Automotive Grade Linux on Raspberry Pi: How Does It Work?

Leon Anavi
Konsulko Group
leon.anavi@konsulko.com
leon@anavi.org
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Konsulko Group

Konsulko Group

- Services company specializing in Embedded Linux and Open Source Software
- Hardware/software build, design, development, and training services
- Based in San Jose, CA with an engineering presence worldwide
- http://konsulko.com/

Agenda

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- Automotive Grade Linux
- Raspberry Pi
- Building an AGL image for Raspberry Pi
- Understanding how AGL works on Raspberry Pi
- Conclusions
- Q&A

Automotive Grade Linux (AGL)

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- Project of the Linux Foundation
- Open source GNU/Linux automotive distribution with In-Vehicle-Infotainment (IVI)
- Based on the Yocto Project and OpenEmbedded
- Founded in 2014

AGL Members


DENSO
mazda
Panasonic
RENESAS
SUZUKI
TOYOTA
HONDA
The Power of Dreams
AISIN AW CO.,LTD.
auto
Mercedes-Benz
Ford
NTT DATA
NTT DATA MSE Corporation
QUALCOMM
SAIC 上汽集团 SAIC MOTOR
VOLKSWAGEN
蓝星科技
Adobe
ADIT
Airbiquity
ALPS ALPINE
ARC CORE
ARKAMYS
arm
audiokinetic
Bayllbre
BearingPoint
BedRock Systems Inc.
BOSCH
BOSE
bright box
Brison
CGISTUDIO
Capgemini
中国移动 China Mobile
cinemo
cloudbees
CodeThink
cognomotiv
COLLABORA
Continental
CRAVE.IO
cybertrust
dellfer
DESAY SV automotive
DRIMAES
Elektrobit
ENEA
epam
ETRI
FIBERDYNE
FORGEROCK
FPT Software
FUJITSU
German Autolabs
GitHub
GlobalLogic
Green Hills SOFTWARE
HARMAN
here
HITACHI Inspire the Next
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HYUNDAI MOBIS
igalia
intel
IOTABZH
IVIS
JVCKENWOOD
Karamba Security
KERNKONZEPT
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KPIT
LEAR
LG
Linaro
LUXOFT
mcloudware
MEDIATEK
Mentor
MERA
MICROCHIP
micware
MITSUBISHI MOTORS
MITSUBISHI ELECTRIC
KOMTAC
mocana
MontaVista
MOVIMENTO
NEC
Neusoft
NEXIUS
NEXTY Electronics
NIPPON SEIKI
NUANCE
NVIDIA
NXP
NYU
OSIGO
OPENSYNERGY
ORACLE
NDS
OTAinfo
OUTCERT
OVO AUTOMOTIVE
PARAGON SOFTWARE
Pioneer
PocketSoft
Qt The Qt Company
RAND & SOUND
SONY
Spireon
SUBARU
TELENAV
Texas Instruments
ThunderSoft
VENIAM
VeriSilicon
VNC Automotive
Suntec
SYMBIO
SYNOPSYS
TOSHIBA
TOTAL
Trillium
voicebox
WIND
wipro
SYSGO EMBEDDING INNOVATIONS
T-Systems
TUXERA Make it work.
Ubiquitous AI Corporation
Witekio EMBEDDING SUCCESS
WITZ
Xevo

AGL Core Technologies

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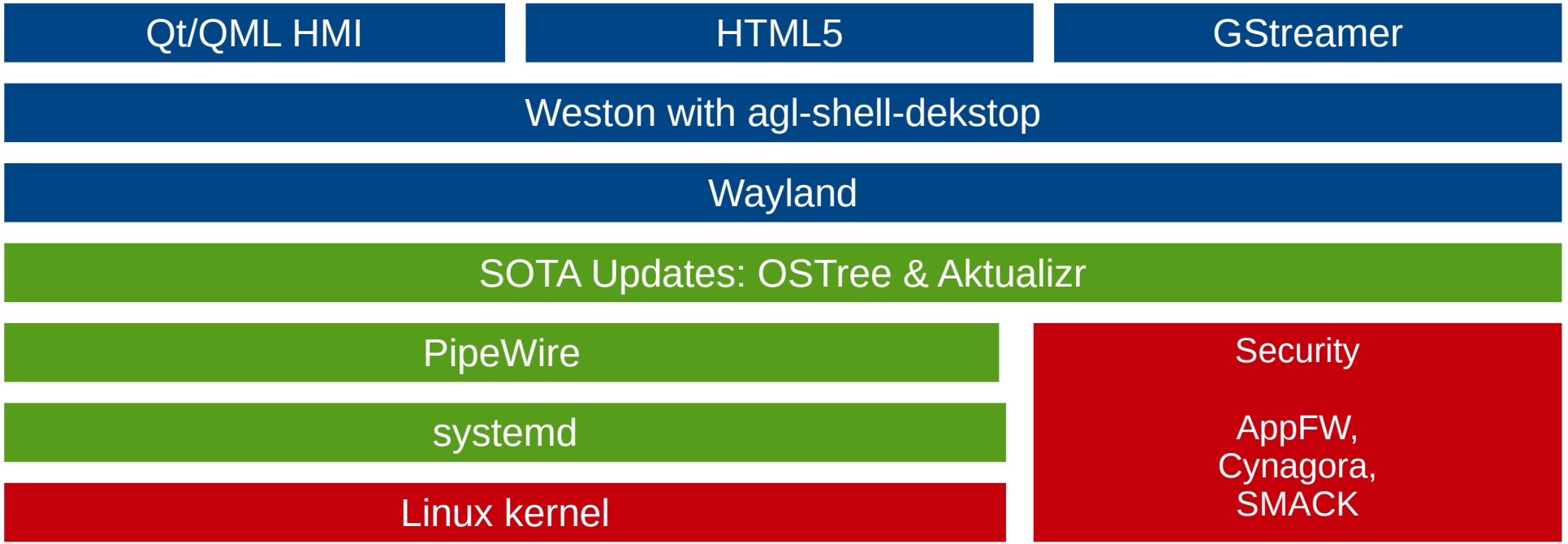

Yocto/OpenEmbedded Layers in AGL

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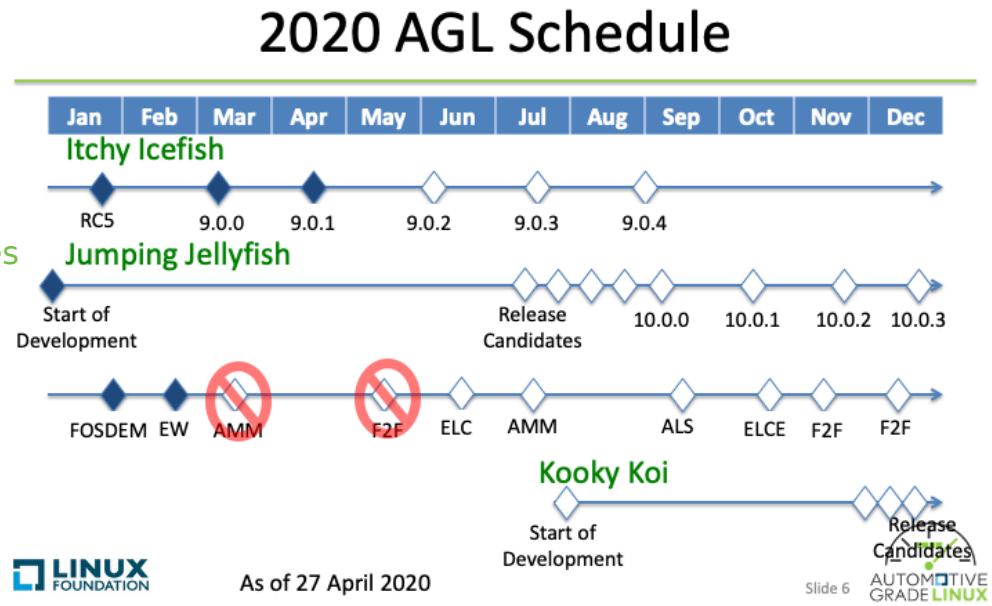
- poky
- meta-agl
- meta-agl-cluster-demo
- meta-agl-demo
- meta-agl-devel
- Meta-agl-extra
- meta-agl-telematics-demo
- meta-openembedded
- meta-security
- meta-virtualization
- meta-qt5
- meta-updater
- neta-spdxscanner
- meta-clang
- BSP layers: meta-raspberrypi, meta-intel, meta-ti, meta-renesas-rcar-gen3, meta-sancloud, etc.

AGL Releases

- Twice per year release cycle
- Releases are named on fishes
- Latest stable release is Itchy Icefish
- https://wiki.automotivelinux.org/agl-distro/release-notes
- https://wiki.automotivelinux.org/schedule



AGL Supported Devices

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- Renesas R Car Starter Kit gen3 board
- Most Intel 64-Bit hardware platforms (including Minnowboard Max/Turbot)
- Quick EMUlator (QEMU) or VirtualBox
- Raspberry Pi 3 and 4
- Various supported ports and/or older AGL releases for multiple other hardware platforms: i.MX6, Dragonboard 410, TI Vayu, Renesas Porter, Intel Cyclone V, Raspberry Pi 2, etc.
- https://wiki.automotivelinux.org/agl-distro?&#supported_hardware

Raspberry Pi

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- Series of small single-board computers developed by the Raspberry Pi Foundation
- All models feature a Broadcom system on a chip (SoC) and ARM CPU
- Designed primary to promote teaching of basic computer science but also very popular in the maker community for hobby projects and demonstrations

Raspberry Pi Milestones

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- 2009 - Raspberry Pi Foundation
- 2012 - The 1st Raspberry Pi
- 2014 - Raspberry Pi B+
- 2016 - Raspberry Pi Zero
- 2016 - Raspberry Pi 3
- 2016 - Raspberry Pi 3 B
- 2018 - Raspberry Pi 3 B+
- 2019 - Raspberry Pi 4 B

AGL Raspberry Pi Milestones

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- 2015 – Mauro Chehab at that time working for Samsung OSG (Open Source Group) ported Tizen based on Yocto/OpenEmbedded to Raspberry Pi 2
- 2016 – GENIVI Dev Platform was ported to Raspberry Pi 2
- 2016 – AGL was ported to Raspberry Pi 2
- 2016 – Support for Raspberry Pi 3 was added in AGL
- 2019 – Support for Raspberry Pi 4 was added in AGL

Building AGL for Raspberry Pi (1/2)

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- Prepare Repo Tool:

```
mkdir -p ~/bin
export PATH=~/bin:$PATH
curl https://storage.googleapis.com/git-repo-downloads/repo > ~/bin/repo
chmod a+x ~/bin/repo
```

- Download source code:

```
mkdir agl-rpi
cd agl-rpi
repo init -b master -u https://gerrit.automotivelinux.org/gerrit/AGL/AGL-repo
repo sync
```

Building AGL for Raspberry Pi (2/2)

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- Set up build environment:

```
source meta-agl/scripts/aglsetup.sh -m raspberrypi4 agl-demo agl-appfw-smack
```

- Launch the build process:

```
bitbake agl-demo-platform
```

- The build from scratch takes a significant amount of the time depending on your Internet connection speed and the hardware capabilities of the build machine

AGL Features and Raspberry Pi Models

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- Supported Raspberry Pi models in the AGL master as of the moment:

```
raspberrypi4
raspberrypi3
```

- AGL features:

```
agl-demo
agl-appfw-smack
agl-sota
agl-netboot

source meta-agl/scripts/aglsetup.sh -h
```

Flashing the Image on MicroSD Card

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- Output Image location in build machine for Raspberry Pi 4:

```
tmp/deploy/images/raspberrypi4-64/agl-demo-platform-raspberrypi4-64.wic.xz
```

- Extract the wic.xz and flash it on a microSD card

```
sudo umount [sdcard device]
xzcat [output image] | sudo dd of=[sdcard device] bs=4M status=progress
sync
```

- Plug the microSD card in the Raspberry Pi and turn in on (the first boot of AGL takes a bit longer)

Common AGL Images

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- agl-demo-platform
- agl-image-ivi - base for IVI targets
- Agl-cluster-demo-platform - cluster demo image
- agl-image-boot - just enough to boot
- agl-image-minimal - minimal filesystem with APIs
- agl-image-weston - minimal filesystem with Wayland and Weston

Booting the image

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- Serial output from AGL on raspberry Pi 4:

```
Automotive Grade Linux 9.90.0+snapshot raspberrypi4-64 ttyS0

raspberrypi4-64 login: root
raspberrypi4-64:~# uname -a
Linux raspberrypi4-64 4.19.115-v8 #1 SMP PREEMPT Tue Mar 10 00:00:00 UTC
2020 aarch64 aarch64 aarch64 GNU/Linux
```

- Serial baud rate: 115200

AGL on Raspberry Pi 4 Screenshots

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Weston on AGL

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```
[[0;1;32m*[[0m weston@display.service - Weston Wayland Compositor
     Loaded: loaded (/lib/systemd/system/weston@.service; static; vendor preset: disabled)
    Drop-In: /lib/systemd/system/weston@.service.d
             `-weston-init.conf
     Active: [[0;1;32mactive (running)[[0m since Tue 2020-03-10 00:01:47 UTC; 3 months 9 days ago
   Main PID: 768 (weston)
      Tasks: 1 (limit: 1703)
     Memory: 28.8M
     CGroup: /system.slice/system-weston.slice/weston@display.service
             `-768 /usr/bin/weston --idle-time=0 --tty=7 –log=/run/platform/display/weston.log

Mar 10 00:01:46 raspberrypi4-64 systemd[1]: Starting Weston Wayland Compositor…
Mar 10 00:01:47 raspberrypi4-64 systemd[1]: Started Weston Wayland Compositor.
```

Supported Raspberry Pi Peripherals in AGL

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- HDMI monitors
- Raspberry Pi official 7” touchscreen display
- WiFi
- Bluetooth
- Various 3rd party add-on boards and HATs

OK, How Does It Really Work?

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The Yocto Project

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- Open source collaborative project of the Linux foundation for creating custom Linux-based systems for embedded devices using the OpenEmbedded Build System
- OpenEmbedded Build System includes BitBake and OpenEmbedded Core
- Poky is a reference distribution of the Yocto Project provided as metadata, without binary files, to bootstrap your own distribution for embedded devices
- Bi-annual release cycle

Yocto Project Releases

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Codename	Version	Release Date	Support Level
Gatesgarth	3.2	Oct 2020	Dreaming
Dunfell	**3.1**	**April 2020**	**Long Term Stable**
Zeus	3.0	October 2019	Stable
Warrior	2.7	April 2019	Stable
Thud	2.6	Nov 2018	Stable
Sumo	2.5	April 2018	Community
Rocko	2.4	Oct 2017	Community

AGL Repo Manifests

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- As of today default.xml is based on Yocto release Dunfell:

```
<project name="poky" path="external/poky" remote="yocto"
revision="a44b8d2856a937ca3991cbf566788b0cd541d777" upstream="dunfell" />
<project name="meta-gplv2" path="external/meta-gplv2" remote="yocto"
revision="60b251c25ba87e946a0ca4cdc8d17b1cb09292ac" upstream="dunfell" />
<project name="openembedded/meta-openembedded" path="external/meta-openembedded" remote="github"
revision="b1aa5f785094d25765657f1df7db0748680ae7fb" upstream="dunfell" />
```

- Use other manifest from AGL/AGL-repo for a specific AGL release: icefish_9.0.0.xml, halibut_8.0.6.xml, guppy_7.0.4.xml, etc.

meta-raspberrypi

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- General Yocto/OpenEmbedded Board Support Package (BSP) layer for the Raspberry Pi boards
- Depends on layers from meta-openembedded: meta-oe, meta-multimedia, meta-networking, meta-python
- Provides specific variables as knobs to enable/disable hardware specific features: ENABLE_I2C, ENABLE_SPI_BUS, RPI_USE_U_BOOT, ENABLE_UART, etc.
- For AGL VC4DTBO must be set to vc4-fkms-v3d to support Wayland, Weston and the apps on both HDMI and the official Raspberry Pi 7” touch screen display

meta-raspberrypi

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- New features and bug fixes are accepted as GitHub pull requests: https://github.com/agherzan/meta-raspberrypi
- Maintained by Andrei Gherzan with more than 90 contributors
- Documentation: https://readthedocs.org/projects/meta-raspberrypi/

Meta-raspberrypi in AGL

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- Script meta-agl/scripts/aglsetup.sh for Rasperry Pi initializes the build environment with conf/local.conf and conf/bblayers.conf
- Yocto/OE layer meta-agl/meta-agl-bsp contains sub-layers with AGL hardware specific configurations
- Configurations from conf/include/agl_raspberrypi4.inc or conf/include/agl_raspberrypi3.inc are automatically included in conf/local.conf depending on the targeted Raspberry Pi model

AGL on Raspberry Pi 4

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- Uses U-Boot as a bootloader
- GPU memory is set to 256MB
- UART is enabled
- Includes kernel modules
- Includes WiFi and Bluetooth firmware

Software Over the Air (SOTA) Updates

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- The agl-sota feature enables support for software over the air (SOTA) updates in AGL images
- Libostree (OSTree) and Aktualizr provide a "git-like" model for committing, downloading and automated provisioning of bootable filesystem trees to a fleet of vehicles
- Yocto/OE layers meta-updater and meta-updater-raspberrypi provide the SOTA implementation for AGL on Raspberry Pi
- For more details:
  https://wiki.automotivelinux.org/subsystem/agl-sota/ostree
  https://docs.ota.here.com/getstarted/dev/raspberry-pi.html

AGL Developer Tools

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- Git & Repo
- Gerrit https://gerrit.automotivelinux.org/
- GitHub https://github.com/automotive-grade-linux
- JIRA https://jira.automotivelinux.org/
- Wiki https://wiki.automotivelinux.org/
- Documentation http://docs.automotivelinux.org/
- Jenkins for CI and Lava + Fuego for running test

AGL Gerrit

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- Free and open source web-based team code collaboration tool for code reviews
- Create an account at identity.linuxfoundation.org to get started
- https://gerrit.automotivelinux.org/

Contributing to AGL

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- Report an issue or a new feature in JIRA
- Modify the source code
- Include references to the JIRA issue in the Git commit messages
- Contribute to the upstream following the AGL Gerrit workflow

AGL Gerrit

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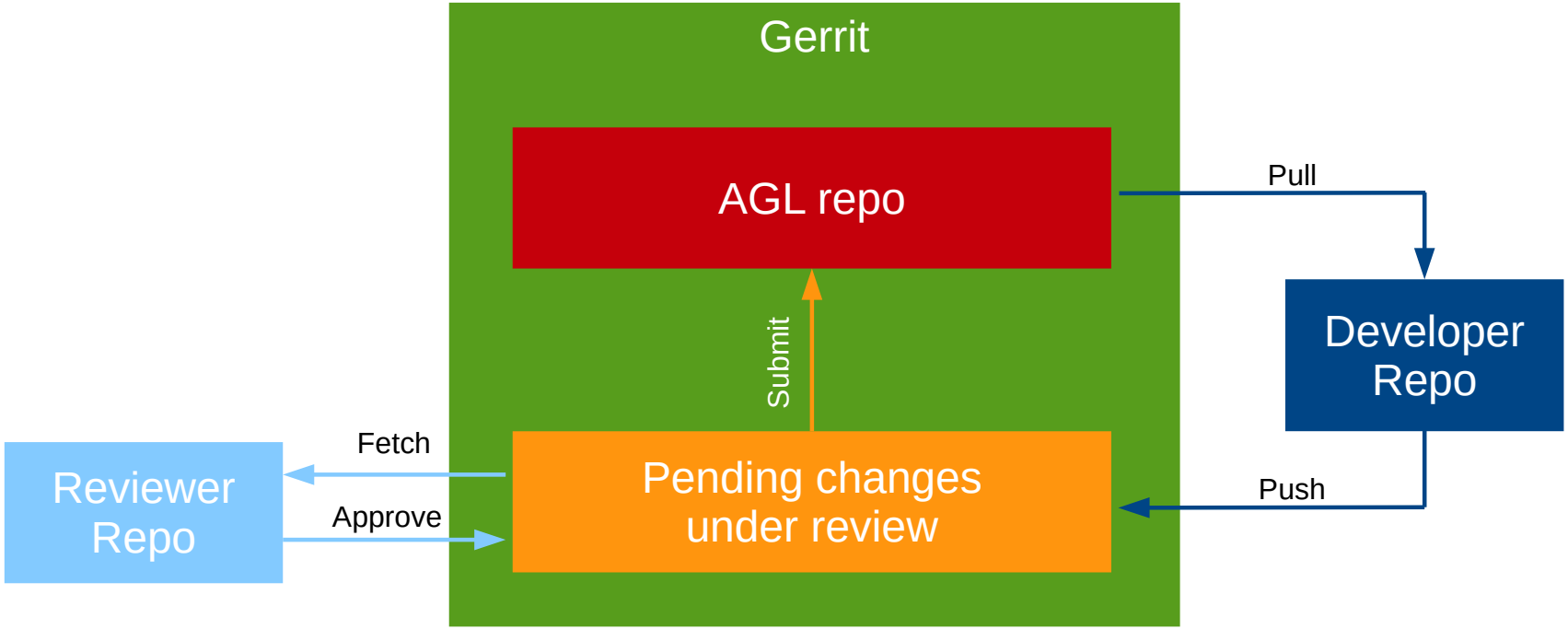

Merged Change in AGL Gerrit

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Gerrit CHANGES YOUR DOCUMENTATION BROWSE LEON ANAVI

☆ Merged as a8f9814 | 22872: agl_raspberrypi3.inc: Switch to firmware KMS REVERT

Updated	Nov 07, 2019
Owner	Leon Anavi
Assignee	Set assignee...
Reviewers	Jan-Simon Moeller, Walt Miner, Tadao Tanikawa, AND 8 MORE, ADD REVIEWER
CC	ADD CC
Repo	AGL/meta-agl
Branch	halibut
Parent	0a620f5
Topic	No topic
Hashtags	ADD HASHTAG

REPLY

```
agl_raspberrypi3.inc: Switch to firmware KMS

Swith to firmware KMS with appropriate Linux kernel and Mesa
version to support both HDMI and the official 7" Raspberry Pi
touch screen display on Raspberry Pi 3B/B+ and 4. Device tree
changes are not required for firmware KMS.

Bug-AGL: SPEC-2465

Change-Id: I5f8f62c0151b7eb79ab1f96419d9c62469a1554e
Signed-off-by: Leon Anavi <leon.anavi@konsulko.com>
```

Relation chain
raspberrypi*/50_local.conf.inc: Update... (Merged)
→ agl_raspberrypi3.inc: Switch to firmwar... (Merged)
bcm2835-bootfiles.bbappend: Update ... (Merged)
linux-raspberrypi_4.19.bb: Update to 4.... (Merged)
rpi-config: Set max_framebuffers to 2 t... (Merged)

Submitted together
AGL/meta-agl: halibut: raspberrypi*/50_local.co...
→ AGL/meta-agl: halibut: agl_raspberrypi3.inc: Swi...
AGL/meta-agl: halibut: bcm2835-bootfiles.bbap...
AGL/meta-agl: halibut: linux-raspberrypi_4.19.bb...
AGL/meta-agl: halibut: rpi-config: Set max_fram...

Cherry picks
master: agl_raspberrypi3.inc: Switch to firmware...

AGL Communication Channels

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- AGL mailing list
  https://lists.automotivelinux.org/g/agl-main
- Weekly Developer Call
  (Tuesday 14:00 - 15:00 UTC)
  https://wiki.automotivelinux.org/dev-call-info
- IRC
  channel #automotive on freenode.net

Conclusion

Konsulko Group

- Automotive Grade Linux is a collaborative open source project that is bringing together automakers, suppliers and technology companies to accelerate the development and adoption of a fully open software stack based on Linux for the connected car.
- Raspberry Pi is a community supported hardware platform compatible with AGL that is useful for getting started and proof of concept demonstrations.
- Join Automotive Grade Linux by contributing to the development, testing and/or the documentation of the project!

Thank You!

Useful links:

- https://www.automotivelinux.org/
- https://docs.automotivelinux.org/
- https://wiki.automotivelinux.org/agl-distro/agl-raspberrypi
- Pre-built binary images: https://wiki.automotivelinux.org/agl-distro?&#supported_hardware