the interface to afb daemon that the binding received at initialisation time when **afbBindingV1Register** is called.

The second argument **message** is a formatting string compatible with printf/sprintf.

The remaining arguments are arguments of the formating message like with printf.

11.7.2. Managing verbosity

Depending on the level of verbosity, the messages are output or not. The following table explains what messages will be output depending ont the verbosity level.

Level of verbosity	Outputed macro
0	ERROR
1	ERROR + WARNING + NOTICE

Level of verbosity	Outputed macro
2	ERROR + WARNING + NOTICE + INFO
3	ERROR + WARNING + NOTICE + INFO + DEBUG

11.7.3. Output format and destination

The syslog level is used for forging a prefix to the message. The prefixes are:

syslog level	prefix
0	<0> EMERGENCY
1	<1> ALERT
2	<2> CRITICAL
3	<3> ERROR
4	<4> WARNING
5	<5> NOTICE
6	<6> INFO
7	<7> DEBUG

The message is pushed to standard error. The final destination of the message depends on how systemd service was configured through its variable **StandardError**. It can be journal, syslog or kmsg. (See man sd-daemon).

11.8. Sending events

Specific documentation exists about sending events.

The binding *tic-tac-toe* broadcasts events when the board changes. This is done in the function ***changed***:

```
/*
 * signals a change of the board
 */
static void changed(struct board *board, const char *reason)
{
    ...
    struct json_object *description;

    /* get the description */
    description = describe(board);

    ...

    afb_daemon_broadcast_event(afbitf->daemon, reason, description);
}
```

The description of the changed board is pushed via the daemon interface.

Within binding *tic-tac-toe*, *reason* indicates the origin of the change. In function **afb_daemon_broadcast_event** the second parameter is the name of broadcasted event. The third argument is the object that is transmitted with the event.

Function **afb_daemon_broadcast_event** is defined here after:

```
/*
```

```
 * Broadcasts widely the event of 'name' with the data 'object'.
 * 'object' can be NULL.
 * 'daemon' MUST be the daemon given in interface when activating the binding.
 *
 * For convenience, the function calls 'json_object_put' for 'object'.
 * Thus, in the case where 'object' should remain available after
 * the function returns, the function 'json_object_get' shall be used.
 */
void afb_daemon_broadcast_event(struct afb_daemon daemon, const char *name,
struct json_object *object);
```

> Be aware, as with reply functions **object** is automatically released using **json_object_put** when using this function. Call **json_object_get** before calling **afb_daemon_broadcast_event** to keep **object** available after function returns.

Event name received by listeners is prefixed with binding name. So when a change occurs after a move, the reason is **move** and every clients receive an event **tictactoe/move**.

> Note that nothing is said about case sensitivity of event names. However, the event is always prefixed with the name that the binding declared, with the same case, followed with a slash /. Thus it is safe to compare event using a case sensitive comparison.

11.9. Writing a synchronous method implementation

The method **tictactoe/board** is a synchronous implementation. Here is its listing:

```
/*
 * get the board
 */
static void board(struct afb_req req)
{
    struct board *board;
    struct json_object *description;

    /* retrieves the context for the session */
    board = board_of_req(req);
    INFO(afbitf, "method 'board' called for boardid %d", board->id);

    /* describe the board */
    description = describe(board);

    /* send the board's description */
    afb_req_success(req, description, NULL);
}
```

This example shows many aspects of a synchronous method implementation. Let summarise it:

1. The function **board_of_req** retrieves the context stored for the binding: the board.

2. The macro **INFO** sends a message of kind *INFO* to the logging system. The global variable named **afbitf** used represents the interface to ***afb-daemon***.
3. The function **describe** creates a json_object representing the board.
4. The function **afb_req_success** sends the reply, attaching to it the object *description*.

11.9.1. The incoming request

For any implementation, the request is received by a structure of type **struct afb_req**.

> Note that this is a PLAIN structure, not a pointer to a structure.

The definition of **struct afb_req** is:

```
/*
 * Describes the request by bindings from afb-daemon
 */
struct afb_req {
    const struct afb_req_itf *itf;  /* the interfacing functions */
    void *closure;          /* the closure for functions */
};
```

It contains two pointers: first one *itf*, points to functions used to handle internal request. Second one *closure* point onto function closure.

> The structure must never be used directly. Instead developer should use the intended functions provided by ***afb-daemon*** as described here after.

req is used to get arguments of the request, to send answer, to store session data.

This object and its interface is defined and documented in the file names *afb/afb-req-itf.h*

The above example uses twice *req* object request.

The first time, to retrieve the board attached to the session of the request.

The second time, to send the reply: an object that describes the current board.

11.9.2. Associating a client context to a session

When *tic-tac-toe* binding receives a request, it musts get the board describing the game associated to the session.

For a binding, having data associated to a session is common. This data is called "binding context" for the session. Within *tic-tac-toe* binding the context is the board.

Requests *afb_req* offer four functions for storing and retrieving session associated context.

These functions are:

- **afb_req_context_get**: retrieves context data stored for current binding.
- **afb_req_context_set**: store context data of current binding.
- **afb_req_context**: if exist retrieves context data of current binding. if context does not yet exist, creates a new context and store it.
- **afb_req_context_clear**: reset the stored context data.

The binding *tictactoe* use a convenient function to retrieve its context: the board. This function is *board_of_req*:

```
/*
 * retrieves the board of the request
 */
static inline struct board *board_of_req(struct afb_req req)
{
    return afb_req_context(req, (void*)get_new_board, (void*)release_board);
}
```

The function **afb_req_context** ensures an existing context for the session of the request. Its two last arguments are functions to allocate and free context. Note function type casts to avoid compilation warnings.

Here is the definition of the function **afb_req_context**

```
/*
 * Gets the pointer stored by the binding for the session of 'req'.
 * If the stored pointer is NULL, indicating that no pointer was
 * already stored, afb_req_context creates a new context by calling
 * the function 'create_context' and stores it with the freeing function
 * 'free_context'.
 */
static inline void *afb_req_context(struct afb_req req, void *(*create_context)
(), void (*free_context)(void*))
{
    void *result = afb_req_context_get(req);
    if (result == NULL) {
        result = create_context();
        afb_req_context_set(req, result, free_context);
    }
    return result;
}
```

The second argument if the function that creates the context. For binding *tic-tac-toe* (function **get_new_board**). The function **get_new_board** creates a new board and set usage its count to 1. The boards are checking usage count to free resources when not used.

The third argument is a function that frees context resources. For binding *tic-tac-toe* (function **release_board**). The function **release_board** decrease usage count of the board passed in argument. When usage count falls to zero, data board are freed.

Definition of other functions dealing with contexts:

```
/*
```

```
 * Gets the pointer stored by the binding for the session of 'req'.
 * When the binding has not yet recorded a pointer, NULL is returned.
 */
void *afb_req_context_get(struct afb_req req);

/*
 * Stores for the binding the pointer 'context' to the session of 'req'.
 * The function 'free_context' will be called when the session is closed
 * or if binding stores an other pointer.
 */
void afb_req_context_set(struct afb_req req, void *context, void
(*free_context)(void*));

/*
 * Frees the pointer stored by the binding for the session of 'req'
 * and sets it to NULL.
 *
 * Shortcut for: afb_req_context_set(req, NULL, NULL)
 */
static inline void afb_req_context_clear(struct afb_req req)
{
    afb_req_context_set(req, NULL, NULL);
}
```

11.9.3. Sending reply to a request

Two kinds of replies: successful or failure.

> Sending a reply to a request MUST be done once and only once.

It exists two functions for "success" replies: **afb_req_success** and **afb_req_success_f**.

```
/*
 * Sends a reply of kind success to the request 'req'.
 * The status of the reply is automatically set to "success".
 * Its send the object 'obj' (can be NULL) with an
 * informationnal comment 'info (can also be NULL).
 *
 * For convenience, the function calls 'json_object_put' for 'obj'.
 * Thus, in the case where 'obj' should remain available after
 * the function returns, the function 'json_object_get' shall be used.
 */
void afb_req_success(struct afb_req req, struct json_object *obj, const char
*info);

/*
 * Same as 'afb_req_success' but the 'info' is a formatting
 * string followed by arguments.
 *
 * For convenience, the function calls 'json_object_put' for 'obj'.
 * Thus, in the case where 'obj' should remain available after
 * the function returns, the function 'json_object_get' shall be used.
 */
void afb_req_success_f(struct afb_req req, struct json_object *obj, const char
*info, ...);
```

It exists two functions for "failure" replies: **afb_req_fail** and **afb_req_fail_f**.

```
/*
 * Sends a reply of kind failure to the request 'req'.
 * The status of the reply is set to 'status' and an
 * informational comment 'info' (can also be NULL) can be added.
 *
 * Note that calling afb_req_fail("success", info) is equivalent
 * to call afb_req_success(NULL, info). Thus even if possible it
 * is strongly recommended to NEVER use "success" for status.
 *
 * For convenience, the function calls 'json_object_put' for 'obj'.
 * Thus, in the case where 'obj' should remain available after
 * the function returns, the function 'json_object_get' shall be used.
 */
void afb_req_fail(struct afb_req req, const char *status, const char *info);

/*
 * Same as 'afb_req_fail' but the 'info' is a formatting
 * string followed by arguments.
 *
 * For convenience, the function calls 'json_object_put' for 'obj'.
 * Thus, in the case where 'obj' should remain available after
 * the function returns, the function 'json_object_get' shall be used.
 */
void afb_req_fail_f(struct afb_req req, const char *status, const char
*info, ...);
```

For convenience, these functions automatically call **json_object_put** to release **obj**. Because **obj** usage count is null after being passed to a reply function, it SHOULD not be used anymore. If exceptionally **obj** needs to remain usable after reply function then using **json_object_get** on **obj** to increase usage count and cancels the effect the **json_object_put** is possible.

11.10. Getting argument of invocation

Many methods expect arguments. Afb-daemon's bindings retrieve arguments by name and not by position.

Arguments are passed by requests through either HTTP or WebSockets.

For example, the method **join** of binding **tic-tac-toe** expects one argument: the *boardid* to join. Here is an extract:

```
/*
 * Join a board
 */
static void join(struct afb_req req)
{
    struct board *board, *new_board;
    const char *id;

    /* retrieves the context for the session */
    board = board_of_req(req);
    INFO(afbitf, "method 'join' called for boardid %d", board->id);
    /* retrieves the argument */
    id = afb_req_value(req, "boardid");
    if (id == NULL)
        goto bad_request;
    ...
```

The function **afb_req_value** searches in the request *req* for argument name passed in the second argument. When argument name is not passed, **afb_req_value** returns NULL.

> The search is case sensitive and *boardid* is not equivalent to *BoardId*. Nevertheless having argument names that only differ by name case is not a good idea.

11.10.1. Basic functions for querying arguments

The function **afb_req_value** is defined here after:

```
/*
 * Gets from the request 'req' the string value of the argument of 'name'.
 * Returns NULL if when there is no argument of 'name'.
 * Returns the value of the argument of 'name' otherwise.
 *
 * Shortcut for: afb_req_get(req, name).value
 */
static inline const char *afb_req_value(struct afb_req req, const char *name)
{
    return afb_req_get(req, name).value;
}
```

It is defined as a shortcut to call the function **afb_req_get**. That function is defined here after:

```
/*
 * Gets from the request 'req' the argument of 'name'.
 * Returns a PLAIN structure of type 'struct afb_arg'.
 * When the argument of 'name' is not found, all fields of result are set to
NULL.
 * When the argument of 'name' is found, the fields are filled,
 * in particular, the field 'result.name' is set to 'name'.
 *
 * There is a special name value: the empty string.
 * The argument of name "" is defined only if the request was made using
 * an HTTP POST of Content-Type "application/json". In that case, the
 * argument of name "" receives the value of the body of the HTTP request.
 */
struct afb_arg afb_req_get(struct afb_req req, const char *name);
```

That function takes 2 parameters: the request and the name of the argument to retrieve. It returns a PLAIN structure of type **struct afb_arg**.

There is a special name that is defined when the request is of type HTTP/POST with a Content-Type being application/json. This name is **""** (the empty string). In that case, the value of this argument of empty name is the string received as a body of the post and is supposed to be a JSON string.

The definition of **struct afb_arg** is:

```
/*
 * Describes an argument (or parameter) of a request
 */
struct afb_arg {
    const char *name;   /* name of the argument or NULL if invalid */
    const char *value;  /* string representation of the value of the argument
*/
                /* original filename of the argument if path != NULL */
    const char *path;   /* if not NULL, path of the received file for the
argument */
                /* when the request is finalized this file is removed */
};
```

The structure returns the data arguments that are known for the request. This data include a field named **path**. This **path** can be accessed using the function **afb_req_path** defined here after:

```
/*
 * Gets from the request 'req' the path for file attached to the argument of
'name'.
 * Returns NULL if when there is no argument of 'name' or when there is no
file.
 * Returns the path of the argument of 'name' otherwise.
 *
 * Shortcut for: afb_req_get(req, name).path
 */
static inline const char *afb_req_path(struct afb_req req, const char *name)
{
    return afb_req_get(req, name).path;
}
```

The path is only defined for HTTP/POST requests that send file.

11.10.2. Arguments for received files

As it is explained above, clients can send files using HTTP/POST requests.

Received files are attached to "file" argument name. For example, the following HTTP fragment (from test/sample-post.html) will send an HTTP/POST request to the method **post/upload-image** with 2 arguments named *file* and *hidden*.

```
<h2>Sample Post File</h2>
<form enctype="multipart/form-data">
    <input type="file" name="file" />
    <input type="hidden" name="hidden" value="bollobollo" />
    <br>
    <button formmethod="POST" formaction="api/post/upload-image">Post
File</button>
</form>
```

Argument named **file** should have both its value and path defined.

The value is the name of the file as it was set by the HTTP client. Generally it is the filename on client side.

The path is the effective path of saved file on the temporary local storage area of the application. This is a randomly generated and unique filename. It is not linked with the original filename as used on client side.

After success the binding can use the uploaded file directly from local storage path with no restriction: read, write, remove, copy, rename... Nevertheless when request reply is set and query terminated, the uploaded temporary file at path is destroyed.

11.10.3. Arguments as a JSON object

Bindings may also request every arguments of a given call as one single object. This feature is provided by the function **afb_req_json** defined here after:

```
/*
 * Gets from the request 'req' the json object hashing the arguments.
 * The returned object must not be released using 'json_object_put'.
 */
struct json_object *afb_req_json(struct afb_req req);
```

It returns a json object. This object depends on how the request was built:

- For HTTP requests, this json object uses key names mapped on argument name. Values are either string for common arguments or object ie: { "file": "...", "path": "..." }
- For WebSockets requests, returned directly the object as provided by the client.

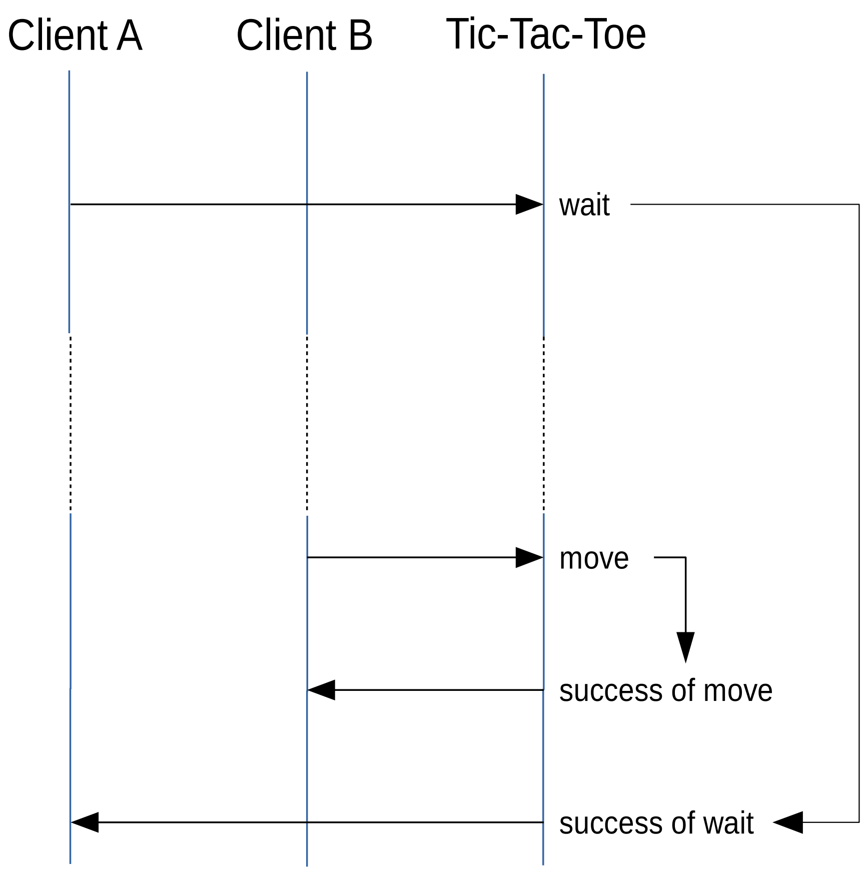
  In fact, for Websockets requests, the function **afb_req_value** can be seen as a shortcut to ***json_object_get_string(json_object_object_get(afb_req_json(req), name))***

11.11. Writing an asynchronous method implementation

The *tic-tac-toe* example allows two clients or more to share the same board. This is implemented by the method **join** that illustrated partly how to retrieve arguments.

When two or more clients are sharing a same board, one of them can wait until the state of the board changes, but this could also be implemented using events because an event is generated each time the board changes.

In this case, the reply to the wait is sent only when the board changes. See the diagram below:



tic-tac-toe_diagram

Here, this is an invocation of the binding by an other client that unblock the suspended *wait* call. Nevertheless in most case this should be a timer, a hardware event, a sync with a concurrent process or thread, ...

Common case of an asynchronous implementation.

Here is the listing of the function **wait**:

```
static void wait(struct afb_req req)
{
    struct board *board;
    struct waiter *waiter;

    /* retrieves the context for the session */
    board = board_of_req(req);
    INFO(afbitf, "method 'wait' called for boardid %d", board->id);

    /* creates the waiter and enqueues it */
    waiter = calloc(1, sizeof *waiter);
    waiter->req = req;
    waiter->next = board->waiters;
    afb_req_addref(req);
    board->waiters = waiter;
}
```

After retrieving the board, the function adds a new waiter to waiters list and returns without setting a reply.

Before returning, it increases **req** request's reference count using **afb_req_addref** function.

> When a method returns without setting a reply, it **MUST** increment request's reference count using **afb_req_addref**. If unpredictable behaviour may pop up.

Later, when a board changes, it calls *tic-tac-toe* **changed** function with reason of change in parameter.

Here is the full listing of the function **changed**:

```
/*
 * signals a change of the board
 */
static void changed(struct board *board, const char *reason)
{
    struct waiter *waiter, *next;
    struct json_object *description;

    /* get the description */
    description = describe(board);

    waiter = board->waiters;
    board->waiters = NULL;
    while (waiter != NULL) {
        next = waiter->next;
        afb_req_success(waiter->req, json_object_get(description), reason);
        afb_req_unref(waiter->req);
        free(waiter);
        waiter = next;
    }

    afb_event_sender_push(afb_daemon_get_event_sender(afbitf->daemon), reason,
description);
}
```

The list of waiters is walked and a reply is sent to each waiter. After sending the reply, the reference count of the request is decremented using **afb_req_unref** to allow resources to be freed.

> The reference count **MUST** be decremented using **afb_req_unref** to free resources and avoid memory leaks. This usage count decrement should happen **AFTER** setting reply or bad things may happen.

11.12. Sending messages to the log system

Afb-daemon provides 4 levels of verbosity and 5 methods for logging messages.

The verbosity is managed. Options allow the change the verbosity of ***afb-daemon*** and the verbosity of the bindings can be set binding by binding.

The methods for logging messages are defined as macros that test the verbosity level and that call the real logging function only if the message must be output. This avoid evaluation of arguments of the formatting messages if the message must not be output.

11.12.1. Verbs for logging messages

The 5 logging methods are:

Macro	Verbosity	Meaning	syslog level
ERROR	0	Error conditions	3
WARNING	1	Warning conditions	4
NOTICE	1	Normal but significant condition	5
INFO	2	Informational	6
DEBUG	3	Debug-level messages	7

You can note that the 2 methods **WARNING** and **NOTICE** have the same level of verbosity. But they don't have the same *syslog level*. It means that they are output with a different level on the logging system.

All of these methods have the same signature:

```
void ERROR(const struct afb_binding_interface *afbitf, const char
*message, ...);
```

The first argument **afbitf** is the interface to afb daemon that the binding received at initialisation time when **afbBindingV1Register** is called.

The second argument **message** is a formatting string compatible with printf/sprintf.

The remaining arguments are arguments of the formating message like with printf.

11.12.2. Managing verbosity

Depending on the level of verbosity, the messages are output or not. The following table explains what messages will be output depending ont the verbosity level.

Level of verbosity	Outputed macro
0	ERROR
1	ERROR + WARNING + NOTICE
2	ERROR + WARNING + NOTICE + INFO
3	ERROR + WARNING + NOTICE + INFO + DEBUG

11.12.3. Output format and destination

The syslog level is used for forging a prefix to the message. The prefixes are:

syslog level	prefix
0	<0> EMERGENCY
1	<1> ALERT
2	<2> CRITICAL
3	<3> ERROR
4	<4> WARNING

syslog level	prefix
5	<5> NOTICE
6	<6> INFO
7	<7> DEBUG

The message is pushed to standard error. The final destination of the message depends on how systemd service was configured through its variable **StandardError**. It can be journal, syslog or kmsg. (See man sd-daemon).

11.13. Sending events

Since version 0.5, bindings can broadcast events to any potential listener. As today only unattended events are supported. Targeted events are expected for next coming version.

The binding *tic-tac-toe* broadcasts events when the board changes. This is done in the function **changed**:

```
/*
 * signals a change of the board
 */
static void changed(struct board *board, const char *reason)
{
    ...
    struct json_object *description;

    /* get the description */
    description = describe(board);

    ...

    afb_daemon_broadcast_event(afbitf->daemon, reason, description);
}
```

The description of the changed board is pushed via the daemon interface.

Within binding *tic-tac-toe*, *reason* indicates the origin of the change. In function **afb_daemon_broadcast_event** the second parameter is the name of broadcasted event. The third argument is the object that is transmitted with the event.

Function **afb_daemon_broadcast_event** is defined here after:

```
/*
 * Broadcasts widely the event of 'name' with the data 'object'.
 * 'object' can be NULL.
 * 'daemon' MUST be the daemon given in interface when activating the binding.
 *
 * For convenience, the function calls 'json_object_put' for 'object'.
 * Thus, in the case where 'object' should remain available after
 * the function returns, the function 'json_object_get' shall be used.
 */
void afb_daemon_broadcast_event(struct afb_daemon daemon, const char *name,
struct json_object *object);
```

Be aware, as with reply functions **object** is automatically released using **json_object_put** when using this function. Call **json_object_get**

> before calling **afb_daemon_broadcast_event** to keep **object** available after function returns.

Event name received by listeners is prefixed with binding name. So when a change occurs after a move, the reason is **move** and every clients receive an event **tictactoe/move**.

> Note that nothing is said about case sensitivity of event names. However, the event is always prefixed with the name that the binding declared, with the same case, followed with a slash /. Thus it is safe to compare event using a case sensitive comparison.

11.14. How to build a binding

Afb-daemon provides a *pkg-config* configuration file that can be queried by providing ***afb-daemon*** in command line arguments. This configuration file provides data that should be used for bindings compilation. Examples:

```
$ pkg-config --cflags afb-daemon
$ pkg-config --libs afb-daemon
```

11.14.1. Example for cmake meta build system

This example is the extract for building the binding *afm-main* using *CMAKE*.

```
pkg_check_modules(afb afb-daemon)
if(afb_FOUND)
    message(STATUS "Creation afm-main-binding for AFB-DAEMON")
    add_library(afm-main-binding MODULE afm-main-binding.c)
    target_compile_options(afm-main-binding PRIVATE ${afb_CFLAGS})
    target_include_directories(afm-main-binding PRIVATE ${afb_INCLUDE_DIRS})
    target_link_libraries(afm-main-binding utils ${afb_LIBRARIES})
    set_target_properties(afm-main-binding PROPERTIES
        PREFIX ""
        LINK_FLAGS "-Wl,--version-script=${CMAKE_CURRENT_SOURCE_DIR}/afm-main-
binding.export-map"
    )
    install(TARGETS afm-main-binding LIBRARY DESTINATION ${binding_dir})
else()
    message(STATUS "Not creating the binding for AFB-DAEMON")
endif()
```

Let now describe some of these lines.

```
pkg_check_modules(afb afb-daemon)
```

This first lines searches to the *pkg-config* configuration file for **afb-daemon**. Resulting data are stored in the following variables:

Variable	Meaning
afb_FOUND	Set to 1 if afb-daemon binding development files exist
afb_LIBRARIES	Only the libraries (w/o the '-l') for compiling afb-daemon bindings

Variable	Meaning
afb_LIBRARY_DIRS	The paths of the libraries (w/o the '-L') for compiling afb-daemon bindings
afb_LDFLAGS	All required linker flags for compiling afb-daemon bindings
afb_INCLUDE_DIRS	The '-I' preprocessor flags (w/o the '-I') for compiling afb-daemon bindings
afb_CFLAGS	All required cflags for compiling afb-daemon bindings

If development files are found, the binding can be added to the set of target to build.

```
add_library(afm-main-binding MODULE afm-main-binding.c)
```

This line asks to create a shared library having a single source file named afm-main-binding.c to be compiled. The default name of the created shared object is **libafm-main-binding.so**.

```
set_target_properties(afm-main-binding PROPERTIES
    PREFIX ""
    LINK_FLAGS "-Wl,--version-script=${CMAKE_CURRENT_SOURCE_DIR}/afm-main-
binding.export-map"
)
```

This lines are doing two things:

1. It renames the built library from **libafm-main-binding.so** to **afm-main-binding.so** by removing the implicitly added prefix *lib*. This step is not mandatory because afb-daemon doesn't check names of files at load time. The only filename convention used by afb-daemon relates to **.so** termination. *.so pattern is used when afb-daemon automatically discovers binding from a directory hierarchy.

2. It applies a version script at link time to only export the reserved name **afbBindingV1Register** for registration entry point. By default, when building a shared library linker exports all the public symbols (C functions that are not **static**).

Next line are:

```
target_include_directories(afm-main-binding PRIVATE ${afb_INCLUDE_DIRS})
target_link_libraries(afm-main-binding utils ${afb_LIBRARIES})
```

As you can see it uses the variables computed by ***pkg_check_modules(afb afb-daemon)*** to configure the compiler and the linker.

11.14.2. Exporting the function afbBindingV1Register

The function **afbBindingV1Register** MUST be exported. This can be achieved using a version script at link time. Here after is a version script used for *tic-tac-toe* (bindings/samples/export.map).

```
{ global: afbBindingV1Register; local: *; };
```

This sample version script exports as global the symbol *afbBindingV1Register* and hides any other symbols.

This version script is added to the link options using the option **--version-script=export.map** is given directly to the linker or using the option **-Wl,--version-script=export.map** when the option is given to the C compiler.

11.14.3. Building within yocto

Adding a dependency to afb-daemon is enough. See below:

```
DEPENDS += " afb-daemon "
```

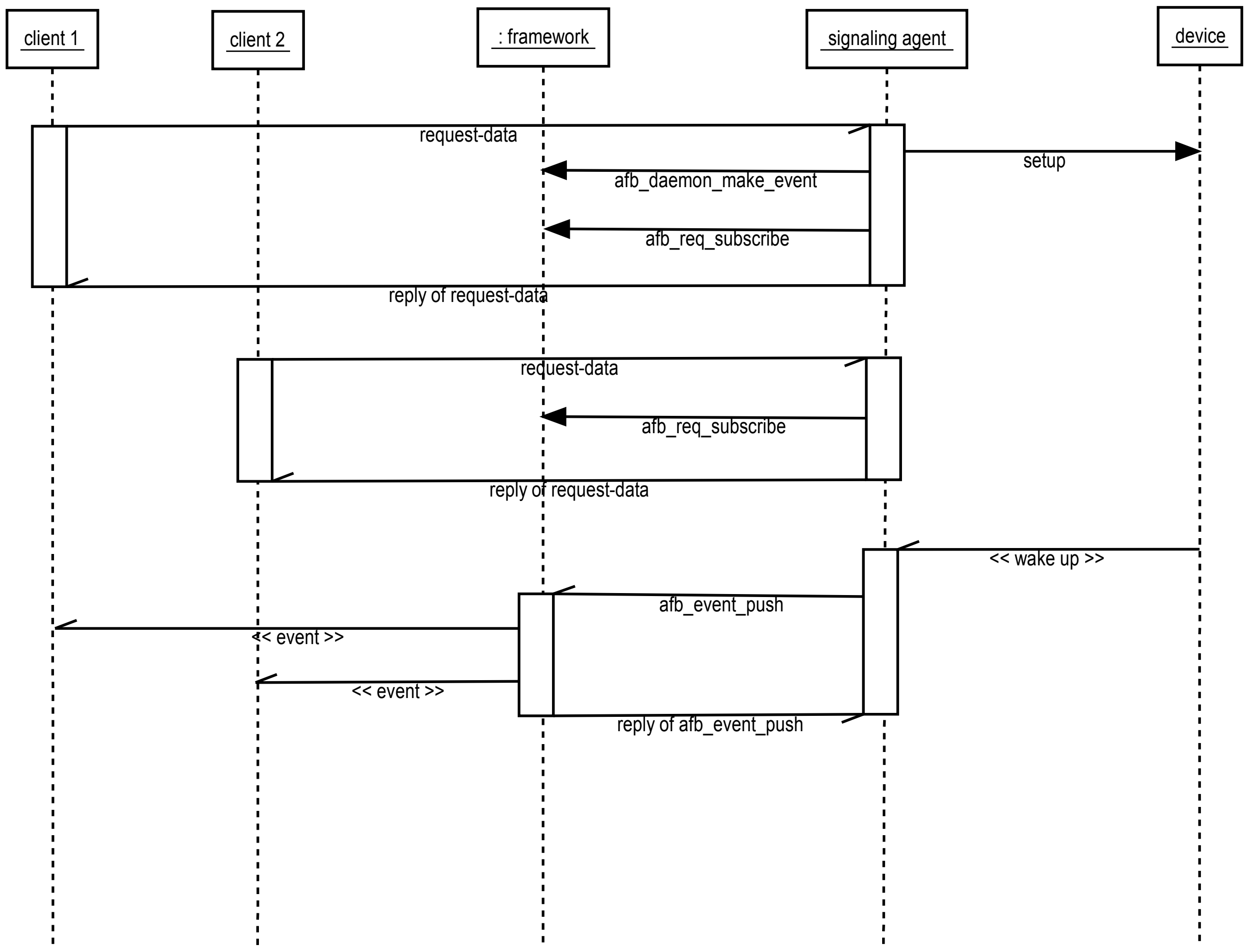
12. Guide for developing with events

Signaling agents are services that send events to any clients that subscribed for receiving it. The sent events carry any data.

To have a good understanding of how to write a signaling agent, the actions of subscribing, unsubscribing, producing, sending and receiving events must be described and explained.

12.1. Overview of events

The basis of a signaling agent is shown in the following figure:



scenario of using events

This figure shows the main role of the signaling framework for the events propagation.

For people not familiar with the framework, a signaling agent and a “binding” are similar.

12.1.1. Subscribing and unsubscribing

Subscribing is the action that makes a client able to receive data from a signaling agent. Subscription must create resources for generating the data, and for delivering the data to the client. These two aspects are not handled by the same piece of software. Generating the data is the responsibility of the developer of the signaling agent while delivering the data is handled by the framework.

When a client subscribes for data, the agent must:

1. check that the subscription request is correct;
2. establish the computation chain of the required data, if not already done;
3. create a named event for the computed data, if not already done;
4. ask the framework to establish the subscription to the event for the request;
5. optionally give indications about the event in the reply to the client.

The first two steps are not involving the framework. They are linked to the business logic of the binding. The request can be any description of the requested data and the computing stream can be of any nature, this is specific to the binding.

As said before, the framework uses and integrates **libsystemd** and its event loop. Within the framework, **libsystemd** is the standard API/library for bindings expecting to setup and handle I/O, timer or signal events.

Steps 3 and 4 are bound to the framework.

The agent must create an object for handling the propagation of produced data to its clients. That object is called “event” in the framework. An event has a name that allows clients to distinguish it from other events.

Events are created using the ***afb_daemon_make_event*** function that takes the name of the event. Example:

```
    event = afb_daemon_make_event(afb_daemon, name);
```

Once created, the event can be used either to push data to its subscribers or to broadcast data to any listener.

The event must be used to establish the subscription for the requesting client. This is done using the ***afb_req_subscribe*** function that takes the current request object and event and associates them together. Example:

```
    rc = afb_req_subscribe(afb_req, event);
```

When successful, this function make the connection between the event and the client that emitted the request. The client becomes a subscriber of the event until it unsubscribes or disconnects. The ***afb_req_subscribe*** function will fail if the client connection is weak: if the request comes from a HTTP link. To receive signals, the client must be connected. The AGL framework allows connections using WebSocket.

The name of the event is either a well known name or an ad hoc name forged for the use case.

Let's see a basic example: client A expects to receive the speed in km/h every second while client B expects the speed in mph twice a second. In that case, there are two different events because it is not the same unit and it is not the same frequency. Having two different events allows to associate clients to the correct event. But this doesn't tell any word about the name of these events. The designer of the signaling agent has two options for naming:

1. names can be the same ("speed" for example) with sent data self describing itself or having a specific tag (requiring from clients awareness about requesting both kinds of speed isn't safe).
2. names of the event include the variations (by example: "speed-km/h-1Hz" and "speed-mph-2Hz") and, in that case, sent data can self describe itself or not.

In both cases, the signaling agent might have to send the name of the event and/or an associated tag to its client in the reply of the subscription. This is part of the step 5 above.

The framework only uses the event (not its name) for subscription, unsubscription and pushing.

When the requested data is already generated and the event used for pushing it already exists, the signaling agent must not instantiate a new processing chain and must not create a new event object for pushing data. The signaling agent must reuse the existing chain and event.

Unsubscribing is made by the signaling agent on a request of its client. The ***afb_req_unsubscribe*** function tells the framework to remove the requesting client from the event's list of subscribers. Example:

```
    afb_req_unsubscribe(afb_req, event);
```

Subscription count does not matter to the framework: subscribing the same client several times has the same effect that subscribing only one time. Thus, when unsubscribing is invoked, it becomes immediately effective.

More on naming events

Within the AGL framework, a signaling agent is a binding that has an API prefix. This prefix is meant to be unique and to identify the binding API. The names of the events that this signaling agent creates are automatically prefixed by the framework, using the API prefix of the binding.

Thus, if a signaling agent of API prefix ***api*** creates an event of name ***event*** and pushes data to that event, the subscribers will receive an event of name ***api/event***.

12.1.2. Generating and pushing signals and data

This of the responsibility of the designer of the signaling agent to establish the processing chain for generating events. In many cases, this can be achieved using I/O or timer or signal events inserted in the main loop. For this case, the AGL framework uses **libsystemd** and provide a way to integrates to the main loop of this library using afb_daemon_get_event_loop. Example:

```
    sdev = afb_daemon_get_event_loop(af_daemon);
    rc = sd_event_add_io(sdev, &source, fd, EPOLLIN, myfunction, NULL);
```

In some other cases, the events are coming from D-Bus. In that case, the framework also uses **libsystemd** internally to access D-Bus. It provides two methods to get the available D-Bus objects, already existing and bound to the main**libsystemd**event loop. Use either ***afb_daemon_get_system_bus*** or ***afb_daemon_get_user_bus*** to get the required instance. Then use functions of **libsystemd** to handle D-Bus.

In some rare cases, the generation of the data requires to start a new thread.

When a data is generated and ready to be pushed, the signaling agent should call the function ***afb_event_push***. Example:

```
    rc = afb_event_push(event, JSON);
    if (rc == 0) {
        stop_generating(event);
        afb_event_drop(event);
    }
```

The function ***afb_event_push*** pushes json data to all the subscribers. It then returns the count of subscribers. When the count is zero, there is no subscriber listening for the event. The example above shows that in that case, the signaling agent stops to generate data for the event and delete the event using afb_event_drop. This is one possible option. Other valuable options are: do nothing and continue to generate and push the event or just stop to generate and push the data but keep the event existing.

12.1.3. Receiving the signals

Understanding what a client expects when it receives signals, events or data shall be the most important topic of the designer of a signaling agent. The good point here is that because JSON[1] is the exchange format, structured data can be sent in a flexible way.

The good design is to allow as much as possible the client to describe what is needed with the goal to optimize the processing to the requirements only.

1 There are two aspect in using JSON: the first is the flexible data structure that mixes common types (booleans, numbers, strings, arrays, dictionaries, nulls), the second, is the streaming specification. Streaming is often seen as the bottleneck of using JSON (see http://bjson.org). When the agent share the same process, there is no streaming at all.

12.1.4. The exceptional case of wide broadcast

Some data or events have so much importance that they can be widely broadcasted to alert any listening client. Examples of such an alert are:

- system is entering/leaving "power safe" mode
- system is shutting down
- the car starts/stops moving
- ...

An event can be broadcasted using one of the two following methods: ***afb_daemon_broadcast_event*** or ***afb_event_broadcast***.

Example 1:

```
    afb_daemon_broadcast_event(afb_daemon, name, json);
```

Example 2:

```
    event = afb_daemon_make_event(afb_daemon, name);
    . . . .
    afb_event_broadcast(event, json);
```

As for other events, the name of events broadcasted using ***afb_daemon_broadcast_event*** are automatically prefixed by the framework with API prefix of the binding (signaling agent).

12.2. Reference of functions

12.2.1. Function afb_event afb_daemon_make_event

The function ***afb_daemon_make_event*** that is defined as below:

```
/*
 * Creates an event of 'name' and returns it.
 * 'daemon' MUST be the daemon given in interface when activating the binding.
 */
struct afb_event afb_daemon_make_event(struct afb_daemon daemon, const char
*name);
```

The daemon is the handler to the application framework binder daemon received during initialisation steps of the binding.

Calling the function ***afb_daemon_make_event*** within the initialisation function ***afbBindingV1Register*** will *fail* because the binding name is not known at this time.

The correct way to create the event at initialisation is to call the function ***afb_daemon_make_event*** within the initialisation function ***afbBindingV1ServiceInit***.

12.2.2. Function afb_event_push

The function ***afb_event_push*** is defined as below:

```
/*
 * Pushes the 'event' with the data 'object' to its observers.
 * 'object' can be NULL.
 *
 * For convenience, the function calls 'json_object_put' for object'.
 * Thus, in the case where 'object' should remain available after
 * the function returns, the function 'json_object_get' shall be used.
 *
 * Returns the count of clients that received the event.
 */
int afb_event_push(struct afb_event event, struct json_object *object);
```

As the function ***afb_event_push*** returns 0 when there is no more subscriber, a binding can remove such unexpected event using the function ***afb_event_drop***.

12.2.3. Function afb_event_drop

The function ***afb_event_drop*** is defined as below:

```
/*
 * Drops the data associated to the event
 * After calling this function, the event
 * MUST NOT BE USED ANYMORE.
 */
void afb_event_drop(struct afb_event event);
```

12.2.4. Function afb_req_subscribe

The function ***afb_req_subscribe*** is defined as below:

```
/*
 * Establishes for the client link identified by 'req' a subscription
 * to the 'event'.
 * Returns 0 in case of successful subscription or -1 in case of error.
 */
int afb_req_subscribe(struct afb_req req, struct afb_event event);
```

The subscription adds the client of the request to the list of subscribers to the event.

12.2.5. Function afb_req_unsubscribe

The function ***afb_req_unsubscribe*** is defined as below:

```
/*
 * Revokes the subscription established to the 'event' for the client
 * link identified by 'req'.
 * Returns 0 in case of successful unsubscription or -1 in case of error.
 */
int afb_req_unsubscribe(struct afb_req req, struct afb_event event);
```

The unsubscription removes the client of the request of the list of subscribers to the event. When the list of subscribers to the event becomes empty, the function ***afb_event_push*** will return zero.

12.2.6. Function afb_event_broadcast

The function ***afb_event_broadcast*** is defined as below:

```
/*
 * Broadcasts widely the 'event' with the data 'object'.
 * 'object' can be NULL.
 *
 * For convenience, the function calls 'json_object_put' for 'object'.
 * Thus, in the case where 'object' should remain available after
 * the function returns, the function 'json_object_get' shall be used.
 *
 * Returns the count of clients that received the event.
 */
int afb_event_broadcast(struct afb_event event, struct json_object *object);
```

This uses an existing event (created with ***afb_daemon_make_event***) for broadcasting an event having its name.

12.2.7. Function afb_daemon_broadcast_event

The function ***afb_daemon_broadcast_event*** is defined as below:

```
/*
 * Broadcasts widely the event of 'name' with the data 'object'.
 * 'object' can be NULL.
 * 'daemon' MUST be the daemon given in interface when activating the binding.
 *
 * For convenience, the function calls 'json_object_put' for 'object'.
 * Thus, in the case where 'object' should remain available after
 * the function returns, the function 'json_object_get' shall be used.
 *
 * Returns the count of clients that received the event.
 */
int afb_daemon_broadcast_event(struct afb_daemon daemon, const char *name,
struct json_object *object);
```

The name is given here explicitly. The name is automatically prefixed with the name of the binding. For example, a binding of prefix "xxx" would broadcat the event "xxx/name".

12.2.8. Function afbBindingV1ServiceEvent

Binding can implement function **afbBindingV1ServiceEvent** which will be called when an event is broadcasted or if service subscribed to an event. That allow a service to react to an event and do what it is to do if this is relevant for it (ie: car back camera detects imminent collision and broadcast it, then appropriate service enable parking brake.). Here is the **afbBindingV1ServiceEvent** definition:

```
/*
 * When a binding have an implementation of the function
'afbBindingV1ServiceEvent',
 * defined below, the framework calls that function for any broadcasted event
or for
 * events that the service subscribed to in its name.
 *
 * It receive the 'event' name and its related data in 'object' (be aware that
'object'
 * might be NULL).
 */
extern void afbBindingV1ServiceEvent(const char *event, struct json_object
*object);

The binding *tic-tac-toe* broadcasts events when the board changes.
This is done in the function **changed**:
```

12.3. Architectural digressions

Based on their dependencies to hardware, signaling agents can be split into 2 categories: low-level signaling agents and high-level signaling agents.

Low-level signaling agents are bound to the hardware and focused on interfacing and driving.

High-level signaling agent are independent of the hardware and focused on providing service.

This separation (that may in the corner look artificial) aim to help in the systems design. The main idea here is that high-level signaling agents are providing "business logic", also known as "application logic", that is proper to the car industry and that can be reused and that can evolve as a foundation for the future of the industry.

The implementation of this decomposition may follow 2 paths: strict separation or soft composition.

12.3.1. Strict separation

The strict separation implements the modularity composition of signaling agent through the framework. The high-level signaling agent subscribes to the low level signaling agent using the standard client API.

Advantages:

- Modularity
- Separation of responsibilities
- Possible aggregation of multiple sources
- Soft binding of agent good for maintenance

Drawbacks:

- Cost of propagation of data (might serialize)
- Difficulties to abstract low-level signaling agent or to find a trade-off between abstracting and specializing

The key is modularity versus cost of propagation. It can be partly solved when logical group of signaling agent are launched together in the same binder process. In that particular case, the cost of propagation of data between agents is reduced[2] because

2 Within the same process, there is not serialization, the propagation has the cost of wrapping a json data and calling callbacks with the benefit of having a powerful callback

there is no serialization.

This reduction of the propagation cost (and of the resources used) precludes implementation of strong security between the agents because they share the same memory.

12.3.2. Soft composition

The soft composition implements the business logic of high-level signaling agents as libraries that can then be used directly by the low level signaling agents.

Advantages:

- No propagation: same memory, sharing of native structures

Drawbacks:

- Cannot be used for aggregation of several sources
- Difficulties to abstract low-level signaling agent or to find a trade-off between abstracting and specializing
- Source code binding not good for maintenance

manager: the event mechanism of the framework.

13. Overview of tests shipped with AFB-Daemon

13.1. List of tests

Here are the tests shipped in the source tree:

- **afb-client-demo** (command-line WebSockets)
- **token-websock.qml** (Qt/QML WebSockets)
- ***.html** (HTML5/JS HTTP-REST & WebSockets)

13.2. Detail of tests

13.2.1. afb-client-demo (command-line WebSockets)

This clients interactively calls bindings APIs from the command line, using the binder WebSockets facility.

If *afb-daemon* has been launched with the following parameters:

```
$ afb-daemon --port=1234 --token=123456 [...]
```

Then run the client with :

```
afb-client-demo ws://localhost:1234/api?token=123456 [<api> <verb> [<json-
data>]]
```

For instance, to initialize the Audio binding from the command line :

```
afb-client-demo ws://localhost:1234/api?token=123456
```

The command doesn't return. You should type requests of type []. So, try:

```
auth connect
hello pingjson true
```

13.2.2. token-websock.qml (Qt/QML WebSockets)

If *afb-daemon* has been launched with the following parameters:

```
$ afb-daemon --port=1234 --token=123456 [...]
```

and Qt5 is installed.

For installing Qt5 on **Ubuntu 16.04**:

```
$ apt-get install qmlscene qml-module-qtwebsockets qml-module-qtquick-controls
```

For installing Qt5 on **Fedora >= 22** :

```
$ dnf install qt5-qtdeclarative-devel qt5-qtwebsockets-devel qt5-
qtquickcontrols
```

Then run the client with :

```
qmlscene test/token-websock.qml
```

and interactively press the buttons, "Connect", "Refresh", "Logout".

13.2.3. *.html (HTML5/JS HTTP-REST & WebSockets)

If *afb-daemon* has been launched with the following parameters:

```
$ afb-daemon --port=1234 --rootdir=$PWD/test [...]
```

("$PWD/test" being the "test" subdirectory of the source tree)_

Then open your preferred Web browser, connect to the following URL:

```
http://localhost:1234
```

and interactively run the various tests.

14. Vocabulary for AFB-DAEMON

14.1. Binding

A shared library object intended to add a functionality to an afb-daemon instance. It implements an API and may provide a service.

Binding made for services can have specific entry point called after initialisation and before serving.

14.2. Event

Message with data propagated from the services to the client and not expecting any reply.

The current implementation allows to widely broadcast events to all clients.

14.3. Level of assurance (LOA)

This level that can be from 0 to 3 represent the level of assurance that the services can expect from the session.

The exact definition of the meaning of these levels and how to use it remains to be achieved.

14.4. Plugin

Old name for binding, see binding.

14.5. Request

A request is an invocation by a client to a binding method using a message transferred through some protocol: HTTP, WebSocket, DBUS... and served by ***afb-daemon***

14.6. Reply/Response

This is a message sent to client as the result of the request.

14.7. Service

Service are made of bindings running by their side on their binder. It can serve many client. Each one attached to one session.

The framework establishes connection between the services and the clients. Using DBus currently but other protocols are considered.

14.8. Session

A session is meant to be the unique instance context of a client, which identify that instance across requests.

Each session has an identifier. Session identifier generated by afb-daemon are UUIDs.

Internally, afb-daemon offers a mechanism to attach data to sessions. When the session is closed or disappears, the data attached to that session are freed.

14.9. Token

The token is an identifier that the client must give to be authenticated.

At start, afb-daemon get an initial token. This initial token must be presented by incoming client to be authenticated.

A token is valid only for a period.

The token must be renewed periodically. When the token is renewed, afb-daemon sends the new token to the client.

Tokens generated by afb-daemon are UUIDs.

14.10. UUID

It stand for Universal Unique IDentifier.

It is designed to create identifier in a way that avoid has much as possible conflicts. It means that if two different instances create an UUID, the probability that they create the same UUID is very low, near to zero.

14.11. x-afb-reqid

Argument name that can be used with HTTP request. When this argument is given, it is automatically added to the "request" object of the answer.

14.12. x-afb-token

Argument name meant to give the token without ambiguity. You can also use the name **token** but it may conflicts with others arguments.

14.13. x-afb-uuid

Argument name for giving explicitly the session identifier without ambiguity. You can also use the name **uuid** but it may conflicts with others arguments.