IJIRMET ISSN (Online): 2456-0448
International Journal of Innovative Research in Management, Engineering and Technology
Vol. 3, Issue 3, March 2018

A Review On Evaluating Determinism In Industrial Ethernet Of Certain Designs

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Abstract: ***The enhancement in speed of Ethernet and as Ethernet based protocols are replacing the serial networks, we come to know that the industrial automation and process control technology has been gradually changing for some decades now. The emergence of digital fieldbus technology has enabled innovation and powerful devices with access to great information, greater accuracy and reliability, and lower wiring costs than previous analog current loop system and direct serial technologies. The design of Ethernet was made for office applications and as it is not deterministic (due to CSMA/CD, latency, queueing in switches, etc.), to fulfil the requirements of industrial automation and process control the concept of real-time industrial Ethernet was introduced to the market. POWERLINK is the most known of these real-time industrial Ethernet solutions used for master slave applications. openPOWERLINK is a software protocol based on standard Industrial Ethernet available on GitHub and source forge websites. This paper includes fixing of some issues or addition of new feature to openPOWERLINK stack. By this work, the customer can work more efficiently in this stack and for industrial automation technologies.***

Keywords: POWERLINK, real-time industrial ethernet, GitHub, Source Forge.

I. INTRODUCTION

Real-Time Ethernet (RTE) is a communication architecture using standard Ethernet hardware with various modifications which introduce real-time and deterministic property to meet the requirements of industrial control system. These technologies are commonly deployed in distributed control and automation systems and are gradually replacing traditional field buses mainly due to the high bandwidth availability and inherent support for vertical integration of automation networks from the field level with the office domain at the enterprise level of the automation pyramid.

Protocols for industrial ethernet include Powerlink, EtherCAT, EtherNet/IP etc. Many of these protocols use a modified MAC (Media Access Control) layer for providing low latency and determinism. The protocol specifies what kind of data messages are sent over the Ethernet network, and some other characteristics like how a message is also being identified and what actions the technology must take to send and receive data. Protocols are needed for a simple reason: for two or more devices should be able to communicate with one another by the same language.

II. POWERLINK PROTOCOL

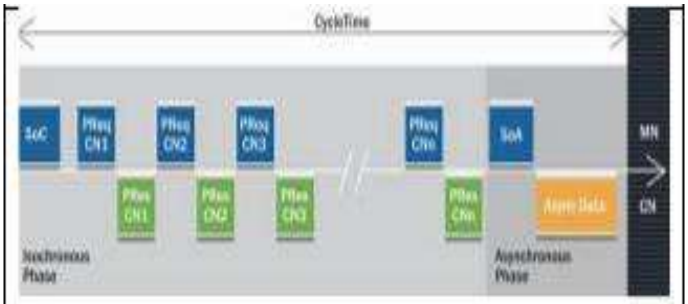
Powerlink protocol was introduced in 2001. It is a vendor-independent, software-based communication system. It also includes real-time capabilities and complies with the IEEE 802.3 Ethernet standard. Another feature of this protocol is it offers users to deploy any network topology. In this system, a Managing Node ensures proper cycle timing on the network, so all devices are synchronized, and data is being sent and received properly. Controlled Nodes receive the data MNs send.

The deterministic fast reaction time of POWERLINK is ensured through a mix of timeslot and polling procedures. Therefore, one node is arbitrarily designated to function as the so-called Managing Node (MN), i.e. serve as the "moderator of the conversation." All other devices operate as Controlled Nodes (CN). The MN defines the clock pulse for the synchronization of all devices and manages the data communication cycle. During one cycle, the MN successively polls each CN.

There are three periods in a POWERLINK cycle:

Start Period: This is when the MN sends a start message frame to all CNs on the network to synchronize the devices.
Cyclic Period: This is when the cyclic isochronous data exchange occurs, allowing for optimized bandwidth.

Asynchronous Phase: This is the start of the phase that makes it possible for the network to send large, yet non-crucial data messages between devices.



SoC: Start of Cycle, SoA: Start of Asynchronous,
PReq: Poll Request, PRes: Poll Response,
MN: Managing Node, CN: Controlled Node.

Fig 1: EPL Cycle

Open POWERLINK is an open source industrial Ethernet solution provided by SYSTEC electronic, B&R, Kalycito infotech. It contains the Ethernet POWERLINK protocol stack for the Managing Node (master) and for the Controlled Nodes (slaves). It is released under the BSD License.

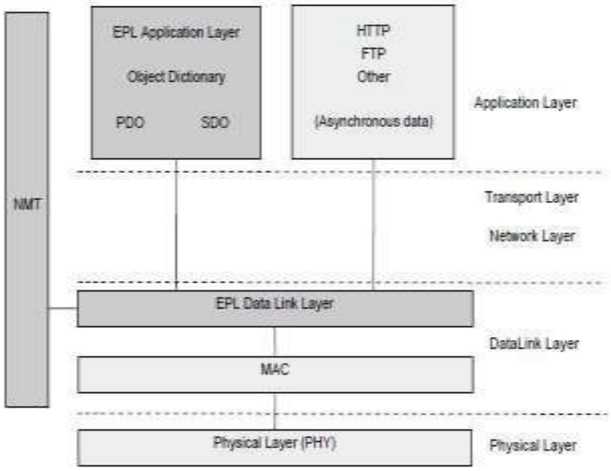


Fig 2: Abstract Model of open POWERLINK

The EPL stack is divided into two parts: low prioritized processes above the Communication Abstraction Layer (CAL) called EPL user part and high-prioritized processes below the CAL called EPL kernel part. Processes which must be processed in every EPL cycle have high priority, e.g. Data Link Layer (DLL), PDO processing and core NMT state machine. All other processes have low priority, e.g. SDO. It is possible to swap out the high-prioritized processes on a separate CPU (e.g. on a SMP machine) to ensure the real-time requirement. The CAL is the communication layer between Kernel and User in Powerlink stack.

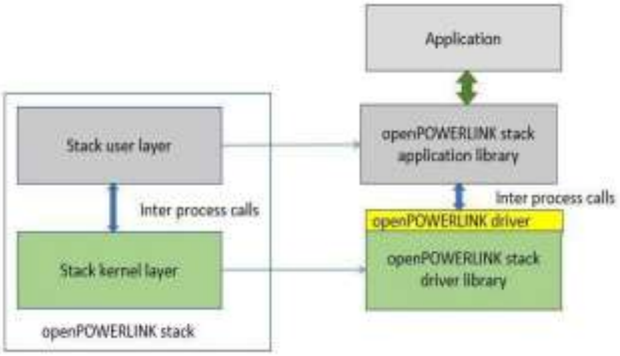


Fig 3: Stack Build options

III. PROPOSED PLAN

The proposed plan for doing the project is explained by the flow chart below. The work in this project is that there are some issues raised on git hub/openPOWERLINK page, which are going to be rectified by making some changes in the stack or code or some addition of new feature will be done.

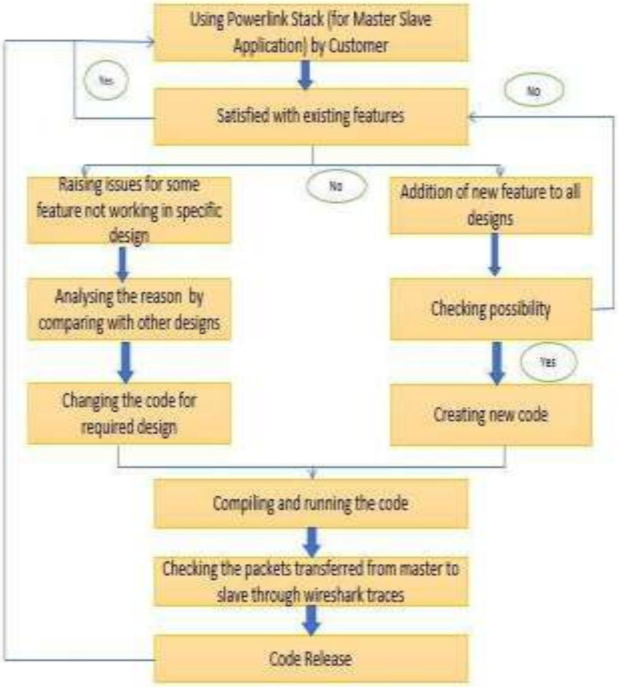
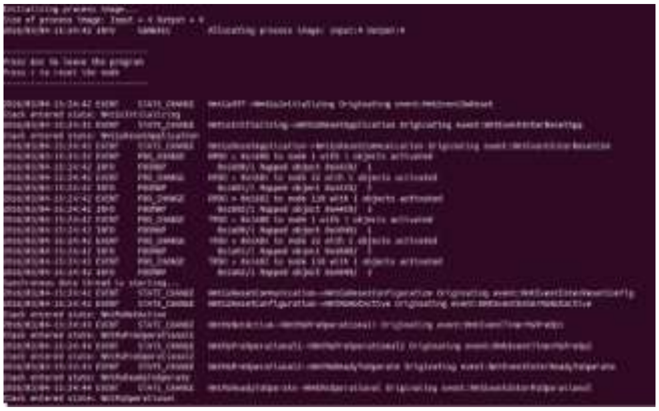

Using Powerlink Stack (for Master Slave Application) by Customer
Yes
No
Satisfied with existing features
No
Raising issues for some feature not working in specific design
Addition of new feature to all designs
Analysing the reason by comparing with other designs
Checking possibility
Yes
Changing the code for required design
Creating new code
Compiling and running the code
Checking the packets transferred from master to slave through wireshark traces
Code Release

Fig 4: Flow Chart

The first step is that we need to understand the issue, then reproduce the issue to check whether the same occurs in our testing also. Then analysing the working of the same in other designs. Then trying to know the reason for the issue in that design. Making modifications in the code by traversing the code with the help of eclipse software and then compiling it and checking whether the issue is rectified or not through Wireshark traces by noticing the required packets have been communicated or not within the networks. If it is rectified, then the changes are verified by Gerrit code review and then pushed to the openPOWERLINK stack for the customer to use for their automation.



```
Initializing process image...
Size of process image: Input = 4 Output = 4
[illegible]

-------------------------------
Press Esc to leave the program
Press r to reset the node
-------------------------------
[illegible]
```

Fig 5: Operation of master to control slave

3.1 Eclipse Software

Eclipse is an open source Integrated development environment used for computer programming (C, C++, Java, PHP, etc.) and easy tool to identify the compilation errors. Through this software one can create java or c code programming for any development or traverse the functions to know where it is called. Thus, with this software one can easily compare the code with another. This software helps in Powerlink stack is that one can easily identify where the error occurs for the issue. We can also create the new feature for all designs.

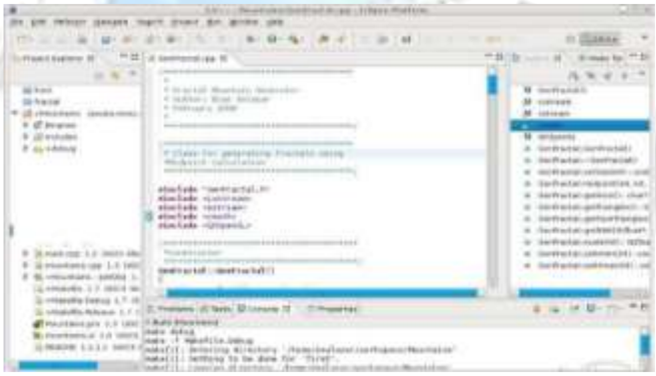


Fig 6: Eclipse Software

3.2 Wireshark Software

Wireshark is the free and open source tool used for packet analysing. It is used for tracing the packets communicated between two networks. It can display the packets along with their meanings as detailed as possible specified by different networking protocols. Captured data's can be filtered, programmatically edited and even converted via command prompt.

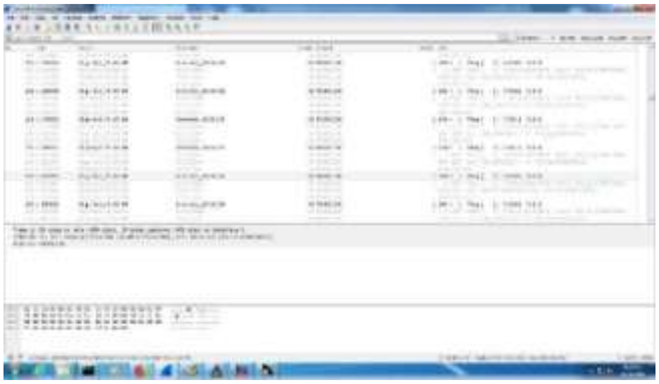


Fig 7: Wireshark traces

3.3 Gerrit Software

Gerrit is a web-based code collaboration available for free where software experts or developers can review other's code and give suggestions for the change as commands or do modifications on the code. Thus, before merging the changes of the code in Powerlink stack it is send for code review and after reviewing the code to a perfect stage it will be released on websites like git hub or source forge. Once the code is released in git hub it will be merged with the existing code thus the customers can use them as per their requirement for the automation.

IV. DETERMINISM EVALUATION

The existing Powerlink version is develop-2.6.2, and now going to release the new version of Powerlink as develop-2.7 by the addition of new features and fixing of issues. The new release will make improvements in the performance of operating based master and slave applications. The handle of Powerlink (Real time Ethernet) makes it even conventional to work on operating systems like Windows or Linux as making the deterministic network. This updating the stack implies that the customer will be ready to use this more efficiently. The jitter and cycle time can also be adjusted for making the Powerlink more efficient as per the requirement from the customer. Another important performance of Powerlink is that the response time of MN and CN. In Powerlink the response time is low which gives a high bandwidth for the usage of the bus. Thus, a high accuracy can be achieved using this Powerlink stack.

V. CONCLUSION AND FUTURE WORK

The Powerlink Stack can be used for both Linux and Windows for different designs as required by the customer for the industrial automation. The high cycle time accuracy provided by this stack will be more sufficient for many industrial applications. As this is a open source solution, provides everyone to implement a cost effective control solution. The technologies that are used by this Powerlink stack are CNC Robotics, Condition monitoring, Industrial IoT, Closed loop control. The products produced are mobile automation, industrial PCs, transport systems, network and fieldbus modules, power supplies and other accessories. The future work of evaluating determinism is that now the accuracy comes to 9ns for 250us jitter time, to improve this value for connecting many CNs at the same time.

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