

**RSA**Conference2018

San Francisco | April 16 – 20 | Moscone Center



#RSAC

SESSION ID:

# MAKE YOUR CAR SELF-DRIVING USING OPEN-SOURCE SOFTWARE

**George Hotz**

comma.ai

AT&T 7:46 PM

SMS  
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Tuesday  
4  
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Stocks

Maps  
280

Clock

Weather  
73°

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Calculator

Notes

Settings

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App Store

Phone

Mail

Safari

iPod



2



# What does a jailbreak do?

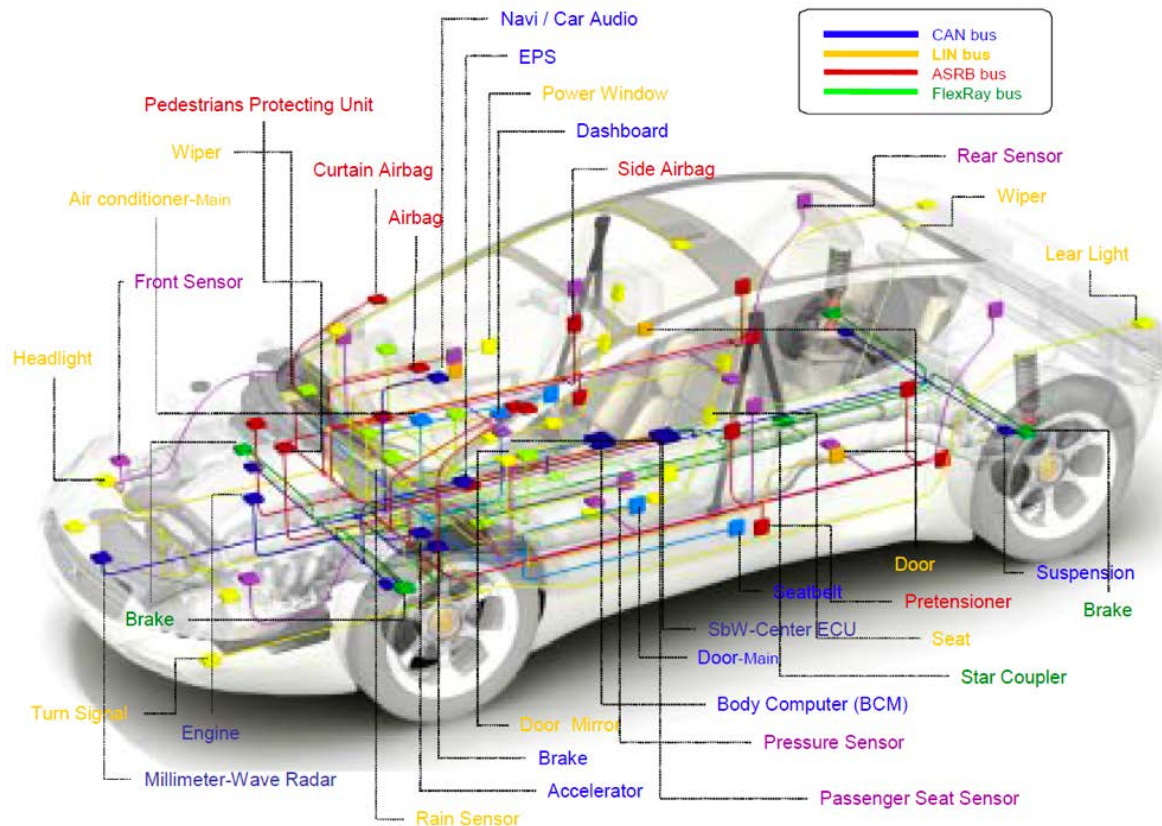


Add functionality the manufacturer didn't include

# Car Networks



#RSAC



The diagram illustrates an ISO 11898-2 Network topology. It features a horizontal bus line with three segments separated by two break symbols (curved lines). Each segment is terminated at both ends with a resistor labeled  $R_{term}$ . Three CAN Nodes are connected to the bus via stubs. Each stub is labeled "Stub Length" with a vertical double-headed arrow. Each node is represented by a dashed box containing the text "CAN Node" and "Not Terminated At Node". The entire diagram is labeled "ISO 11898-2 Network" at the bottom center.

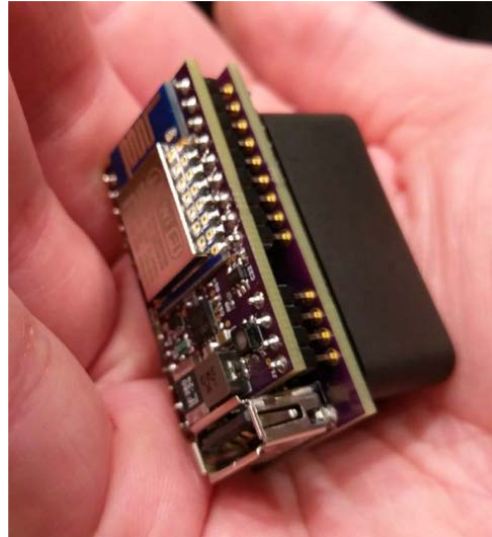




# panda (interface)



#RSAC



[github.com/commaai/panda](https://github.com/commaai/panda)

# Reverse Engineer in cabana



comma cabana

Log in with GitHub

CURRENTLY EDITING:  
toyota\_rav4\_2017\_pt.dbc

Load DBCCopy Share LinkSave DBC

AVAILABLE MESSAGES

Filter

Name	ID	Count	Bytes
STEERING_LKA	128:2e4	18000	23 00 00 00 8d 00 00 00
KINEMATICS	0:24	14921	02 00 01 c0 41 fe 80 8a
STEER_ANGLE_SENSOR	0:25	14921	00 00 00 00 4f ff 00 7b
WHEEL_SPEEDS	0:aa	14921	2b 04 2a ff 2a ea 2a e8
undefined	129:141	8999	00 00 00 46 00 00 00 00
STEER_TORQUE_SENSOR	0:260	8997	08 ff 42 00 00 ff d5 37
SPEED	0:b4	7460	00 00 00 00 91 10 ec 39
undefined	0:ba	7461	02 0f 00 cf 00 00 00 00
undefined	0:1c4	7642	07 c7 16 08 31 00 e3 8d
undefined	0:223	7461	00 00 00 00 00 00 00 2d
BRAKE_MODULE	0:224	7461	00 00 00 00 00 01 00 08
ACCELEROMETER	0:228	7460	01 fe 00 2d 00 00 00 00
undefined	0:2d5	7643	10 49 00 00 00 00 00 00
undefined	129:128	6000	f4 01 90 83 00 37 00 00
undefined	0:1d0	5670	0d 4c 10 00 03 00 03 48
PCM_CRUISE	0:1d2	5670	81 04 00 7c 00 95 00 31

SELECTED MESSAGE:  
ACCELEROMETER

Edit

▼ Edit Signals

time: 463.882

0	0	0	0	0	0	0	1	01
1	1	1	1	1	1	1	0	fe
0	0	0	0	0	0	0	0	00
0	0	1	0	1	1	0	1	2d
0	0	0	0	0	0	0	0	00
0	0	0	0	0	0	0	0	00
0	0	0	0	0	0	0	0	00
0	0	0	0	0	0	0	0	00

> ACCEL\_X

> ACCEL\_Z

Hide PlotShow Plot

Message PacketsEXPAND ALL

ACCELEROMETER

ACCEL\_X

Hide Plot

# DBC (Protocol Definition) Files



```
BO_ 342 STEERING_SENSORS: 6 EPS
SG_ STEER_ANGLE : 7|16@0- (-0.1,0) [-500|500] "deg" NEO
SG_ STEER_ANGLE_RATE : 23|16@0- (1,0) [-3000|3000] "deg/s" NEO
SG_ COUNTER : 45|2@0+ (1,0) [0|3] "" NEO
SG_ CHECKSUM : 43|4@0+ (1,0) [0|3] "" NEO
```

A Steering Sensor Message

ID = 342 = 0x156

STEER\_ANGLE starts at bit 7 and is 16 bits long

It is signed, scale of -0.1, and range -500, 500



# opendbc



commaai / **opendbc** Watch 30 Star 105 Fork 106

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democratize access to car decoder rings

138 commits 1 branch 0 releases 12 contributors

Branch: master [New pull request](#) [Find file](#) [Clone or download](#)

**alessbelli** committed with **rbiasini** Created toyota iQ base plus reversed some signals (#48) Latest commit 3a62ece 5 days ago

<a href="#">.gitignore</a>	make opendbc import work, and ignore junk	5 months ago
<a href="#">README.md</a>	Update README.md	3 months ago
<a href="#">_init_.py</a>	make opendbc import work, and ignore junk	5 months ago
<a href="#">acura_lix_2016_can.dbc</a>	Honda/Acura: added name to msg 0x37c (892)	2 months ago
<a href="#">acura_lix_2016_nidec.dbc</a>	Nidec radar: name change to RADAR_DIAGNOSTIC msg	2 months ago
<a href="#">ford_cgea1_2_bodycan_2011.dbc</a>	ford cgea 1.2 2011 (#32)	a month ago
<a href="#">ford_cgea1_2_ptcan_2011.dbc</a>	ford cgea 1.2 2011 (#32)	a month ago
<a href="#">gm_global_a_chassis.dbc</a>	Volt gen 2 support	4 months ago
<a href="#">gm_global_a_lowspeed.dbc</a>	Volt gen 2 support	4 months ago
<a href="#">gm_global_a_lowspeed_1818125.dbc</a>	Update gm_global_a_lowspeed_1818125.dbc (#34)	a month ago
<a href="#">gm_global_a_object.dbc</a>	Volt gen 2 support	4 months ago
<a href="#">gm_global_a_powertrain.dbc</a>	Volt gen 2 support	4 months ago
<a href="#">honda_accord_touring_2016_can.dbc</a>	Cleanup and corrections to the accord DBC.	26 days ago
<a href="#">honda_civic_hatchback_ex_2017_can.dbc</a>	Civic Hatchback DBC (#35)	a month ago
<a href="#">honda_civic_touring_2016_can.dbc</a>	Honda: fixed gas interceptor offset bug	17 days ago
<a href="#">honda_crv_ex_2017_can.dbc</a>	More updates to support work on 2017 CR-V port (#33)	a month ago
<a href="#">honda_crv_touring_2016_can.dbc</a>	Honda/Acura: added acc speed offset to dbc files	2 months ago
<a href="#">hyundai_l30_2014.dbc</a>	add hyundai_l30_2014.dbc	2 months ago

- Acura
- Ford
- GM
- Honda
- Hyundai
- Subaru
- Tesla
- Toyota
- VW

# Drive by Wire (Honda)



Message 0x30C  
Speed Control

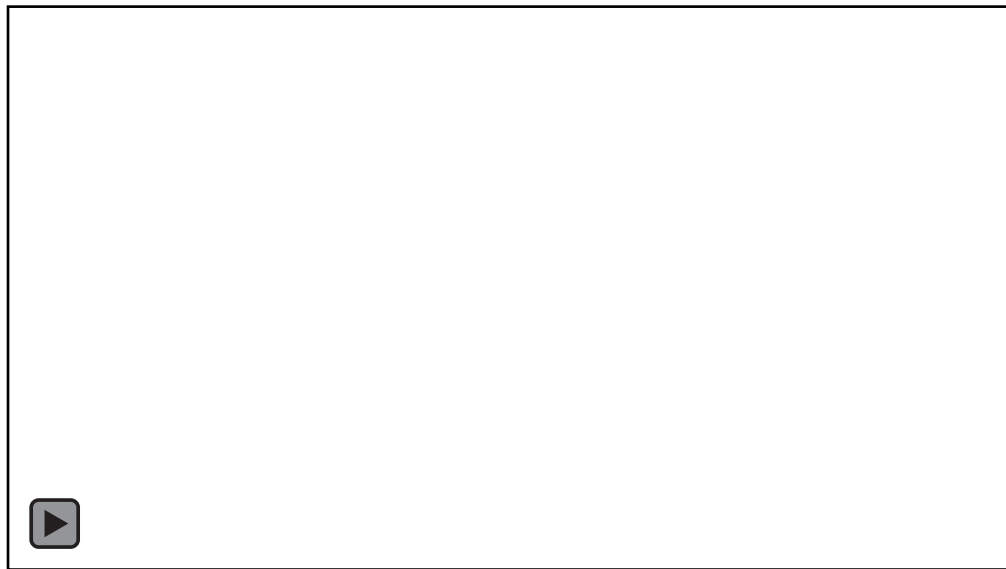
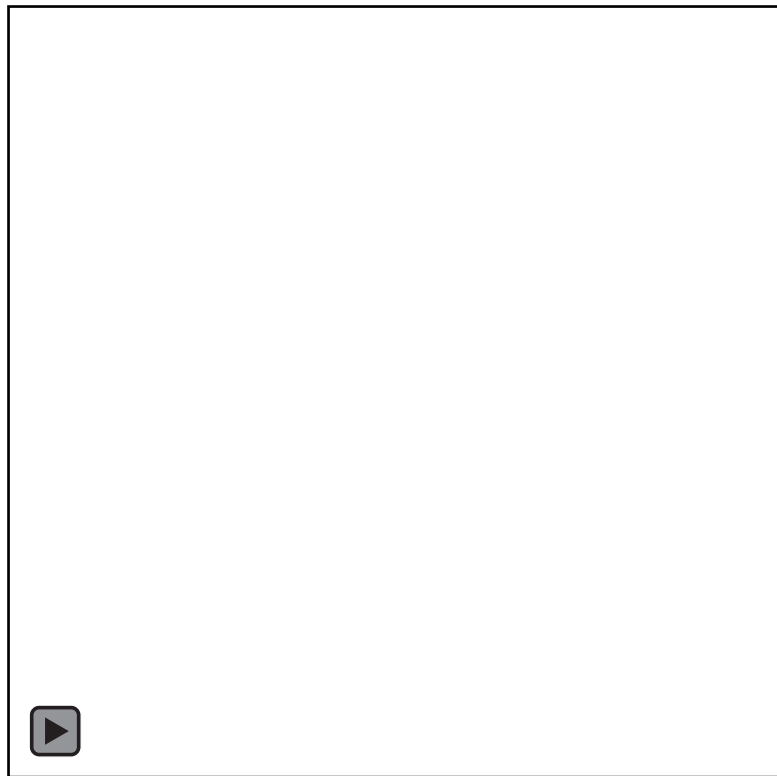


Message 0x1FA  
Brake Amount  
Pump  
Lights



Message 0xE4  
Apply steering torque

# Driving is a *dance*





# We need compute (EON)



Okay...it's a phone in a case

# And NEOS (Android fork)



## NEOS

## NEOS

OS for the NEO robotics platform

<https://github.com/commaai/neo>

Repositories 11

People 0

Search repositories...

### [android\\_kernel\\_oneplus\\_msm8996](#)

Forked from CyanogenMod/android\_kernel\_oneplus\_msm8996

● C 48 GPL-2.0 Updated on May 17

### [android\\_frameworks\\_base](#)

Forked from CyanogenMod/android\_frameworks\_base

● Java 1,394 Updated on Dec 13, 2016

```
controlsAllowed = false,
gasInterceptorDetected = false,
startedSignalDetected = false )
( logMonoTime = 1374985957755,
thermal = (
  cpu0 = 395,
  cpu1 = 398,
  cpu2 = 395,
  cpu3 = 385,
  mem = 401,
  gpu = 379,
  bat = 32000,
  freeSpace = 0.96687138,
  batteryPercent = 100,
  batteryStatus = "Charging",
  fanSpeed = 0 ) )
running updated <Process(updated, stopped)>
running ui <Process(ui, started)>
running logcatd <Process(logcatd, started)>
running pandad <Process(pandad, started)>
running gpsd <Process(gpsd, started)>
running uploader <Process(uploader, started)>
running tombstoned <Process(tombstoned, started)>
running logmessaging <Process(logmessaging, started)>
```

1 bash - 2:python - 3 bash - 4 bash

18/10 19:46:21

## SSH, tmux, and bash!

commaai / openpilot

Watch 672 Star 6,467 Fork 1,475

Code Issues 39 Pull requests 4 Projects 1 Insights

open source driving agent

79 commits 2 branches 17 releases 12 contributors MIT

Branch: devel New pull request Find file Clone or download

Vehicle Researcher update releases Latest commit 2cfdbe1 a day ago

apk	openpilot v0.3.4 tweaks	3 months ago
cereal	openpilot v0.3.8.2 tweaks	2 days ago
common	openpilot v0.3.8.2 release	6 days ago
opendbc @ 835a973	openpilot v0.3.8.2 release	6 days ago
panda @ 849f688	openpilot v0.3.8.2 release	6 days ago
phonelibs	openpilot v0.3.7 release	a month ago
pyextra @ 4eda4dd	openpilot v0.3.7 release	a month ago
selfdrive	openpilot v0.3.8.2 tweaks	2 days ago
.gitignore	openpilot v0.3.7 tweaks	a month ago
.gitmodules	openpilot v0.3.4 release	3 months ago
.travis.yml	openpilot v0.3.7 release	a month ago
Dockerfile.openpilot	openpilot v0.3.8.2 release	6 days ago
LICENSE.openpilot	openpilot v0.2.1 release	11 months ago
Makefile	openpilot v0.3.8.2 release	6 days ago
README.md	openpilot v0.3.8.2 release	6 days ago
RELEASES.md	update releases	a day ago
SAFETY.md	openpilot v0.3.8.2 tweaks	2 days ago
requirements_openpilot.txt	openpilot v0.3.4 release	3 months ago
run_docker_tests.sh	openpilot v0.3.7 release	a month ago



## Open Source Driving Agent



# openpilot emulates ECUs



=



...and replaces them with better versions

# hundreds of **openpilot** users today



## Driving with OpenPilot 0.3.7

pjlao • 644 views • 1 month ago

Testing OpenPilot version 0.3.7 in a 2016 Civic Touring.



## Openpilot 0.3.3

Jeffrey Peacock • 882 views • 3 months ago



## Openpilot 0.3.2 at Night

Vasily Tarasov • 1.3K views • 4 months ago

Source code and installation guidelines for Chevy Volt 2017 Premier:  
<https://github.com/commaai/openpilot/pull/104>.



## Open Source self-driving car (Comma ai/openpilot) with a 2015 Honda CR-V Touring

John J • 1.8K views • 4 months ago

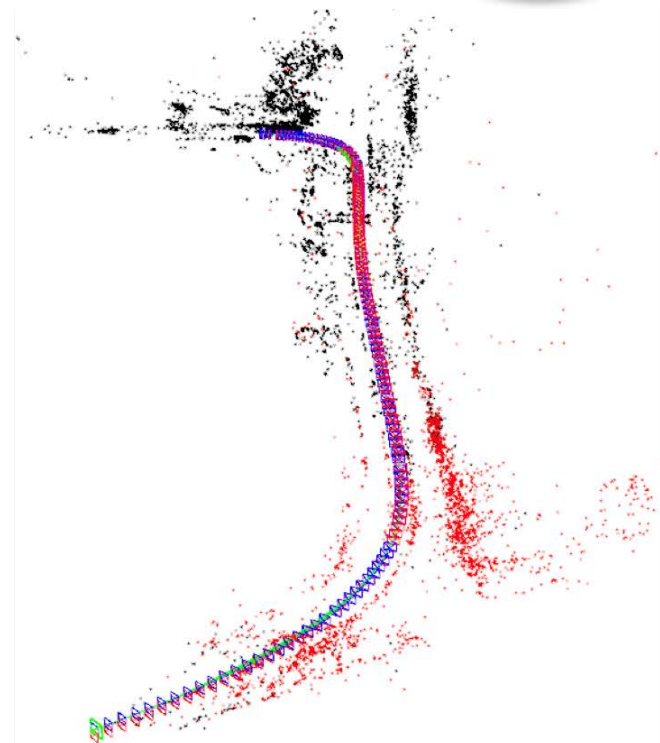
Courtesy of Comma.ai.



*all mapping the world for driving*

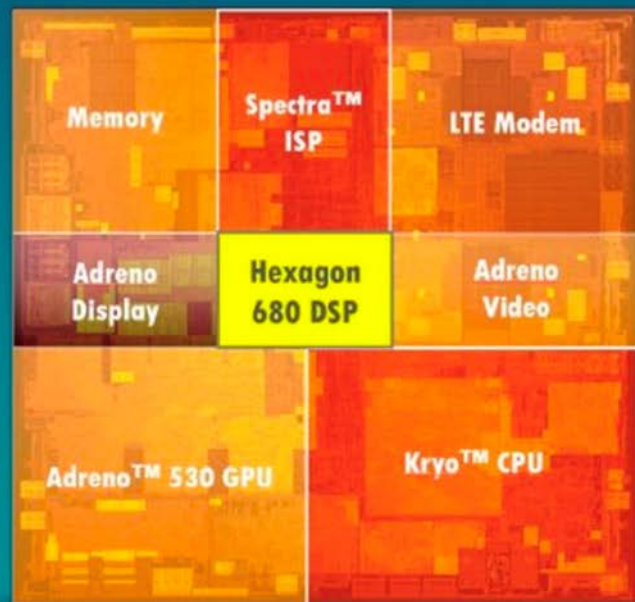


# 3D maps without LIDAR





3000 ORB  
features  
@  
20 FPS



\* Not to scale

## Snapdragon 820 Mobile SoC





but the DSP only runs signed code...

<http://freethedsp.com/>



[slack.comma.ai](https://slack.comma.ai)



Cars are replaced ~9 years

And there's no OTA updates!





# Questions?