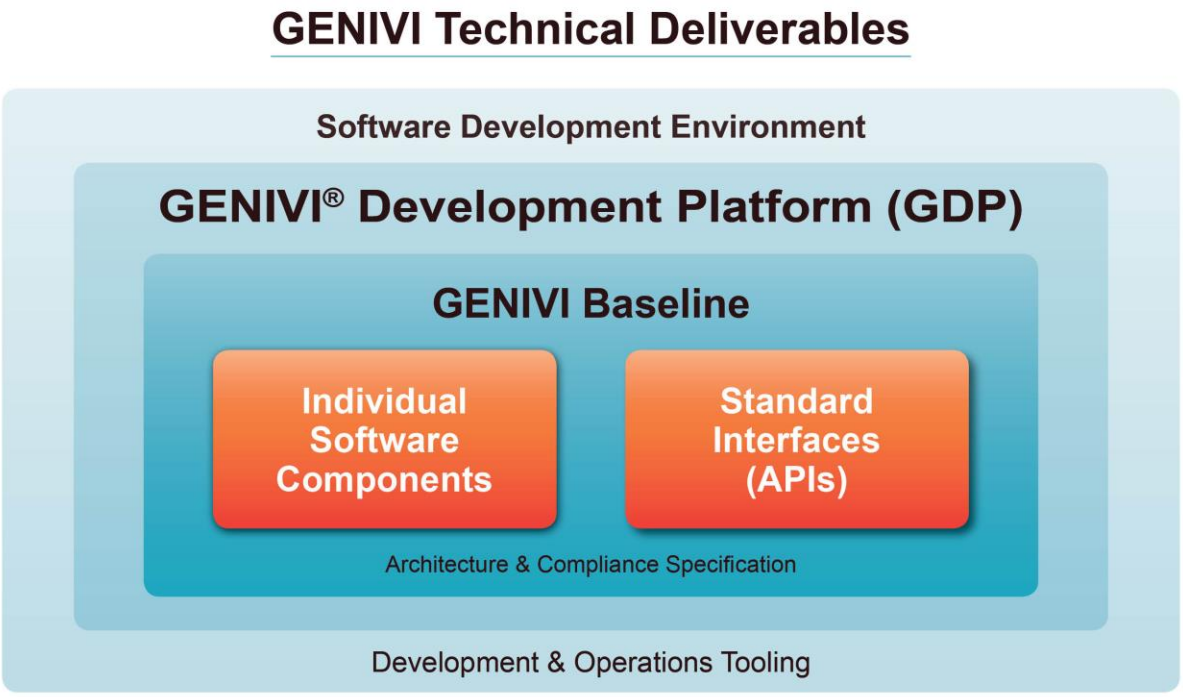
Technical Resource Kit

Introduction

The GENIVI Technical Resource Kit offers the best access to all great technical deliveries provided by GENIVI. The kit is intended to guide you in your journey with GENIVI and help you understand **what is available**, **what for**, **where you can find it** and **how you can use it**.



GENIVI Alliance delivers a set of documents and code modules that allow you to easily build your In- Vehicle Infotainment solution. These deliverables are detailed in following chapters:

- 1. GENIVI Development Platform (GDP)
- 2. Reference Architecture and Compliance Specification
- 3. GENIVI Baseline
- 4. GENIVI Components and Interfaces (API)
- 5. Get Familiar with GENIVI Tools
- Appendix 1: Understand Open Source SW Development Model
- Appendix 2: GENIVI Roadmap
- Appendix 3: A Look at GENIVI Architecture

Several types of companies can benefit from the GENIVI Technical Resource Kit.

If you are an automaker or a tier one supplier to automakers, you can use:

- To evaluate technologies
- To build a platform basis for a serial product; your development will be much faster and cheaper thanks to the great amount of existing code maintained by the community

If you are a software company, you can use:

- To demonstrate an integration of your software products in a GENIVI environment
- To get the “Works with GENIVI(r)” branding
- To build a platform basis for a serial product that you intend to deliver to an Automaker or to a Tier one supplier

If you are silicon vendor or hardware company, you can use:

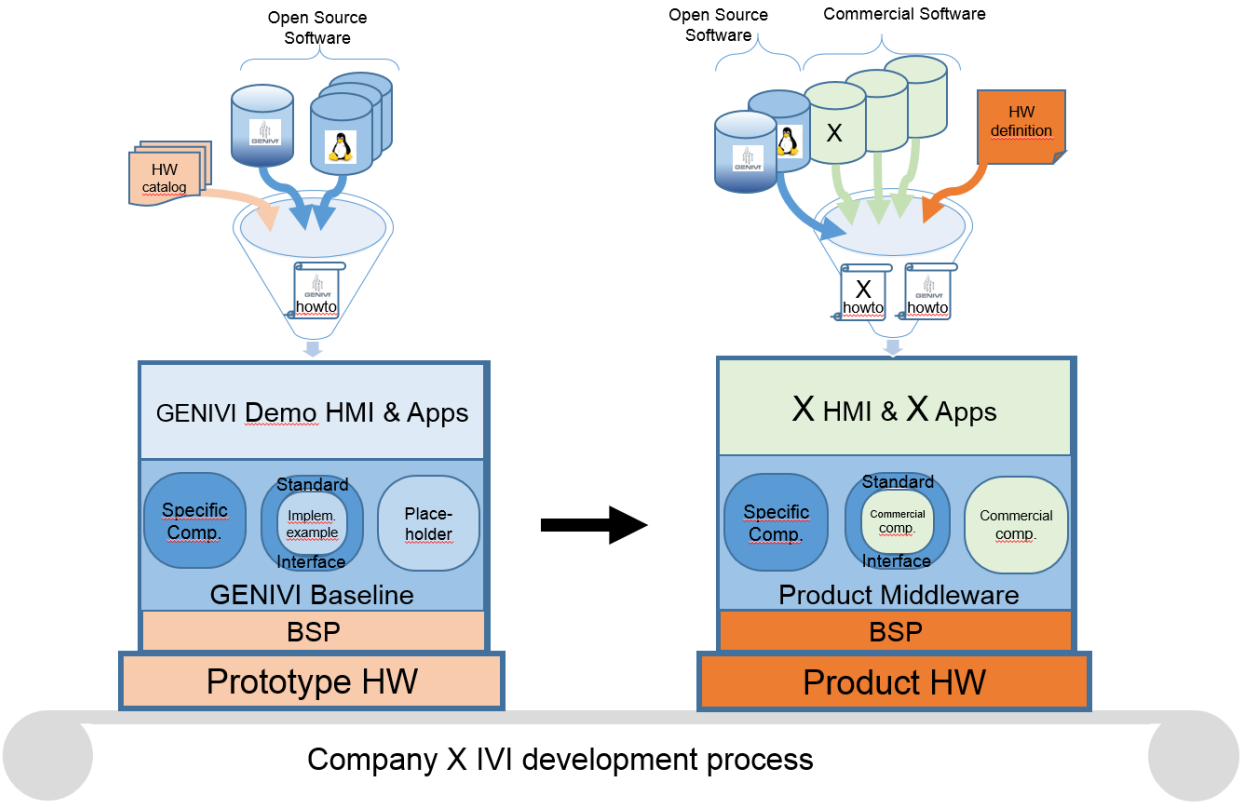
- To demonstrate that a GENIVI stack runs on your hardware
- To demonstrate the performance of your hardware when running a GENIVI stack
- To get your hardware promoted on GENIVI website

Different individual profiles will use the GENIVI Technical Resource Kit in different ways. We will consider two categories in the following chapters: managers – developers.

This icon indicates areas that will go deeper into technical details and will be of great interest to developers but managers may prefer to skip.

IVI Development Process Using GENIVI

To begin your experience with all that GENIVI delivers, we will start with the GENIVI Demo Platform (GDP) in the first chapter and then guide you along the details that will help you to build your IVI solution and customize it to your needs. The Technical Resource Kit will help you understand how a GENIVI "tool box" consisting of many different tools can bring efficiency in the IVI development process.



1. GENIVI Development Platform (GDP)

Rationale

The GENIVI Development Platform (GDP) is the industry standard platform for In-Vehicle Infotainment (IVI) systems and connected car concepts, demonstrations and innovation projects using open source and Linux. GDP is also a default starting point for numerous IVI production programs based on Linux. It contains a compliant GENIVI middleware platform widely used by major OEMs and Tier 1s.

The GDP has three main goals:

- Deliver a system developers can use to create software components for automotive
- A platform focused on automotive use cases to enable developers to create applications and demos targeting the industry
- A starter kit that can be downloaded and customized for different hardware focused in automotive use cases

Value

Depending on whether you are rapidly prototyping IVI solutions or need a near-product-ready starting point for a commercial product or IVI program, the GDP is a great tool for reaching your goals. A fully functioning GDP proves that GENIVI component choices can work together and is an available reference for developers to integrate, test, and build their own IVI modules, applications, and connected car solutions.

Contributing to the GENIVI Development Platform

The GENIVI Development Platform is a public GENIVI OSS project, developed in the open so any individual is welcome to contribute. To learn more on how to contribute, please see the GDP Wiki page.

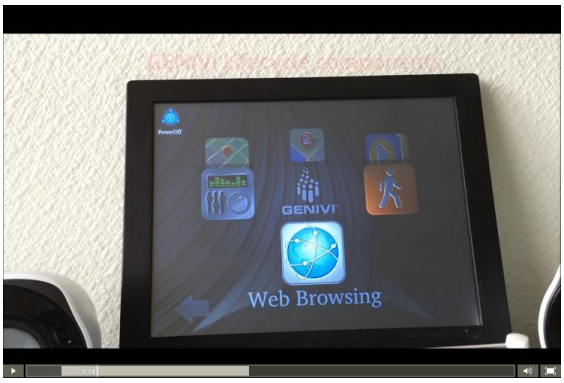
GDP Delivery

In order to follow the activity of the current GDP delivery team, visit the GDP Wiki page to learn more about the resources you may utilize.

See the Demo

It is important to understand that the GENIVI community is developing and delivering the GDP iteratively. That means that certain functional pieces of the platform are yet to be integrated and fully tested. We welcome your help in identifying gaps and helping to close them with contributed, open source software either produced by you or available in upstream projects. In some ways, the GDP is a tool box that you can use to build your own IVI and connected car solution. Along your journey in GENIVI, you will have to choose your path depending on your needs and preferences. And this is the case with the GDP in that there are several possible variants of GDP (a variant being a combination of target hardware, a software baseline, and demo applications).

One variant is presented in the following video:



GDP explained by Steve Crumb:

Selecting Hardware

To configure your demo you have to choose from bottom to top a target hardware and the Demo Apps you want to integrate.

Demo Apps	Remote Vehicle Interaction Audio Manager Monitor Web Browser PoC 3D Navigation rendering Fuel Stop Advisor			
App & HMI Framework	Qt / HTML / Android Auto / SDL			
Yocto Baseline	version TBD	**meta-ivi 12**	**meta-ivi 12**	**meta-ivi 12**
Hardware	Intel Based Minnowboard MAX	PC Emulation Qemu x86-64	Renesas RCar M3	Raspberry Pi 2 and 3

A current list of boards supported can be found here.

Build Your Own Demo

The instructions to build a demo can be found on the GDP Wiki pages.

GDP Wiki Pages

- GDP FAQ
- GDP Master
- GDP Download page
- GDP releases
- GDP in detail.
- GDP Out There
- GDP Status Reports
- How-to articles
- GDP Spins
- GDP Software Development Environment (SDE)
- GDP 11
- Hackfest proposals
- GDP 12
- GDP Scrum process
- GDP Contribution Process
- GDP generic Definition of Done (DoD)
- GDP/meeting-minutes
- Naming strategy for bitbake extension layers
- GDP Tools and Project Organization

2. Reference Architecture and Compliance Specification

Rationale

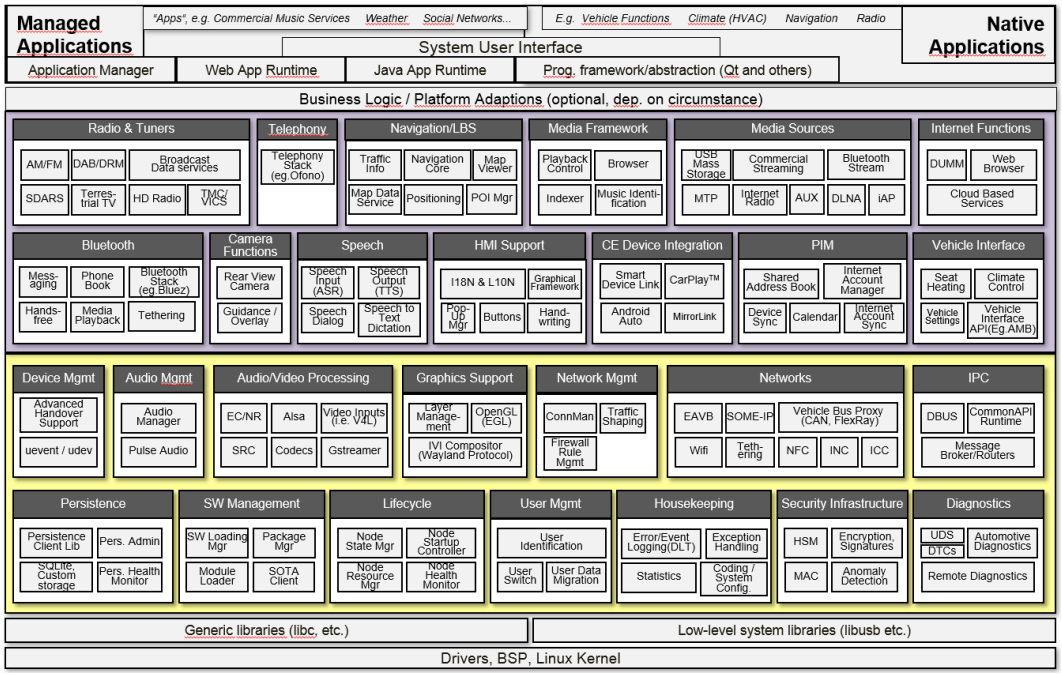
GENIVI builds its reusable, IVI platform based on a flexible but standard Reference Architecture. This Reference Architecture serves as a blueprint for building a full IVI solution and it also shows the primary target functional areas of the work from GENIVI. The Compliance Specification steers the standardization, specifying exactly what is expected in the architecture implementation to build a GENIVI Compliant(r) solution.

Value

This common description allows you to use trusted open source components when building an Infotainment solution. The architecture also helps to avoid fragmentation on non-competitive areas of the software design. Members using the Compliance Specification to build a solution can register their product under the GENIVI compliance program and obtain a license to use the GENIVI Compliant(r) trademark in their solution marketing materials. This branding will give buyers confidence that the solution adheres to GENIVI standards and to the component choices that ease integration and extension of the solution.

Architecture Overview

GENIVI does not deliver a given design but a tool box that will let you make choices. In order to have a common understanding of the pieces in the box with a high level view of their role, a reference Block Diagram has been drawn.

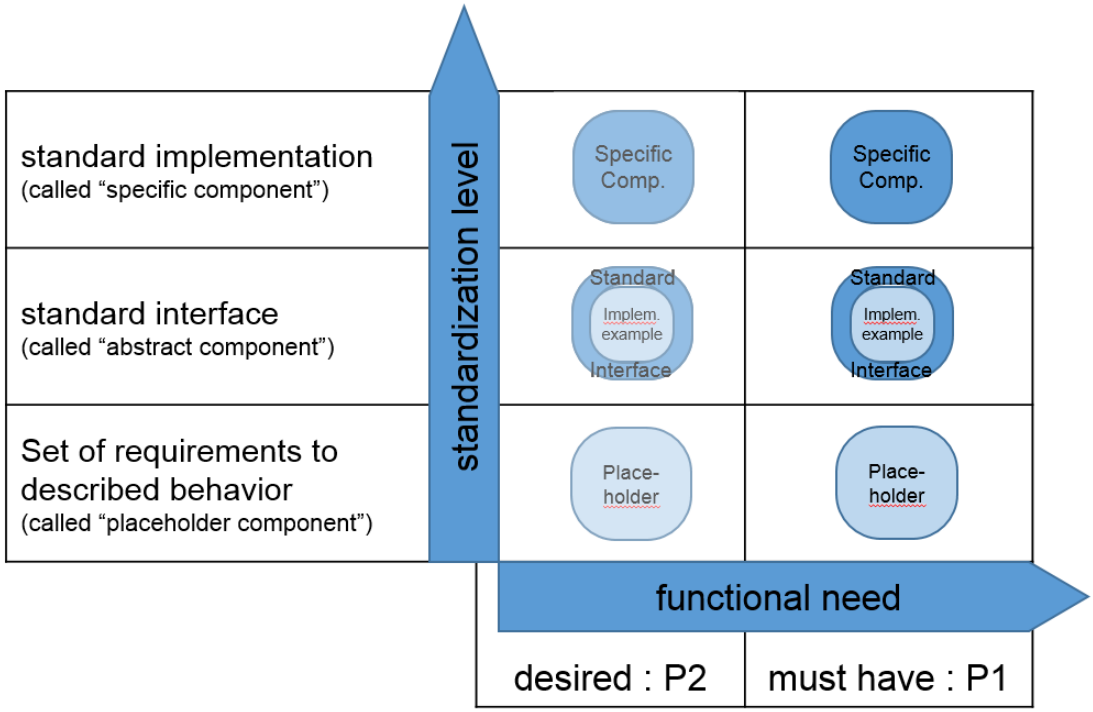


- GENIVI focus is on the “middleware” represented here by the yellow and the purple layers.
- The yellow layer deals with key infrastructure domains. The smaller blocks map to individual software components, that are available in the open source community, some of them being developed in GENIVI open source projects.

- In the purple layer above, the smaller blocks represent functional domains that may need several software components to be addressed, part of the software components needed may be commercial software components.

GENIVI Compliance Specification

GENIVI compliance specification defines requirements on the middleware. The content of the Compliance Specification document can be seen as a list of software components that are described in different ways depending on their importance in the system built and the level of standardization that GENIVI wants to achieve in the area.



Thanks to the compliance specification mechanism, GENIVI can steer standardization level to maximize reuse where it is worth and let freedom where competition brings more value. The use of P2 level let some flexibility both on features content (i.e., navigation interfaces are P2 as they would not be needed in a radio) and on standard enforcement (where the community is not ready to decide a unique standard), the use of P1 level leads to a strict standardization of either code, interfaces or requirements.

Companies can show their commitment to the standard through GENIVI Compliance programs.

- "GENIVI Compliant" branding for platforms or products
- "Works with GENIVI" branding for pieces of code

Learn more about these programs on http://www.genivi.org/genivi-compliance-program

How does the compliance specification cover the architecture block diagram?

GENIVI target has been defined and work is still in progress in several areas.

The detailed status is available in the documents listed in the next section. An overview on how GENIVI defines its roadmap is also given in the appendix 2 "GENIVI Roadmap".

More details on Architecture and Compliance Specification

You can get a description of each domain of the block diagram in Appendix 3.

A static high level block diagram is not enough to describe an architecture. Developers need to understand deeper the data structures used and communication between the components.

Detailed Architecture and Compliance Specification are part of the members' benefits. If your company is not a member yet you can find member benefits at http://genivi.org/join.

Promote these benefits in your company and join us!

Full Reference Architecture Document

Compliance Specification

Foreseen Target for Compliance Specification

GENIVI UML Model

3. GENIVI Baseline

Rationale

Architecture description and compliance specification are documents and not code. In order to be sure that what has been written in these documents really works, the first verification step is to confirm that one can build and run an In-Vehicle Infotainment software stack that complies with these documents.

Value

The baseline proves the compliance specification consistency and can constitute a starting base to prototype and design a product. It is used in the GENIVI Development Platform.

Description

What is a GENIVI baseline?

A GENIVI "baseline" is an integrated, installable image of GENIVI components and their dependencies based on a time-based snapshot of a version of the GENIVI compliance specification. A GENIVI baseline contains about 150 components, each of which performs different functionality. A GENIVI baseline is not to be considered production-ready with respect to performance or functionality. The baseline image, when coupled with hardware, can be a starting point for developers who wish to create and test software in a GENIVI context.

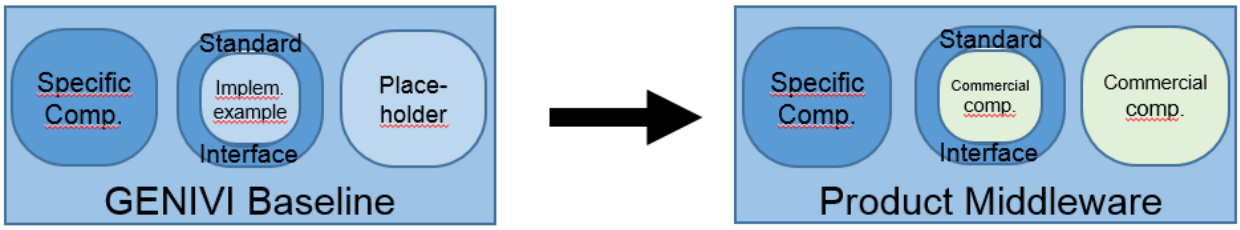
Synchronously with each compliance specification release (that is to say twice a year in April-May and October), the Baselines Integration Team (BIT) of GENIVI proposes the Yocto baseline proved to run on a Personal Computer simulation (Qemu environment) and respecting GENIVI compliance specification.

Baseline Project

The Yocto Baseline is shared in Open Source Projects and uses built environments that are open and maintained by the open source community. Details on the Yocto Baseline can be found through the following link:

- Yocto Baseline (**meta-ivi)**

Automakers, their tier 1 suppliers, software companies propose other builds that are GENIVI compliant as well, and become other proof points for GENIVI compliance specification quality.



4. GENIVI Components and Interfaces (API)

Rationale

GENIVI launches and manages Open Source Projects for automotive software components. Generally, GENIVI prefers to work in existing, upstream projects, but in many cases, the required automotive software is not yet available in other open source communities. GENIVI fills this gap in the automotive software ecosystem by hosting open code development projects for this automotive software.

Value

GENIVI components are standard implementations used in all GENIVI Compliant builds. The burden to define and maintain these components is shared by a community of adopting companies. As this software is used by multiple adopters, the quality of the software improves as bugs are found and fixed by those adopting companies.

Description

In the table below, the links to GENIVI Open Source Projects for Components and Interfaces are presented. The blocks are consistent with the architecture block diagram shown earlier. You may navigate to these projects through the links below or use the GENIVI Open Source projects main page.

If you have any questions about GENIVI Open Source Projects, you can look at the community office page or send an email to the community manager.

Radio & Tuners

IVI Radio

IVI Navigation

IVI_Positioning

IVI_NavigationandMapViewer

IVI_POIService

Media Manager

Media Control

Media Indexer

Media Browser

Internet functions

Web browser PoC

IVI Speech

Speech Output Service

Speech Input Service

Speech Dialog Service

CE Device Integration

Smart Device Link

Vehicle Interface

Vehicle Web API

Driver Workload Assessor

Audio Management

Audio Manager

Graphic support

IVI Layer Management

Wayland IVI Extension

IPC

Common API Runtime

Persistence

Persistence Client Libr.

Persistence Admin. Service

Lifecycle

Node state Manager

Node Startup Controller

Node Health Monitor

Housekeeping

Diagnostic Log and Trace

5. Get Familiar with GENIVI Tools

Rationale

GENIVI uses a community-based development methodology which is common among open source developers. Common tooling is needed to bring consistency in the code delivered by developers from many different companies.

Value

GENIVI tools help developers be more productive in a community-based development environment. GENIVI tooling also simplifies the coding of interfaces through interface generation and translation.

Description

The section about tools will be of real interest for developers who want to contribute to GENIVI Open Source Projects.

Some Open Source tools were created and are maintained by GENIVI.

Franca is a tool for defining and transforming software interfaces. It provides a standard way to document interfaces which is programming-language agnostic. It is widely used in GENIVI.

CommonAPI C++ is a C++ framework for interprocess and network communication. The basic objective is not to provide a new mechanism for interprocess or network communication (IPC), but to define a high-level C ++ API, which can be used for different mechanisms.

YAMAICA **Y**et **A**nother **M**odel **A**nd **I**nterface **C**onversion **A**pplication, is a collection of Eclipse features which implement transformations between different interface description languages, editors and code generators.

IoNAS is a proof of concept to show that from an Franca interface description, you can generate .arxml AUTOSAR RTE descriptions as well as CommonAPI. Linux-Programs can communicate with AUTOSAR-Applications.

The GDP Software Development Environment is a self-contained development environment designed to get you started with developing with GDP. It includes an SDK and two IDEs for developing and deploying system services and graphical applications.

GENIVI also uses existing Open Source and commercial tools. The complete view can be found on GENIVI Tooling main page here.

Appendix 1: Understand Open Source SW Development Model

Rationale

Open Source development model is very powerful but needs to be well understood and properly deployed in your company.

Value

This section will explain best practices of planning for, deploying, and managing open source software in your company.

Description

Why is it important to contribute?

An open source ecosystem is based upon a win-win development model.

Automakers know very well that sharing the load of development with partners who are also their competitors is a sound business practice. They do this through one to one contracts on car models, platforms or engines. These contracts precisely define the roles and responsibilities of both parties and what they get from the cooperation.

What's new in open source software model is that the win-win situation is not "contracted" in the same way. Open source licenses define some rules (see next section) but the development is based upon the good will of the many partners involved.

The biggest temptation of the open source model is to take useful software but not give back bug fixes or software your company has developed. You could get the benefits but no one else benefits from your work. But this approach is short-sighted and not as beneficial as it may seem. If you take a software component from an open project (called branching) and then you keep your modifications and improvements for your own, then you will have to maintain that branched software for decades. On the other hand, if you push your proposals of improvements to the community (called "upstreaming") and they get accepted, the code you wrote will be tested and improved by other engineers for free.

This open source ecosystem approach has proved its efficiency in several industries. But one should not neglect the need to change the cultural mindset when deploying open source in a company, plus the need to adapt some processes to this new way of development.

IVI Serial development projects are big machines involving hundreds of people and multiple companies over years. Organization, contracts, work breakdown structure are key entry data of development process that will guide behaviors of all parties along the project. These entry documents are prepared during the RFQ process when an OEM starts discussions with suppliers. People do not start from a blank sheet of paper to prepare these documents but use references that they have in their company. If we want to get the expected "upstream attitude" during development, the root document that describes how projects run needs to be updated accordingly. It is best that this root document is prepared before RFQ process. It needs to be confirmed in the organization description in the contracts all parties sign. The work breakdown structure needs to list such upstreaming activities so that the resource plan is defined accordingly.

During development, resource managers have to fight with daily difficulties; pushing bug fixes and enhancements into upstream projects cannot be their first priority. Managers will not allocate time to this important activity unless it is a standard established at the start of the program. The program management should make it clear that contributing back to upstream projects is a rock-solid standard in the company.

The key message to conclude: **if you want to make your Open Source projects sustainable, make sure your company is organized to contribute.**

License Management

Open Source code may be free but it not free from obligations on the usage and distribution of the code. When the author of the code, who owns the copyright and any other intellectual property rights associated with the code, chooses to attach an Open Source license to his code, he has defined those obligations to anyone who uses the code.

Hundreds of Open Sources licenses exist, with a large variety of obligations to fulfill. For example, simple licenses mention the name of the author and give access to the Source Code by the final customer. Others add more obligations such as letting the final customer modify a product based on the code. The licenses also define the rules when some piece of code is modified : can it become commercial, should it remain Open Source code? There are also some tricky rules about code integration and some licenses may "propagate" to code into which it is integrated.

The important message is not to be frightened, but to realize that license compliance must be managed. GENIVI is not only a good example of sound license compliance management, but many of its members can help an organization plan for the open source processes that are essential to using and distributing open source software in a company's products. GENIVI has defined its own process to deal with compliance and has worked with Tier one suppliers to understand their difficulties and fears on this topic. GENIVI has defined its own licensing policy and works with preferred licenses. The License Review Team manages the licensing and legal activities of the alliance and is chartered to ensure that the technical work of the alliance is founded on legally sound approaches that are acceptable to the membership of the alliance and to the broader open source community.

During some GENIVI All Member Meetings, GENIVI will give a primer on how to work with open source software. Organizations like the Linux Foundation deliver courses on Open Source License Compliance. And GENIVI also has recommended partners who can also equip organizations with processes and tools to help establish license compliance.

GENIVI networking in the Open Source community is also very useful. GENIVI in the past could alert members that compliance issues were raised on a product and help solve these.

Appendix 2: GENIVI Roadmap

Rationale

It is important to understand GENIVI momentum and not only understand what GENIVI is but also foresee what GENIVI will be in the next months or years.

Value

Get a detailed view on where the standardization and code production will occur in the next releases.

Description

GENIVI Releases

GENIVI uses a time-boxed approach to development. A new release appears every 6 months and coincides with All Member Meeting events. The releases have code names that are ordered alphabetically. The names have a spaceship- or astronomy-related theme.

Apr 2016 - Compliance Release **10.0** - Baseline Release **LEVIATHAN** -

Oct 2016 - Compliance Release **11.0** - Baseline Release **MIRANDA** -

Apr 2017 - Compliance Release **12.0** - Baseline Release **NOSTROMO** -

Oct 2017 - Compliance Release **13.0** - Baseline Release **QUASAR** -

Apr 2018 - Compliance Release **14.0** - Baseline Release **PULSAR** -

The baselines versions when released get available in GENIVI Open Source Projects -- Yocto Baseline.

Future Content Roadmap

GENIVI offers a toolbox which allows to accelerate and simplify development of Infotainment systems through standardization and reuse of code components. This toolbox is not complete and also needs to address a moving target. To define its roadmap GENIVI uses multiple entries:

- Lessons learned from serial product developments allow to identify gaps and holes
- Member companies involved in expert groups raise new topics that they would address anyway for themselves and that they prefer to share with the community
- Board members drive the strategic trends of GENIVI scope

These entries are shared between Expert Groups and Project Management Office, then each Expert Group defines its Roadmap in its domain. If you need more background on GENIVI organization you can get the information here: *http://www.genivi.org/how-genivi-works*, *http://projects.genivi.org/*.

A detailed roadmap on each component is available in the Compliance Specification document which is part of the member benefits. If your company is not a member and you would like to learn about member benefits, please visit http://genivi.org/join. Promote these benefits in your company and join us!

GENIVI Platform Compliance Specification (members-only document).

Appendix 3: A Look at GENIVI Architecture

Rationale

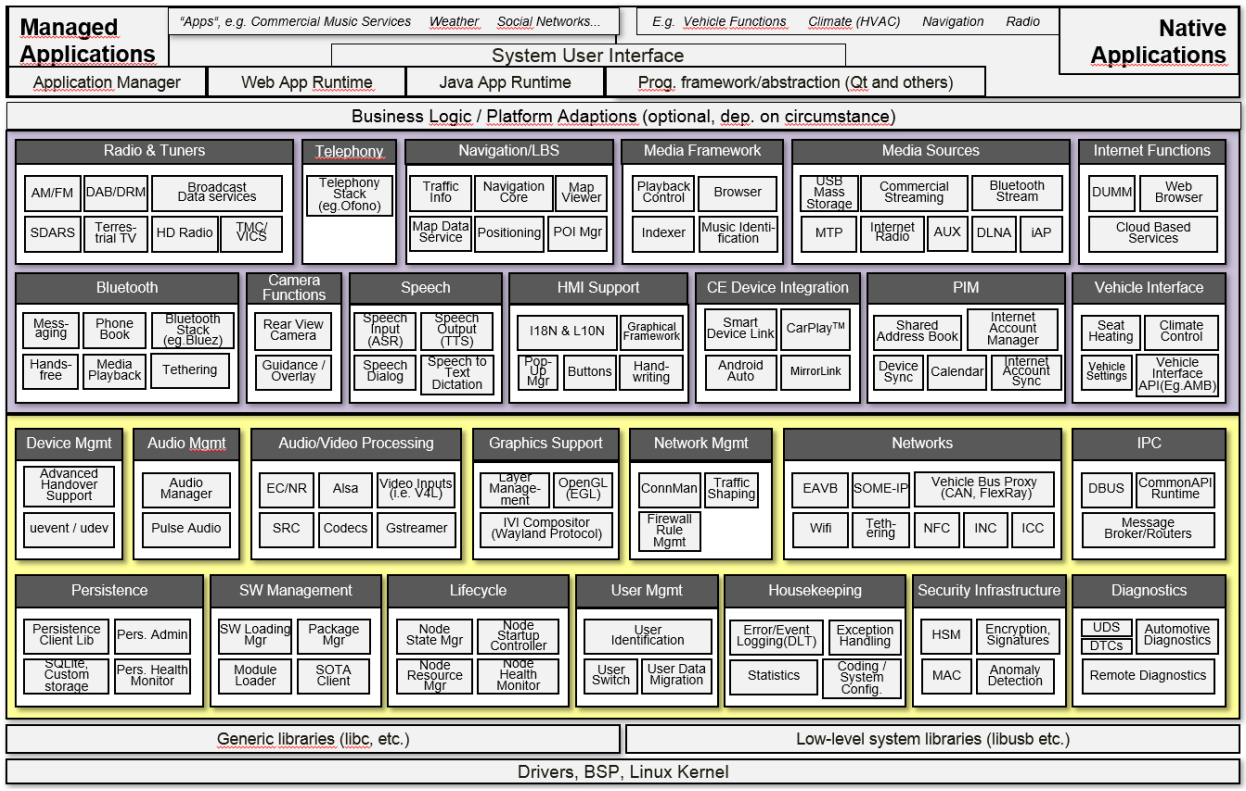
This appendix provides a brief introduction to each areas (domain) included in the scope of the reference architecture block diagram.

Value

The description will help developers to better what component is in which domain and thus avoid misunderstanding and confusion.

Description

The domain areas are defined mostly per *function* area.



Persistence

The Persistence Management subsystem is responsible for providing a shared solution to persistent data storage. Persistent data includes all data that is dynamically changed but needs to be stored on a head unit between restarts. It includes for example the state of user parameters when the system shuts down (what media is on, sound level and balance, historical data on destinations and phone calls,...). All types of dynamically changing but persistently stored data are expected to use the persistence subsystem. It does however not deal with software code, navigation map data and similar databases, which would typically be handled by Software Management.

Software Management

Software Management manages the storage of all program code running on an ECU including how to download and update programs, via standardized automotive diagnostic protocols, from storage devices or over a network (e.g., software-over-the-air or SOTA).

A software management implementation updates different parts of the system and handles issues like rolling back unsuccessful updates to a known stable state. All the required steps like verifying software integrity/authenticity, system compatibility and similar issues need to be taken into account.

An Infotainment ECU frequently contains many different types of hardware, such as individual radio tuners, Bluetooth modules and other peripherals, some of which in turn need to be loaded with their own software or firmware using special protocols.

Lifecycle

Lifecycle deals with the startup, shutdown and management of the running of system components and integrated applications. It also keeps track of the state, and the status (health) of the system, including:

- Power-, Node state-, Boot- and Resource management
- Interfaces to/of Thermal- and Supply management

User Management

User Management is the support for multiple independent users, each having their own profiles and settings, and the mechanisms for keeping track of who is active (logged in) on different parts of the system. In combination with other subsystems it also cares for protection of personal data from unwanted disclosure in its interface to Personal Information Management subsystem.

The reference architecture describes some technical approaches for creating a multi-user system and solutions for storage and separation of private data and how to use GENIVI provided components to achieve this.

Housekeeping

This domains groups typical software modules that monitor software behavior and handle errors.

It includes Automotive Diagnostics Log and Trace (DLT) which is one of the earliest GENIVI software. It is an advanced log and trace framework that provides interfaces for applications to log messages at different levels from debug, info, to critical errors. In comparison to Linux mechanisms used in server and desktop systems like syslog / journald, DLT differs primarily by being highly optimized for embedded systems, primarily designed

(not as secondary addition) for moving log messages out over a network to another node. Most of all however, DLT follows an automotive logging standard from AUTOSAR which makes it appropriate to integrate in a larger context of automotive systems and AUTOSAR tooling. Combinations with other Linux technologies are of course still possible. DLT is often used in GENIVI components for logging / tracing and is a much appreciated development tool.

Security Infrastructure

This subsystems groups together all cryptography libraries and other support functions for security solutions, abstractions and libraries for interacting with Hardware Security Modules (HSM), the management of signatures and encryption, intrusion/anomaly detection, and a Mandatory Access Control solution implemented by a Linux Security Module (LSM).

Diagnostics

This domain implements automotive diagnostics features. Unified Diagnostic Services (UDS) are codified in ISO 14229-1:2013 and allow diagnostics to control functions on an in-vehicle Electronic Control Unit (ECU). Standard on-board Diagnostic Trouble Codes (DTCs) are used.

Inter Process Communication (IPC)

The domain includes standards for internal communication such as d-bus, any additional infrastructure to support communication (such as a message broker, if used). It also includes the Common API Runtime. The domain includes Common API Runtime. CommonAPI is an *Inter Process Communication* (IPC) language binding API, that enables applications to use different IPC middleware as backend without any changes to the application code. The current primary implementation is C++ based although a C-based variant is being developed. CommonAPI is tightly connected to Franca IDL - tools require Franca IDL described input and the communication semantics must match. To read more about Franca, see the project website.

The currently well-tested communication backend for CommonAPI C++ is D-Bus while some companies make their own backends. Future development may support kdbus as an alternative.

Networks

The Infotainment system often plays the role of a hub in a vehicle as it is connected to vehicle network on one side and to external resources on the other side (smart devices, cloud, ...). A large set of network technologies and protocols are envisioned (CAN, Flexray, USB, Wi-Fi, NFC, AVB, ...).

A SOME/IP communication stack, and connection to CommonAPI is available. Whatever the type of IVI system we expect there is always some connection to a vehicle network. At the maximum the IVI system implements a user interface for lots of vehicle related functions including climate, seats, turning on and off driving features, powertrain settings and many other domains. At the very minimum, the power states (sleep, wakeup, etc.) of the ECU are typically controlled by another node in the electrical system.

The Networks subsystem is intended to group the implementations of different network technologies. Note however that Bluetooth is treated in its own subsystem. The basic implementation of Ethernet AVB support also resides here, while it is used by Audio Management and occasionally video subsystems.

Network Management

Network Management includes all the infrastructure required to set up, take down, monitor and control network connections. Connection management (using connman), and helper libraries like Download Upload Messaging Manager (DUMM) are in this domain. Depending on the system, things like traffic shaping, firewalling and similar features would also be considered part of this subsystem.

Graphics Support

This includes graphical support libraries for rendering and compositing. Examples are the IVI Layer Manager, Compositor implementations based on Wayland protocol, IVI extension to Wayland, OpenGL and similar low-level graphics standards. Prominent image processing libraries could be put explicitly into this category, but just as often they may be just considered part of the "Generic libraries" section of the platform.

Audio/Video Processing

This subsystem includes the codecs and infrastructure for putting together a processing pipeline for audio or video. Typically this means audio and video codec implementations, or interface libraries to such implementations if they exist in specialized hardware, optimized DSP code or similar. GStreamer provides pipeline/processing support.

Audio Management

The Audio domain deals with management, connection and routing of audio streams taking into account unique automotive (IVI) audio requirements (priorities, mixing, foreground/background, etc.). The primary implementation is the GENIVI AudioManager framework which consists of a shared implementation of the AudioManagerDaemon plus typically a set of product specific implementations of the plug-in abstract components. In this group we typically also include some available Linux technologies for the management of audio (pulseaudio, alsa).

Device Management

Low level support function reacting to and distributing events for connected devices ranging from simple USB memories up to connected Bluetooth devices. An interesting challenge to implement in this subsystem is preparation of the higher level logic that may be required to react to device connections, such as handing over from one connection (wireless) to another (physical) originating from the same device. A typical implementation may require product unique logic but the platform solution should consider how general patterns can be provided to allow reuse between projects.

Bluetooth

Typically a full-featured Bluetooth Stack is expected in a modern IVI system to support use cases such as data exchange, networking, media streaming and hands-free telephony. Because of its importance and its many parts and features Bluetooth software components are in their own separate subsystem.

Camera Functions

This subsystem contains code that implements, or supports implementing, camera based functions such as rear-view (reverse gear) camera, camera assisted parking, surround-views, etc.

Speech

Different components, from the basic technology libraries to databases, and dialog-control, and the necessary connections to other HMI functions make up a working speech subsystem.

HMI Support

HMI (Human Machine Interface) includes all technologies that the user interacts with. In addition to graphical displays, this includes buttons and knobs, speech control, gestures and handwriting recognition. A subsystem is created to include implementation of button routing, recognizers for gestures/handwriting, prioritization of HMI events, etc.

There are also typically more elaborate supporting frameworks used for graphical user interfaces above the low level features provided by Graphics Support subsystem. These may include frameworks helping the implementation of GUIs (Qt, GTK, etc.) It may differ from one GENIVI system to the next which, if any, of such libraries should logically be considered part of the platform or be seen as added on top of it. This is why the reference block diagram also suggests that technologies like Qt can if desired be considered to exist outside of platform specification.

CE Device Integration

This deals with the interaction between smartdevices and the IVI system. Some different standards include SmartDeviceLink, MirrorLink™, CarPlay™ and Android Auto.

Personal Information Management (PIM)

In the context of an IVI system PIM first to keep a database of personal information about other people, such as an address book, including also phone numbers, email address, social application identities, etc. It also includes the user's own information of similar kind (web service accounts, passwords, etc.) and therefore interfaces with the user management domain.

Although some address books may be fetched or synced with Bluetooth, others may have an Internet account management elsewhere. It's assumed that many features may need access to PIM information, for example supporting a use case like navigating to the address of a contact. Designing platform components responsible for PIM enables such information to be shared and available to multiple applications instead of locked into individual ones.

In some systems PIM extends to calendar information, appointments, todo-tasks. This tends to be heavily integrated with Email, which slides over to mobile office and even social networks. Typically we group those user functions into the "Internet Functions" group, but significant interaction with PIM is likely and different products may do it slightly differently depending on required integration.

Vehicle Interface

This subsystem deals with any abstraction or connection to typical automotive vehicle networks, and to the signals and information handled there. In some systems this may include connection to a peripheral CPU, which in turn is actually connected to vehicle buses. In practice designing all the software for a function together of course makes sense even if different parts are deployed on different CPUs - nonetheless it is worthwhile to remind that the GENIVI reference architecture deals mainly with the main "Multimedia" SoC, if the IVI system is a multi-CPU solution.

Internet Functions

This domain includes a traditional interactive Web Browser function and non-interactive renderers for HTML documents, as well interfaces to cloud based services. Very often frequently changing user features will be implemented as "apps" on top of a platform, but in any system where these are considered integrated into the platform, then features like email, social networks etc. may also be included in Internet Functions subsystem.

Media Sources

This platform subsystem includes the actual implementations that access media data from different sources, typically presenting their result in a uniform way to the Media Framework.

Network streams and connected devices (DLNA®, Bluetooth, Internet streaming), as well as other removable media and embedded storage are typically included, but broadcast technology such as AM/FM, SiriusXM, DAB, Television broadcasts, are grouped into another subsystem.

Media Framework

This is a platform support for media applications which includes the generic logic that can be shared between Media players and is extended by the sources provided by the Media Sources subsystem.

A media framework supports media applications with the ability to connect and integrate different sources of media as a combined resource.

In addition to playback logic, primary features include maintenance of music metadata, music identification services and coordination of media playback.

Navigation & Location Based Services (LBS)

This domain deals with traditional IVI navigation systems and the supporting technology for these such as positioning

It also includes all data services and innovative features that have location as their primary feature.

Telephony

This is the telephony software stack. It complements the Bluetooth communication (typically) with the actual logic for connecting and managing phone calls, call-waiting, conferences and so on. There may be multiple technologies behind such as an in-car embedded phone, or VOIP functionality and the telephony stack could (if desired) manage them similarly.

Radio & Tuners

This domain includes traditional broadcast technologies including receivers for radio technologies (AM/FM, DAB, HD-Radio, SiriusXM, …) as well as television broadcasts. Note that streaming and the "Internet Radio" type of sources are addressed in the Media Sources domain. The functionality of the Tuner API is verified in the IVI Radio project.

Applications Layer

GENIVI makes the distinction between Native Applications like Vehicle Functions, Climate, Radio, Navigation, etc. and Managed Applications that may be added by the user like Music Services, Weather, Social Networks, etc.

The exact features implemented in the Native and Managed domain respectively are decided by the system builder - GENIVI has only provided some typical examples. In fact, it's optional to use the Managed or Native or (recommended) combining both approaches.

The reason and rationale behind the two design philosophies are described in more detail in the Reference Architecture document.