Network Database Validation using dSPACE Simulator

JIHAS KHAN & RAKESH KRISHNA

TRANSPORTATION BUSINESS UNIT –HILS TEAM

TATA ELXSI

ABSTRACT

In modern times Network database tests have become a vital part of Automotive vehicle validation, these tests are used to prove out the network database of each of the ECUs. Though there are multiple Network management test solutions available in the market, they are all not comprehensive to address the challenges of modern day ECU network management requirements and doesn't have automation capabilities.

This "NetDM© - Network management validation using dSPACE simulator" paper is trying to address, how Tata Elxsi have implemented a Network database test solution using dSPACE HILS environment. NetDM© (Network Database Manager) is capable of addressing ECUs under a single CAN network, ECUs under Multiple CAN network and also a single ECU in a CAN Network.

INTRODUCTION

THE IMPORTANCE OF NETWORK MANAGEMENT

Most of the ECUs in the Automotive systems are deriving power from car battery especially when ignition feeds are turned off, for example : functions like Radio, Music systems, Phone, Power Window, Key FOB related activities etc. Network Management functions are critical when the Battery power is to be managed efficiently. And this is achieved by identifying sleep states or low power modes during the ignition lock/off.

Network Management functions are part of modern day ECUs which are implemented through a dedicated layer called network layer, which controls the bus activities related to the network. Network Management functions are required to wake up the system during the scenarios like : Key Fob activities, Passive Entry, Door Open etc. Network Management tests are therefore necessary to ensure proper sleep and wake up functions of an ECU network.

The essential task of Network Management is to ensure the safety and the reliability of a communication network for ECUs. The level of Network Management required depends upon the node type of the ECU, for example : modules that are capable of waking up the other nodes on a network will require more complex Network Management functions than those powered from an ignition feed.

NetDM© OVERVIEW

NetDM© is an efficient way of implementing Network database test management through dSPACE HILS system, this method analyzes the Network Management messages to a much deeper level and conforms its adherence to the latest Vehicle Networking Standard.Direct Network Management principle is implemented as part of the NetDM©, and a 'Logical Ring' is formed to monitor the nodes in the network. NetDM© will analyze the wake-up and sleep patterns of permanently powered ECUs.

NetDM$^{©}$ allows automated Network database tests with a minimal human intervention, and NetDM$^{©}$ is highly reliable in identifying Network Management errors, which are very significant to the overall vehicle performance especially like the case of ' Ignition Off Drain Current issues'. Usage of same Vehicle Networking Protocol by most of the OEMs for designing the network layer of their ECUs points to the relevance of NetDM$^{©}$ in the current scenario. NetDM$^{©}$ is capable of proving the conformance of any vehicle network to the latest Vehicle Networking Standard and also conformance to any OEM specific Network Management requirements.

MAIN SECTION

NetDM$^{©}$ ARCHITECTURE :

NetDM$^{©}$ is a combination of multiple capabilities implemented through a MATLAB/Simulink environment, Microsoft Visual Studio environment and Python scripts. Algorithms for simulating the latest Vehicle Networking Protocol conditions and checks are implemented through Matlab/Simulink environment, NetDM $^{©}$ contains following algorithms:

 Interfacing Algorithm : allows NetDM$^{©}$ to be integrated with dSPACE Simulator, through the RTI CAN Multi Message BLOCK SET. NetDM$^{©}$ access the CAN Interface and thereby act upon ECU network. A combination of NetDM$^{©}$ and ControlDesk would ensure a successful model variable access.

DBC file extraction algorithm : (Keeping Vector CAN DBC File format as standard) makes the DBC file available to the model in an easily readable format.

Protocol Timing algorithm : calculates the timing intervals between different Network Management Messages with utmost precision.

Network analyzing algorithm : searches for any network protocol violations continuously. Entire Vehicle Network is analyzed with reference to the logical ring, sleep-wake up patterns etc.

Automation Algorithm : Model File generation is automated using an m-file depending upon the customer requirement.

Simulation Algorithm : E.C.U simulation and Network Management error simulation is done here.
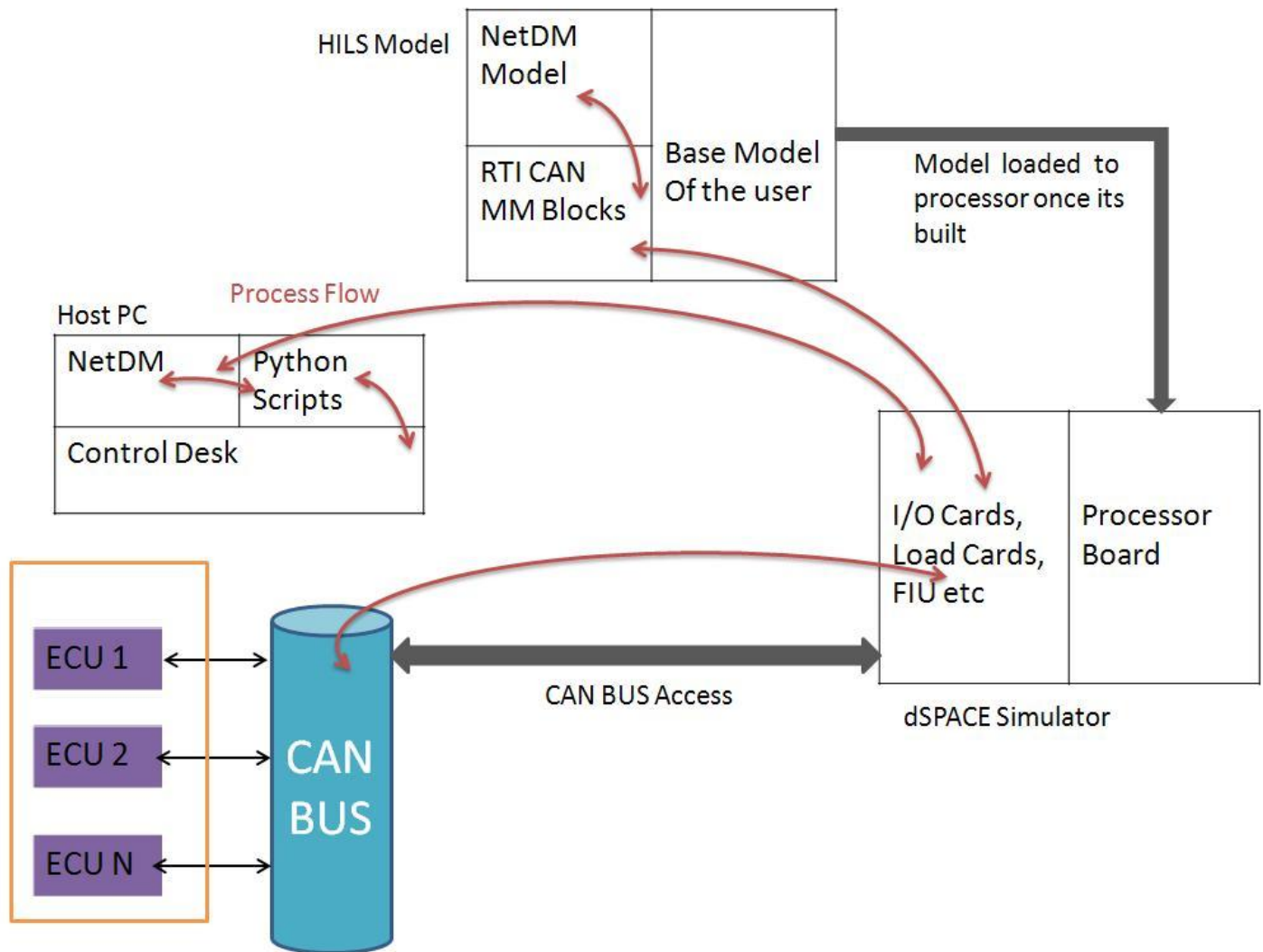
1)Fig.1: The HILS Setup used for NetDM$^{©}$

NetDM$^{©}$ OPERATION

NetDM$^{©}$ could test Network Management behavior of a single ECU or a network of ECUs.

If it's a Multi ECU Network (With more than one ECU) , NetDM$^{©}$ checks whether :

- Logical ring formation is according to the standards and to display it pictorially using animations in the GUI: (Network Management Implemented ECUs will form a logical ring for the synchronized behavior of the Network)

- Proper sleep implementation of the CAN BUS is maintained in all scenarios.

- Proper wake up implementation of the bus is not violated.

- Entry and skipping of an ECU in the logical ring is according to the standards.

- Error recovery after bus-off is satisfied

- Ignition Off Drain Current is within limits.

- Time interval between different Network Management messages is within the limits.

- Bus Load at any instant is within the safe limits. Test Engineer can also increase or decrease the busload using NetDM$^©$ and see how the CAN BUS responds to these variations.

- All the ECUs have sent an Alive message at least once.

- The start up time and shut down time of the network are within limits.

- Master Configuration ID is successfully acknowledged.

- All modules implement bus-off recovery robustly and return to normal operation following a bus-off event.

If the Network Management of a single ECU is to be tested, NetDM$^©$ does the following :

- NetDM$^©$ Simulates two ECUs. A Logical successor and a logical predecessor to the real ECU. Entire Network Management Protocol of a real ECU is simulated inside the simulated successor and the predecessor. This helps NetDM$^©$ to check the network protocol of the Real ECU under all conditions.

Two other hurdles in the Network Management implementation faced by most OEMs are :

- Rate of the Network Management communication in a network should be controlled to reduce the Bus Load.

- Network Management Messages should be synchronized to avoid negative effects on application data by message bursts.

NetDM$^©$ can test these effectively.

A single Network Management Test can be repeated 1000/10,000 times as the test engineer wish, using NetDM$^©$. Repeatability of a single test is very important from the point of view of Network Management.

Test report shall be generated after the Test cycle completion. Report shall have test description and Pass/Fail information of each test.

- Checks conformance of Vehicle Network to the latest networking protocol

- Checks the logical ring formation procedure of the ECUs

- Presence of a proper network sleep and wake up is conformed

- Ignition Off Drain Current, NM Timing Parameters, Bus Load are calculated in real time and makes sure that they are within limits
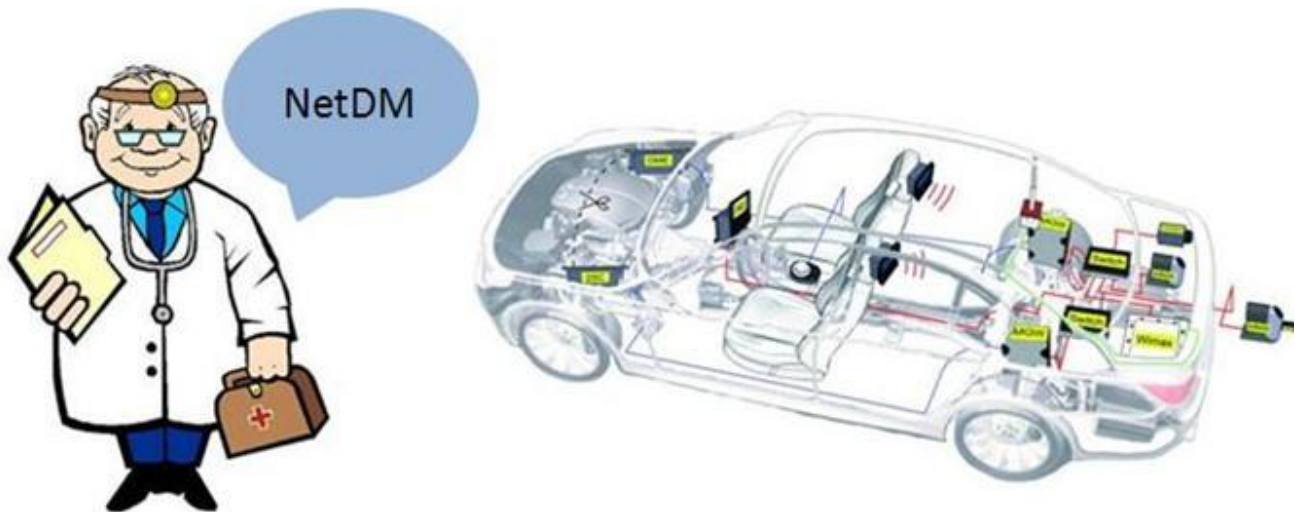
- Master Configuration ID check test, Bus Off Recovery test are done

- Testing of a single ECU or a network of ECUs, can be done with the same tool

- OEM specific NM tests could be easily integrated to NetDM©

- Very elegant GUI, descriptive test result generation are the other highlights

Fig..2: NetDM© diagnosing the vehicle network through different tests

NetDM© displays the following in the GUI:

- Current status of the logical ring (Alive, Ring, Limp Home, Sleep)

- A trace showing all the Network Management messages coming in the CAN BUS, using different views along with the time stamps.

- Bus Load

- Test Status

- Network Protocol violations

- ECUs that exited from the current ring

- ECUs which do not require CAN BUS right now

- Which ECU took the decision to send the CAN BUS to sleep.

An elegant and attractive GUI is used for displaying these information in an orderly fashion.

OEM Specific Network Management Tests can also be integrated to the NetDM$^©$ with ease.

dSPACE SIMULATOR USAGE:

The simulation model of NetDM$^©$ will run on the processor hardware (single-processor or multiprocessor systems). dSPACE Simulator Mid-Size/Full-Size generates and measures I/O signals via the integrated dSPACE I/O boards.

NetDM$^©$ makes use of RTI CAN Multi Message Blocksets of dSPACE available in the MATLAB Simulink Library Browser for interfacing the model logic to dSPACE hardware. Different APIs of Control Desk is used to access the model variables using an efficient Python Script.

BENEFITS

- Significant cost reduction in comparison to other test methods.(An existing HILS setup can be used for a network management test without any additional hardware requirements)

- Currently Network management is tested using general tools which are designed for some other purpose, this results in an incomplete test process. NetDM$^©$ fine tunes the requirement, so that a complete network analyzing is possible with no room for errors

- Testing of NetDM$^©$ in the HILS setup has proved that, its far better than the existing test solutions.

- Easy to test and can accommodate higher levels of testing.

- AUTOSAR Compliant.

STANDARDS

   Latest Vehicle Network Protocol

SYSTEM REQUIREMENTS

   dSPACE Full Size or Mid Size Simulator
   dSPACE ControlDesk 3.7.1 or higher
   MATLAB 2006 or higher

OPERATING SYSTEMS

   Windows XP (32-bit, SP3) and Windows 7 (32 + 64-bit, SP1)

GENERAL PC REQUIREMENTS

Processor clock $\geq$ 1.5 GHz
RAM: $\geq$ 500 MByte for Windows XP
$\geq$ 1 GByte for Windows 7
Python
.NET Frame Work 4.0 or greater

LANGUAGES USED FOR DEVELOPING NetDM$^©$:

MATLAB
PYTHON
C#

SPECIFICATIONS FOLLOWED FOR NetDM$^©$:

CAN DBC file in VECTOR format
MAAB Guidelines for Modeling

CONCLUSION

When put together, NetDM$^©$ is a complete Network Management Test solution using dSPACE simulator environment, which is easy to implement and have automation capabilities. NetDM$^©$ can cater to the varying Network database prove out requirements of the OEMs.

REFERENCES

1. DSPACE DOCUMENTS

LINK : http://www.dspace.com/en/inc/home.cfm

CONTACT

Jihas Khan
Mail id : jihask@tataelxsi.co.in

Rakesh Krishna
Mail id : rakeshkrishna@tataelxsi.co.in

DEFINITIONS, ACRONYMS, ABBREVIATIONS

HILS (Hardware-In-the-Loop Simulation) : is the method used to test the functions, system integration, and communication of electronic control units

NetDM© (Network Database Manager) : is the Automated Test Tool for testing the Network Management of an in Vehicle Network (CAN) with reference to the Standard Network Protocol

CAN : Controller Area Network

LIN : Local Interconnect Network

ECU : Electronic Control Unit

GUI : Graphical User Interface

SDF : (Standard Data Format) File obtained, once the MATLAB Model is built using Real Time Workshop

MAAB : (MathWorks Automotive Advisory Board) a Board focusing on the usage and enhancements of MathWorks controls, simulation, and code generation products including Simulink, Stateflow, and Embedded Coder.

API : Application Programming Interface

OEM : Original Equipment Manufacturer