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Rapid Proto typing of Gateway ECU formixed/ complex automotive net work architecture

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Abstract *— Vehicle systems are composed of automotiveelectricalarchitectureconsistingofalargenumberofelectronic control unit (ECU) which carry out variety offunctions in vehicle system like safety, comfort and fuelconsumptionsinformofsafetybags,antilockbrakingsystem,audio,windowetc.AgatewayECUiscentralnetwork interconnecting system to link various field buseslikeCAN,LIN,FlexRayetc.*
A gateway ECU is used to connect controller area network(CAN), localinterconnectednetwork (LIN)andFlexRay.AconnectionbetweenCAN-LIN,CAN-FLEXRAY,LIN-FLEX RAY is called as mixed network architecture.
ForMixedNetworkArchitecture,usuallygatewayECUisavailableattheendofdevelopmentcycleandhenceintegrationt estingcannotbedoneattheearlyphasesoftheprojectwhichleadstohigher completiontime.
Keywords: *Gateway ECU, CAN, LIN, FLEX RAY, CANoeSoftware,VN8900hardware.*

I. INTRODUCTION

Since the 1970's, an exponential increase in the numberof electronic systems has been observed that have graduallyreplaced those that are purely mechanical or hydraulic. Therising numbers of sensors, actuators and electronic controlsincreases the complexity of automotive networks. Moreover,multiple network systems have evolved to meet the differentrequirementscomingfromautomotiveapplications. AgatewayElectronicControlSystem(ECU)isacentralnetworkinterconnecting system to link various field buses in a vehicleas well as to route the required data from one bus to anotherbus. Thus, gateway ECU plays a very critical role in mixedautomotive network architecture. A gateway ECU is necessaryfor addressing the communication and network challenges intoday's vehicles.

Simulation of gateway ECU or rapid prototyping of gatewayECU using VN8900 hardware enables integration testing atearlyphasesofprojectandeventuallyhelpinreducingproject completiontimeandeliminatesissuesatearlyphasesofproject.Configuring VN8900 hardware as gateway ECU formixedarchitecture is less time consuming and less tedious. Vectoruses its hardware VN8900 which can be configured readily asperneedsofcustomerusingitssoftwareCANoe.CANoesoftwareisusedtosimulatethehardwareusingCAPLlanguag ewhichisinbuiltlanguagewhichcommunicateswiththehardwarewhichactsasgatewayECUformixedarchitecture.

Rapidprototypingof gateway ECUwillenable integrationtesting atearly stagesof projectwhichis needof hour inautomotiveindustry.Thisalsosatisfiesourmotivebehinddoing this project and making ECU effective for better use incars. Rapid prototyping of gateway ECU also ensures desireddata routing across different buses like CAN bus, LIN bus etc.This means accurate data is transferred fromsource bus todestinationbuswhichistherole ofgatewayroutingmatrix.

Aslot oftimeissaved,thenumberofeffortsforrepeatedtestedis also reduced which in turn saves money. This is becauseconfiguring VN8900 as per customer uses in different protocolis veryeasy.

Ex: -Possiblegateway inLPVsegmentshavingCAN-LINmixedarchitectureis:CAN-LINgatewayECU.
(LIN – Sensor's, Door Control unit …etc.), (CAN – Engine,Immobilizer,ABS).

II. LITERATURESURVEY

1) NXPHalbleiter Deutschland GmbH TechnicalInformationCenterSchatzbogen7:-
Buildingvehicleswithgateways–electronicdevices that enable secure and reliable communicationsamong a vehicle's electronic systems – is an emergingtrend in the automotive industry. Increased consumerdemand for greater vehicle functionality is driving morecomplexelectronicsincarswithanincreasednumberof computers called Electronic Control Unit (ECUs) withdifferentnetworkinterfaces.ModernVehiclescanintegrateover100ECUsconnectedovermultiplenetworks such as CAN (Control Area Network) , LIN(LocalInterconnectNetwork),FlexRayandEthernet.

2) VectorInformatikGmbHIngersheimerStraße24D –70499Stuggart:-
CANwasdevelopedbyRobert Boschinthemid-1980s. Earlier in the vehicle it becomes difficult forpoint-to-point communication due to increased wiringwhich makes system bulky. CAN is a serial bus systemused for interfacing different ECUs with the universalgateway ECU.Itis a message oriented multi-masterprotocolwithdata transmissionspeedup to 1Mbps.CAN provides flexible and robust communication withboundeddelayandhavinglowcostandsimplicity.

3) RalfSchwering,SoftwareDevelopmentEngineer,VectorInformatikGmbH:-
LINnetworkisbasedonMaster-Slavearchitecture. One network node is chosen to control allcommunicationcalledLINMaster.LINisalowcostandlowspeed(20kb/s) serialbusinvehiclecommunicationnetworkthatistypicallyusedforbody/comfortfunctions. LIN uses master/slave mechanism, in whichthe master node manages the message transmissions bysending header frame on the bus, and then the slave thatpossesses the message with the header sends the data.Today,LINiswidelyusedinthebodydomainofautomobiles becauseofbeingsimpleandlow-cost.

III. Software Requirements

1) <u>CANoeSoftware: -</u>

- CANoe is the comprehensive software tool fordevelopment, test and analysis of individual ECUs andentireECUnetworks.
- It supports network designers, development and testengineers throughout the entire development process –fromplanningtosystem-leveltest.
- By using this tool basically, we can do simulation of theentire network bus and we can simulate all the nodes onthesebuses.
- Itwillsupportthealltypesofcommunicationprotocolsthoseusedintheautomotiveindustry.
- The simulation and testing facilities inCANoe areperformed withCAPL,aprogramminglanguage.

TheusesoftheCANoesoftwareareasmentionedbelow: -

- Itswidespreaduseandlargenumberofsupportedvehicle bus system makes it especially well-suited forECU development in conventional vehicles as well ashybridvehiclesandelectricvehicles.
- CANoe supports CAN, LIN, Flex Ray, Ethernet andmost bus systems as well asCAN-based protocols suchasJ1939etc.
- CANoe is also used in industries such as heavy trucks,rail transportation, special purpose vehicles, avionics,medical technologyandmanymore.

IV. Methodology

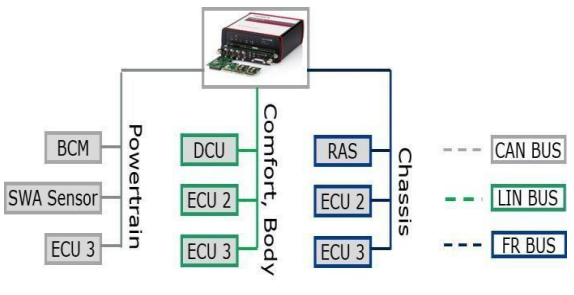

Fig 1:Gateway Concept

Fig3.1.1:GatewayConceptDiagram

From figure 3.1.1, powertrain, body, chassis run overdifferentbussessuch asCANbus,LINbus,Flex Raybus.
BCM- Body Control Module (BCM) is an electronic controlunitresponsibleformonitoringandcontrollingvariouselectronicdevicesthroughout thecar.

- Wheel speed data from Body Control Module (BMCECU) on CAN bus is required by DoorControl Unitforautomaticlocking.
- Wheel speed data from Body Control Module (BMCECU) and steering wheel angle sensor data from CANbus is required by Rear Axle Steering(RAS ECU) onFRbus.

DCU-TheDoorLockControlUnitisresponsibleforcontrolling and monitoring various electronic accessories ina vehicle's door. A modern vehicle contains a number ofECUs (Electronic Control Unit) and the Door Control Unit(DCU)isaminoroneamongst them.

RAS- Real Axis Steering operates very similar to the frontwheel steering. At high speeds, all four wheels will turn inthe same direction. At lower speeds, the rear wheels willturn in opposite of the front wheels, allowing for greatermaneuverabilityandfastercorneringresponse.

Building Blocks of CANoe

1) AnalysisWindow: -

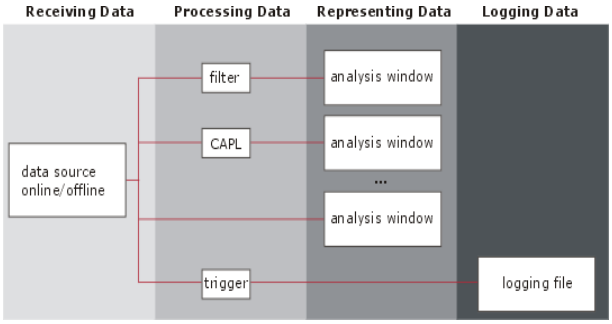

Fig5.1.1: AnalysisWindow

From fig 5.1.1, we understand different types of data such asreceivingdata,processingdata,representing dataandloggingdata.

- Configurationof measurementsetup withevaluationofdataisdoneintheAnalysisSetup.
- Analysis in CANoe is based on data flow from the datasource to the display or recording, in which the data can beadditionallyprocessed.
- Thedataflowisrepresentedgraphicallyinthemeasurementsetupandcanbeconfiguredthere.

2) SimulationSetup: -

- Insimulationsetup,theoverallsystemisdisplayedgraphicallywithnetworks,devices andallnetworknodes.
- With the interactive generator you can configure and sendmessages whilemeasurementisrunning.
- Depending on where we link yourinteractive generator,we caneithersend messagesto the busorcontroltheanalysiswithoutsendingmessages.
- We can configure messages within the transmit list andsignalswithinsignallist.
- Advantages ofCANIG:-
  - Quick,improvisedwaytoinfluenceameasurement.
  - NoCAPLprogrammingnecessary.

Database Editor: -

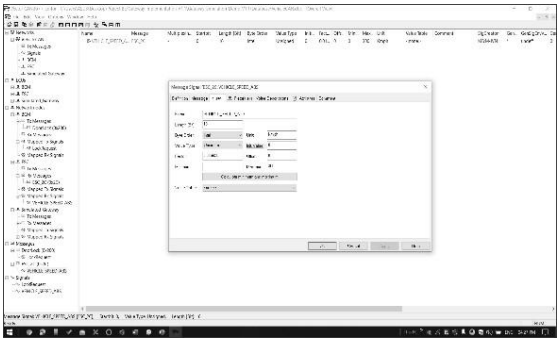

Fig5.3.1: -Database Editor

Fig5.3.1showcasesushowdowecreatedifferentdatabasebasedonourrequirement.

- Databaseare createdandeditedwiththe helpoftheCANdb++editor.
- Databasesconsistsofnetworknodes,ECU's,messagesignals.
- Wecaneditalltheaboveparametersasperourrequirement.
- AttributeDefinitionandValueTablescanbecreatedinthesimulationSetup.
- TheassignmentofDatabasesmustbemadeinSimulationSetup.

3) CAPL: -

- Based on C programming language, CAPL or CANAccessProgrammingLanguage,istheprogramming language used exclusively within thePC – based tool environments of CANalyzer andCANoe.
- CAPL is used in CANoe helps to monitor CANtrafficofrealmoduleandsynthesisofothermodules presentinthenetwork.
- CAPL is a C like language. Its structure is based onCandhasadditionalfeaturesrelatedtoCAN.

FeaturesofCAPL Language: -

- CAPLis aeventdrivenprogramminglanguage.
- EachCAPLprogramisatask,alltasksareindependent.
- EachtaskhasitsownONstartandONstopeventprocedures.
- Eachtaskcanhavennumberoftimers.
- CAPLhaveGUIusingpanelsusingsignal(CANoe).
- WritewindowactslikeoutputscreeninCprograms.
- Communication protocolfunctionsforRS32,TCP/IPareavailable.
- Hence,wecaninterfaceexternaldevices usingstdnetworkprotocol.

Panel Designer: -

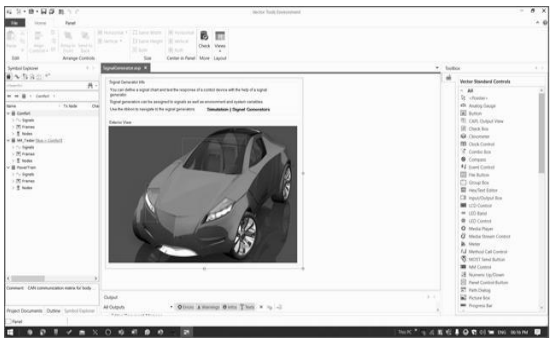

Fig5.5.1:Panel Designer

Figure5.5.1showsapaneldesignerwhichisusedtocreategraphic panels and also usedto checkthe message routingfromoneECUtootherECUviabus.

- Youcanuse the Panel Designer to creategraphic panelsonwhichthevaluesofsymbolscanbemodifiedanddisplayed interactivelybytheuserduringsimulation.
- It is used to check whether the message is routed

properlyfromoneECUtootherECUviaBUS(CAN,LIN,Flex Ray).

- So,the panelsimulation is controlled by the codewritteninCAPLbrowser.
- The panel helps us to get a better understanding about thehardwareintheactualenvironment.

I. CANoe Simulation Setup

1) Creation of Simulation Setup: -

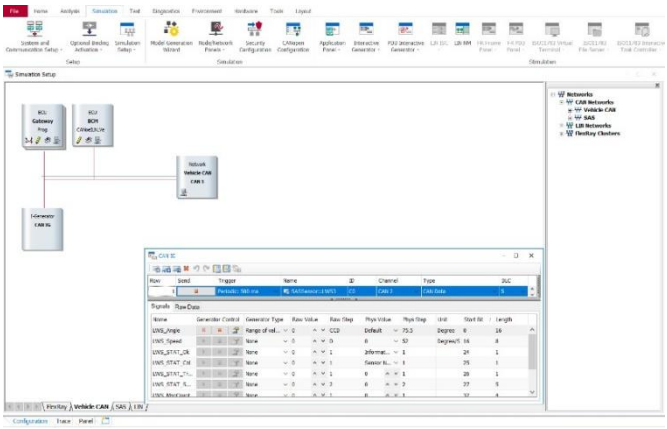

Fig:6.1.1SimulationSetup

From fig 6.1.1 we can see different nodes such as gateway ECU,BCM-ECU,VehicleCANandCANIG.

- We create different nodes like CAN IG, Vehicle CAN,BCM ECU, Gateway ECU as per the requirement in thescopeofwork.
- Then we configure the nodes in the CAPL browser as perthegatewayroutingmatrix.

a) GatewayRoutingMatrix: -

Source						Destination				
Database	Tx ECU	Message Name	Signal name	Length(bit)	Unit	Database	Rx ECU	Signal name	Length(bit)	Unit
VehicleCAN.dbc	ESC	ESC_2C	VEHICLE_SPEED_ABS	16	kmph	Flexray Cluster	RAS	VehSpeed	12	kmph
SASSensor.dbc	SAS	LWS_3	LWS_Angle	16	Degree	Flexray Cluster	RAS	StWHL_Angle	14	Degree
VehicleCAN.dbc	BCM	DoorLock	LockRequest	1	–	NA	Simulated_Gateway	LockRequest	1	–

Fig6.1.a: -GatewayroutingMatrix

Fromfig6.1.1varioussourcebusanddestinationbusesareshown.

- RoutingMatrixdeterminesspecificchoiceofroute.
- Routing Matrix defines from which source bus to whichdestination bus data should be routed and what data to berouted.

2) PanelDesigning: -

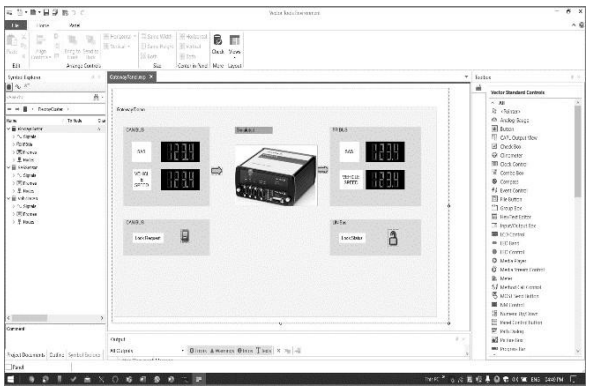

Fig6.2.1PanelDesigning

Fromfig6.2.1showcasestheoutputofsimulation setup.

- Panelelementsareselectedaspertherequirementsfromthetoolbox.

- Theswitchesareeditedandconfiguredfromtheattachedvariableblock.

3) CodeImplementation: -

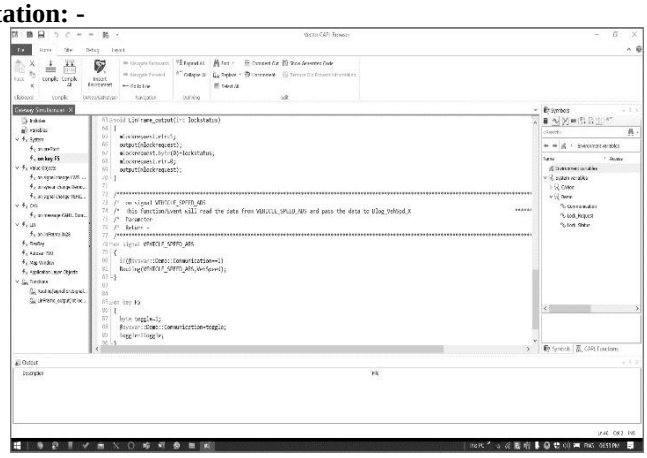

Fig6.3.1:CodeImplementation

Fig6.3.1showcasesthecodeimplementationrequiredinCANoe.

- Afterclickingtheeditbuttononthenodeinthesimulationsetupwearedirectedto CAPLbrowser.
- Differenteventhandlersareusedtowriteasuitablecode Ex: -OnSysvar,OnKeypress etc.
- Thecodeiswrittenasperthegateway routingmatrix and the required message is routed whichdecidestheentireexecutionofthesimulationsetup.
- Codeimplementationisdoneforbelowpoints: -
  - To start Gateway ECU routing on Keyboardevent(F3).
  - CANtoFRrouting.
  - CANtoLINrouting.

V. Future Scope

If number of signals / data to be routed is small, manuallyimplementing gateway logic using CAPL for routing data isgood approach, however if number of signals to be routedincreases standalone application to read routing matrix andimplement gateway logic will help in time reduction andeliminateredundantimplementation.

As VN8900 hardware approach supports different networkinterfaces (CAN, CAN FD, FR, Ethernet) it can be easilyconfiguredformixedarchitectureandgatewayimplementation for mixed architecture can be done usingCANoeinsimilarapproach.

VI. Conclusion

After testing Gateway ECU in simulation below points areobserved: -

1) CAN – LIN, CAN- Flex Ray architecture works asperroutingmatrixandverifiedusinganalysiswindow.[TracePanelGraph]
2) RapidPrototypingofECUfordifferentECUnetwork can be easily implemented using CANoesimulation.

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