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PICNET Network Configurator for Distributed Control System

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Abstract: In this paper, a method for the efficient implementation of the PICNET network configurator for a distributed control system(DCS) is proposed. The network configurator is composed of the time parameter estimator and the period scheduler, the file generator. The main role of network configurator estimates time parameter, the pre-run time scheduling of the user input and make the period transmission table for operating the PICNET based distributed control system.

Keywords : PICNET, Network Configuration, Pre-run time Scheduler, Time Estimator, Period Transmission Table

1. Introduction

Time is an important characteristic that should be taken into account in an industrial environment. Real-time systems are systems in which each task must not only be functionally correct but also meet its timing constraint. So, each task can only be invoked after its ready time, and must be completed before its deadline. A common approach to characterizing hard real-time tasks with repetitive requests is the periodic task model. In periodic task model, every task needs to be executed once during each of its periods[1,2]. In this model, each task T_i has a period P_i and an execution time. T_i must be executed once in each of its periods. A execution of the task in any one period is scheduled independently of a execution of the same task in other periods[3]. That is, each execution, called a job request (or simply, a job), of a task has a fixed ready time and a fixed deadline, which are the beginning and the end of its period, respectively. Every job must start its execution after its ready time and completes before its deadline.

The studies on the Distributed Control System network, which is necessary for considering real-time property[4,5]. In some DCS applications, the control network system consists of two systems, a data gathering system, and an event data processing network system. A data gathering network system exchanges data which are collected in each consisting network node on the spot. This exchange occurs periodically. An event data processing network system processes a urgent message and data. In plant environment, the network is called as a control network generally[6,7].

In considering the real-time property of a network, it depends on the network MAC method mostly. The IEEE 802.4 token-passing bus access method, one of the popular timer-controlled token-passing bus access method, is widely adopted for control networks of DCSs. Since the network user can control the rotation time of the token, the real-time and deterministic data transmission can be obtained using this method. In addition, the method provides a priority scheme, which can be efficiently used for urgent data transmission. Thus, the IEEE 802.4 token-passing bus access method can be considered suitable for a control network in a DCS. According to the standard, the IEEE 802.4 token-passing bus access method is used together with the IEEE 802.4 physical layer[9,10,11].

In this paper, the network configurator of the token bus network based 802.3 is proposed. The network configurator is composed of three parts. The time parameter estimator is estimates THT(Token Hold Time), TTRT(Target Token Rotation Time), etc. The time period scheduler is transformed the input period into optimal period based LCM. The file generator is generates *.c, *.h file for application. The proposed method is focuses on the effective pre-run time scheduling. Memory reduction resolving scheduling methods and time parameter estimation(as lke token rotation time) for the network to satisfy the corresponding system constraints. To solve this memorization and time constraints, it modifies the period of each variables to reduce the size of the scheduling table. A control network using this method is implemented and applied to a DCS system. This paper is organized as follows: Section 2 presents architectureof PICNET. Section 3 presents the architecture of PNC. Finally, the experiment and the conclusion is drawn.

2. Plant Instrumentation and Control Network

The PICNET network architecture use the IEEE 802.4 token-passing bus. The proposed method is based on a network architecture combining the merits of the IEEE 802.4 token-passing bus access method and the IEEE 802.3 physical layer[13]. The IEEE 802.4 token-passing bus access method and the IEEE 802.3 physical, it can provide reliable and deterministic communication services. They define different symbol systems, different frame formats, and different interface functions. Therefore, develops a physical layer service translator to provide an interface between the IEEE 802.4 token-passing bus access method sublayer and the IEEE 802.3 physical layer. Example of PICNET based DCS is shown in Fig. 1.

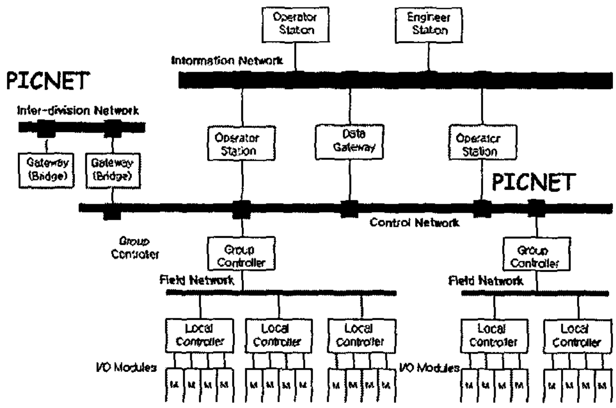

Fig. 1 Application Example of PICNET

3. PICNET Network Configurator(PNC)

The PICNET Network Configurator is operated as following procedure(Step1-Step5).

Step 1: Pre-processor replace predefined value and input data is trimmed and verified for the suitable input of PNC.

Step 2: For the efficient usage of databae, the parser make the database table .

Step 3: Within the period bound, input period transformed to optimal period for the scheduling.

Step 4: Transformed periods is allocated in the period transmission table.

Step 5: *Through the time parameter, determine the* availability of generated table and make file for application process

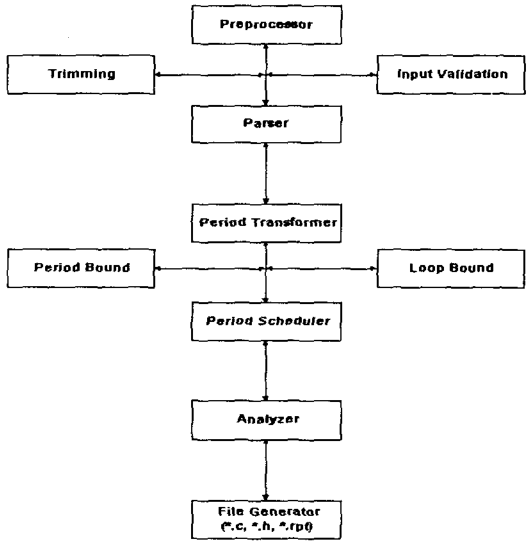

Fig. 2 Architecture of Network Configurator

For the application program, NIU(Network Interface Unit) is initialized in first. In initialization of NIU, the nm_h_initialize( ) function transfer initialization parameters to NIU. This parameter are adjusted by the configuration and application or determined by expert. These parameters must set during initialization. The user make netfile(as like Table1) for previous setting in network. As inputs, network file is used for application file and emulating ROM. In this process,

Table. 1 Sample of User Input File

network PICNET_NP	h_receives:
{	PRES_3
	TEM_5
stations:	ID_6
NODE_1 0x0002	s_receives:
NODE_2 0x0004	PRES_3
NODE_3 0x0006	ID_4
groups:	TEM_5
GROUP_1 NODE_1 NODE_3	ID_6
}	ur_sends:
station NODE_1	UR_ID_1 NODE_2 LEN ACK 300
{	UR_ID_2 NODE_3 LEN ACK 300
h_sends:	ur_receives:
MAVE_ID_2 800 NODE_3	UR_ID_10
TEM_1 400 NODE_3	h_size:
ID_2 600 NODE_3	100
MAVE_ID_3 100 NODE_2	h_VME_sh_mem_base:
s_sends:	0x10300000
TEM_1 400 NODE_3	}
ID_2 600 NODE_3	station Node_2, Node_3.........

the report file(*.rpt) presents successful operation of the generated file. In the case of expert, the parameters is set optionally, so setting expert parameter generate network performance and fault management in details. If user is not setting the expert parameter, default values are set in the value of NIU ROM in initialization. PNC code is composed of file generator module, parser module, time estimator module, time scheduler module, report module, etc. Table. 1 represents the user input file named netfile. The user defines the number of stations ,groups and period value for operations of distributed control system.

Stations on the token bus network conceptually make up a logical ring. Each station can transmit some frames in its own queue. And it is proved that a possible minimum period is equal to the maximum token rotation time by using the time bandwidth mode. In addition, the related scheduling condition for periodic variables is deduced and the maximum transmission delay of aperiodic variables is also deduced. The proper periodic variable scheduling method for the token bus networks is proposed and its algorithm to implement are presented. This scheduling method presents the scheme that exchanges the periodic variable in the IEEE 802.4 token bus network. The scheme is to apply the DCTS scheduling to make a variation of the variable periods and then to arrange the period-modified variable in the table (period transmission table) with the consideration for the frame structure of IEEE 802.4 token bus network.

With the scheme, it is possible to transmit the periodic variables with the periodic property and the simple periodic-transmission-table. As the exchange of the periodic variable is implemented with the use of the IEEE 802.4 token bus network, virtues of the network are available[13].

4. Experiments

As the input file, the user sets values named net file(Table.1). In this file, the user sets the station, group number and scheduling of the period variable is make period transmission table. The eight variables H_ID_NUM_MAX, S_ID_NUM_MAX, H_FRM_NUM, S_FRM_NUM, H_PR_NUM, S_PR_NUM, H_T_RX_ID_NUM S_T_RX_ID_NUM are determined after the period scheduling process using the user's input data. Using this parameters, the period transmission table is produced. For the period scheduling, making database by parser, so this database is used repeatedly. Scheduler part is divided two part, the one is period transformer to make period well applied to scheduler. and the other is allocated transformed period to period table.

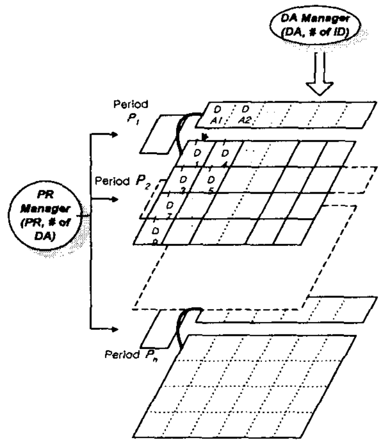

Fig. 3 Threee Dimensional Map of Period Transmision Table

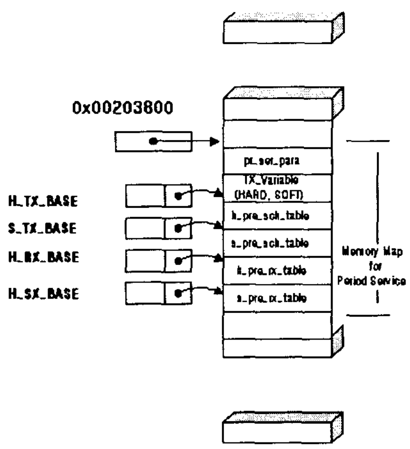

Fig. 4 Address Map of Period Table

Table. 2 Configuration Parameter

```
const NETWORK_CONFIG_PARAM_TYPE init_NETWORK_CONFIG_param_val =
{
 0x0002, /* uint16 manager_addr */
 1, /* uint8 station_level : 1->manager / 0->common */
 0x0004, /* uint16 init_PS_addr */
 0x0006, /* uint16 init_NS_addr */
};

const DLL_PARAM_TYPE init_DLL_param_val =
{
 0x0002, /* Uint16 TS_node_addr */
 0x03, /* Uint16 TS_group_addr */
 5, /* Uint16 init_max_intersolicit_count */
 0x438, /* Uint16 hi_pri_tok_hold_time */
 0x5ad, /* Uint16 target_rot_time4 */
 0x18d, /* Uint16 target_rot_time2 */
 0, /* Uint16 target_rot_time0 */
 0x59d, /* Uint16 target_rot_time_ring_maintenance */
 0x1000, /* Uint16 ring_maintenance_timer_init_val */
 0x0800, /* Uint8 in_ring_desired */
};
const EXPERT_SETTING_PARAM_TYPE init_EXPERT_SETTIING_param_val =
{
 0xffff, /* Uint16 flag_use_default */
 0x0000, /* Uint16 slot_time */
 0x10d7, /* Uint16 tx_lifetime */
 0x10d7, /* Uint16 rx_lifetime */
 0x10d7, /* Uint16 ack_time */
 0x0000, /* Uint8 max_retry */
 0x0000, /* Uint8 max_sap_count */
 0x00, /* Uint8 st_machine_num */
 1, /*Uint16 TBC_interrupt_mask1*/
 1, /*Uint16 TBC_interrupt_mask0*/

 {
  0x00, /* Uint8 LLC_st_ind_err_thr */
  0x01, /* Uint8 U_service_conn_err_thr */
  0x00, /* Uint8 H_service_conn_err_thr */

  ..........
  ......................
  0x00, /* Uint8 DLL_ACK_Expire_q_err_thr */
  0x00, /* Uint8 DLL_P_tx_q_err_thr */
  0x00, /* Uint8 DLL_P_upd_q_err_thr */
  0x00, /* Uint8 DLL_ACK_Expire_ind_q_err_thr */
  0x00 /* Uint8 Timer_q_err_thr */
 }, /* err_thr */

 {
  0x00, /* Uint8 BIEX_THR1 */
  0x00, /* Uint8 BIEX_THR2 */
  0x00, /* Uint8 NRES_THR */
  0x00 /* Uint8 AFTER_SWITCH_COMPEN */
 } /* du_manage */
};
.................
```

Fig, 4 represent to the three dimensional period transmission table. In this table, H(S)_ID_NUM_MAX, H(S)_FRM_NUM, H(S)_PR_NUM determines size of the hard(soft) real time period transmission table. In Fig. 5, the address mapping of period transmission table is shown, The generated h_pre_sch_table, s_pre_sch_table, h_pre_rx_table, s_pre_rx_table is located in calculated each allocating points. In Table. 2, the time constraint parameter as like THT, TRT4, TRT2, TRT0, Tx_lifetime, Rx_lifetime are set by the result of the period scheduler. Using this time constraint parameter, the availability of generated period transmission table is determined. If the generated table is not satisfy given time constraints, the failure message is informed by report file. In the report module, the schedulability of period table and faults in input file from the user's error is informed by verifying module. So, the user find out the cause of failure easily and restart process. As output files, _PR_NODE_n.h _PR_NODE_n.c, _NODE_n.c, _VIEW_NODE_n.c (n=0,12,3...) is generated. These _PR_NODE_n.h _PR_NODE_n.c, contain information about the memory allocation and generated period transmission table. The _NODE_n.c includes the information of configuration and expert parameters for the network management and the fault management. The _VIEW_NODE_n.c is used for monitoring of period transmission status in test-bed.

5. Conclusion and Future Works

In this paper, a method for the efficient implementation of the network configuration generator for the distributed control system(DCS) is proposed. The proposed method is focuses on the real-time property using time parameter estimation and pre-run time scheduling of input data. To solve the memorization size and time constraints, it modifies the period of each variables to reduce the size of the scheduling table. In future, user interface and report file about handle will be added. And, it is necessary that the comparison with the previous systems that exchange the periodic variable should be made so that the availability of the system may be verified explicitly and that research for the scheduling method in the IEEE 802.4 token bus network should be made.

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