Prototype Implementation of RTnet in Industrial Distributed Control System

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Abstract - **The aim of this work is to implement RTnet in industrial distributed control system environment. RTnet it is one of the hard real-time network protocol stack introduces a hardware independent and flexible communication in real time environment. Now-a-day's real time communication is one of the key feature in Distributed Control Systems. In this work, we proposed a prototype system for the real time data acquisition and monitoring with real time compliant data transfer both qualitatively and quantitatively in industries. In this system it consist of One Master node and two slave nodes in which all are working under Xenomai (real time operating system) and on top of this RTnet protocol stack is built .The slave nodes are connected to field elements for data acquisition via RS485 and communicate with master node via RTnet. Low latencies and jitter and gives deterministic behavior in industrial distributed control systems.**

Keywords - **RTnet, Xenomai, Deterministic, Real-time.**
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I. INTRODUCTION

Presently the use of the Xenomai in embedded system is more popular because it is well suitable for hard real-time network. Xenomai is a real time development frame work cooperating with Linux kernel. It implements micro kernel with real time scheduler. It is having priority domain than Linux kernel. It is having its own API for the creating real time tasks, semaphores etc. Distributed Control system (DCS) [1] refers to the control units which are widespread in the system each may control its own sub units.

The whole system is connected in network and communicates and monitor of the entire system. Therefore Communication between these units should be hard real-time requirement and fast []. It has been known that by using the Ethernet in industrial networking is non deterministic in nature because the media access control (MAC) of Ethernet is the contention-based carrier-sensing multiple access collision detection (CSMA/CD) that produces non deterministic in nature []. Why because when two nodes send the data at a time to the common bus then it will go to (CSMA/CD) provides a delay for transmission of data. RTnet overcome this disadvantage and makes Ethernet network is used in real-time communication networking.

RTnet supports almost all Network identification card (NIC) drivers. It is implemented like UDP/IP protocol so that makes fast, reliable in nature [2][5]. It allows the token based network protocol [2]. Its supports POSIX socket API to real time user space process and kernel modules. RTnet uses its own stack implementation.
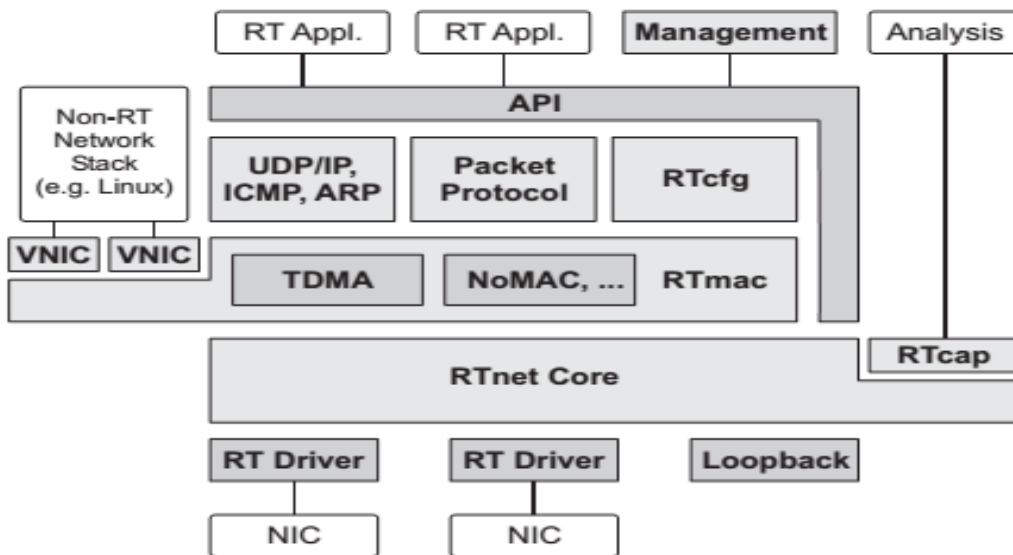
II. OVERVIEW OF RTNET STACK:

Fig1: RTnet protocol stack.

1. Packet management:

RTnet implements the real-time capable protocol stack. In One of the important parts of the RTnet is the packet management .packets that to be transmitted first passed to the stack in the context of the sending task therefore real-time application or internal RTnet service the packets that are received are first passed to the network controller driver to stack manager.

2. UDP/IP layer:

In RTnet implementation of the UDP/IP is bit different firstly the address resolution protocol (ARP) in static in nature normally they will be dynamic in nature. If the destination address is later unknown then it will gives transmission error in return to the caller.

Second, the routing process was simplified in nature it has limited amount of entries in the routing table and the table contains the ARP results also like hardware address.

Network interface cards (NIC) layer:

It's quite different from the normal driver model for getting the accurate time stamps. It does not depends on inbuilt time stamps clocks of the NIC, in this driver only provide the time while receiving of packet and transmitting of the packet from NIC driver.

3. Real time media access control (RTmac) layer:

RTmac is optional to RTnet but to get deterministic access control of the data RTmac is mandatory. The basic functionally of RTmac are control of incoming data and outgoing data by redirecting to specific handler. For every NIC registered a individual MAC is registered.

In this TDMA is one of the main services of the RTmac layer .RTnet provides the time slot based MAC discipline in which master and slave based protocol. In this slave node can join to the network at any time if it knows the slot parameters. Slot parameters are those at which slot of time the node can send data to master node. At first Master node will send synchronization frame to slave nodes in the network. Then slave nodes will send the calibration frame to master nodes. Synchronization frame contains the transmission time stamp the value of reference clock located at Master and scheduled transmission time, contains the reference time with when transmission was intended to perform.

4. Real time configuration services (RTcfg):

It is used for monitoring the active nodes in the network and transferring the physical and logical address between the nodes. It is based on the server-client based protocol. It is used for maintain the ARP table in the server side. In server side it stores parameters sets of every managed client in the network.

5. Application programming interface:

By using these, applications programs can be attached to RTnet through it POSIX conforming sockets and I/O interface. This socket interface is deterministic in nature for UDP and packet data exchange.

III. OVERVIEW OF RS485:

It is the standard cable for communicating long distance and at electrically noise areas. The mode of operation is differential data transmission, up to 32drivers and 32 receivers. Maximum cable length is about 4000ft and data rate is about 10Mbps.it is defined under physical layer. Different types of Network topology [7] accepted are point-point, multi-drop, multipoint. The RS-485 standard can be used to implement 'two-wire' or 'four-wire' networks, which distinguish half or full duplex communications. Two-wire networks use the same pair of conductors for the go and return signals, implying that only

one device on the network may transmit at any given time. Four-wire networks are capable of 'full-duplex' RS-485 communications because data can travel along both twisted pairs simultaneously.

IV. EXPERIMENTAL SETUP

In a distributed control system is realized with the concern of the zero data loss. Proposed system is shown as in Fig2, in this setup it consists of the two Slave nodes for data acquiring like temperature, humidity etc..., and one master node for controlling their respective slaves.

1.Field elements:

STM32f3 are used in my proposed diagram as it is used to sense and acquire the industrial environmental data like temperature, pressure etc…, For this purpose STM32f3 ARM cortex m4 board is used in which it consists of On-board ST-Link/V2.

This board has large set of sensors like digital linear acceleration sensor, digital magnetic sensor and communicating with slave node through UART, STM32f3 has TTL logic for communicating with RS485 so it required MAX485 for logic conversion.

2.Slave Node Implementation:

The slave node (PC) is installed Xenomai which is RT extension of Linux and RTnet works over it. These slave nodes are communicated with the field elements via RS485 through a real time driver module. The temperature sensor is connected to the STM32f3 discovery board for data acquisition. It is operate scanning its inputs temperature at fairly fast rate. The slave node have ability to do some processing such as change the state processing and time stamping of changes. When polling by controlling master, the salve will respond to the request, which may be as simple as "give me all your data", to do any control function to be executed.
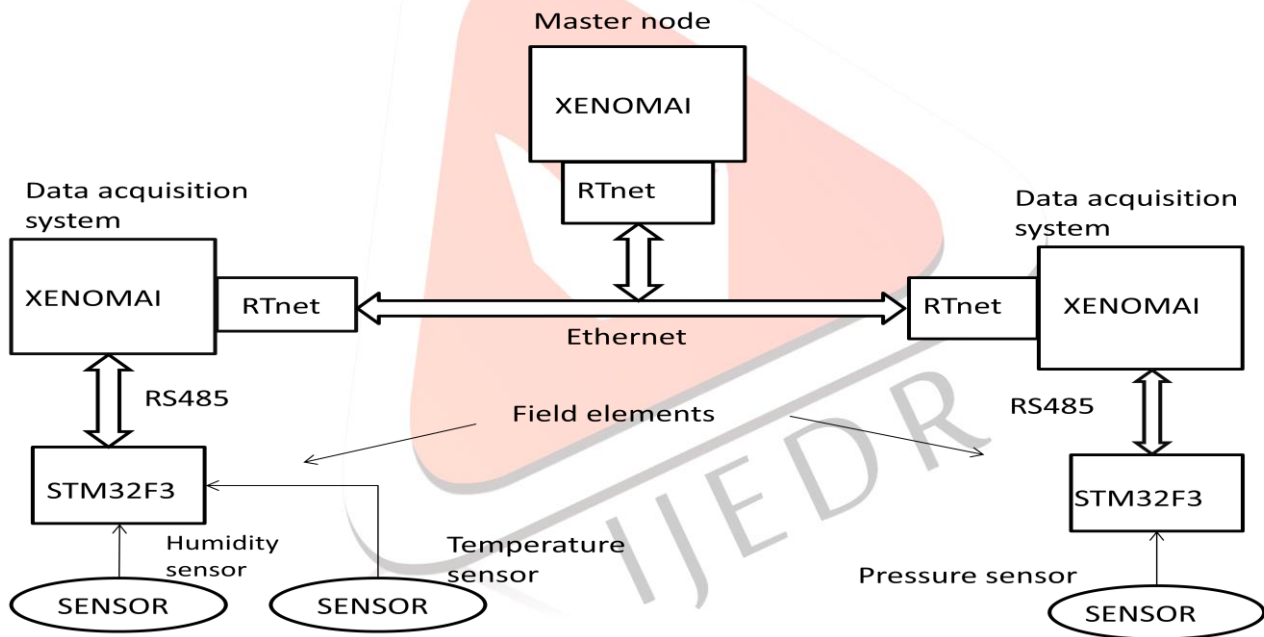
Fig2:Block diagram of proposed system

3. Master Node implementation:

Master nodes (personal computer) works under the Xenomai on top this RTnet was built. These Master nodes are identical hardware configuration and control real time application runs on both. To work on RTnet, first we want to block the normal Ethernet driver and we want to enable the real time Ethernet driver. After that, load the required Rtnet real-time modules into kernel. To communicate between them Master and slave nodes first it requires configuration on both nodes.

1. Master node will send the request packet to the slave node.
2. Then slave node respond and send the data acquired to the master node.
3. For every 10msec the request packet to data acquisition system is sent from master node.
4. Packet is processed only after checking the CRC code.
5. If it is not matching the packet was dropped.
6. If the packet loss is occurs more than the 2 cycles from data acquisition system that particular system is failure.

By communicating between the slave node and field element via RS485 and from master node to data acquisition system fig3.shows the result of this communication.

Fig3. Acquiring the temperature from field elements.

Conclusion:

By implementing RTnet protocol in Distributed Control System (DCS) gives deterministic communication over Ethernet. Data communication from master node to slave node in real time environment without any data loss,with low lattency and low jitter value.

Acknowledgment:

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