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Communication performance analysis and comparison of two patterns for data exchange between nodes in WorldFIP fieldbus network

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ABSTRACT

Data exchange patterns between nodes in WorldFIP fieldbus network are quite important and meaningful in improving the communication performance of WorldFIP network. Based on the basic communication ways supported in WorldFIP protocol, we propose two patterns for implementation of data exchange between peer nodes over WorldFIP network. Effects on communication performance of WorldFIP network in terms of some network parameters, such as number of bytes in user's data and turn-around time, in both the proposed patterns, are analyzed at length when different network speeds are applied. Such effects with the patterns of periodic message transmission using acknowledged and non-acknowledged messages, are also studied. Communication performance in both the proposed patterns are analyzed and compared. Practical applications of the research are presented. Through the study, it can be seen that different data exchange patterns make a great difference in improving communication efficiency with different network parameters, which is quite useful and helpful in the practical design of distributed systems based on WorldFIP network.

1. Introduction

WorldFIP protocol is one of the profiles that constitute the European fieldbus standard EN-50170. It is particularly well suited to be used in distributed computer-controlled systems where process variables and information must be shared among network devices. WorldFIP fieldbus is increasingly applied in process control, manufacturing industry, power system automation and traffic information integration. It is unparalleled with its dual-bus redundancy techniques ensuring high communication reliability in process control [1,2]. Distributed intelligent control network based on WorldFIP technology is completely distributed in function, high in reliability and intelligence. Bus schedule algorithms and patterns for data exchange between nodes in WorldFIP network are quite important and meaningful in improving the communication performance of the network. As for previous research work, almost all the studies on improving WorldFIP network performance and communication efficiency, dealt with WorldFIP network scheduling algorithms and designs of BAT (Bus Arbitrator Table) or ST (Schedule Table). More attention is paid to algorithms on scheduling of periodic or aperiodic data frames. Luís Almeida presented response-time-based schedulability analysis for WorldFIP real-time traffic and used a fixed-priorities-based policy to schedule the periodic traffic [3]. Zhi Wang investigated real-time traffic of the aperiodic messages using WorldFIP and analyzed the worst-case responding time of the aperiodic message in order to improve scheduling methods [4]. Jiming Chen compares performance under various traffic loads of aperiodic messages in WorldFIP and FF fieldbus [5]. Control performance and schedule issues for periodic message with sequence constrain are also investigated [6,7]. Methodology ensuring real-time constrain for the aperiodic message in FF fieldbus, which is technologically similar to WorldFIP, is researched and approaches to improve the protocol is given as well [8]. Some important research results dealing with function blocks (FB) and their applications (FBA) for WorldFIP network to check and improve the communication efficiency of WorldFIP network are presented in our previous work [9–11] and Pang's research [12]. Simulation related problems for different layers in WorldFIP and Foundation Fieldbus protocols were investigated in our previous research [11], and also studied by Zhou [13] as well as Mossin [14]. Some devices' development and practical applications based on WorldFIP are also reported [15–17].

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In addition to the scheduling related issues, other issues on data exchange between nodes in WorldFIP network also have great effects on communication performance of WorldFIP network. Data exchange between nodes in WorldFIP networks can be implemented by different means. Two kinds of basic data exchange fashion, which are variable exchange and message transmission, are supported in WorldFIP protocol. In this paper, rather than focusing on scheduling related problems, we investigate the methodologies to improve communication efficiency from a different perspective. Based on the basic ways, two patterns for data exchange between nodes in WorldFIP network are presented. The relationship between some important network parameters, such as number of bytes in user data and the communication efficiency, is analyzed and compared. Effects of both patterns on communication performance of WorldFIP network in terms of number of bytes in user's data and turn-around time, are analyzed when different network speeds are applied. Such effects of periodic message transmission pattern using acknowledged and non-acknowledged message approaches are analyzed respectively. Communication performance of WorldFIP network is analyzed and compared when the proposed patterns applied. The study demonstrates that different data exchange patterns make a significant difference in improving communication efficiency with different network parameters. Furthermore, the two proposed patterns are related closely with hardware chips used in WorldFIP system design, namely WorldFIP communication controllers including MICROFIP and FULLFIP2. Practically, it is more meaningful and helpful in the design of distributed intelligent systems based on fieldbus network.

This paper is organized as follows: In Section 2, we briefly introduce the two basic ways for data exchange between nodes in WorldFIP network supported in WorldFIP protocol, which are (1) variable exchange and (2) message transmission. The relationship between the two ways and two different WorldFIP communication controllers, namely MICROFIP and FULLFIP2, is presented. Then, based on the basic communication ways, we propose two kinds of pattern for data exchange between nodes with MICROFIP chips. In Section 3, we present the proposed pattern I for data exchange over WorldFIP network, namely by means of variable exchange and LAS forwarding at length. Then, analysis of network communication performance under circumstance of single data exchange and maximum communication cycles between nodes respectively when Pattern I is applied is given at length. In Section 4, we present the proposed Pattern II for data exchange over WorldFIP network, namely by means of WorldFIP periodic message to achieve direct data exchange. Analysis of network communication performance under circumstance mentioned in Section 3 when Pattern II is applied is given in detail. In Section 5, we conduct comparison of network communication performance under circumstance mentioned in Section 3 when Pattern I and II are applied respectively. Two practical applications of the research to design logic and process control systems based on WorldFIP network are presented in Section 6. Some conclusions, which are useful in system design to improve communication efficiency, are given and opportunities for future work are pointed out in the last part of the paper.

2. Basic and the proposed patterns for data exchange between nodes in WorldFIP fieldbus network

Centralized medium control strategy is used in WorldFIP network, which is a schedule-based communication system. Two kinds of network nodes, which are Link Activity Scheduler (LAS) and elementary nodes respectively, are included in WorldFIP fieldbus network. Variable exchange and message transmission, both supported in WorldFIP protocol, are the two basic patterns for data exchange between nodes in the network [1,18].

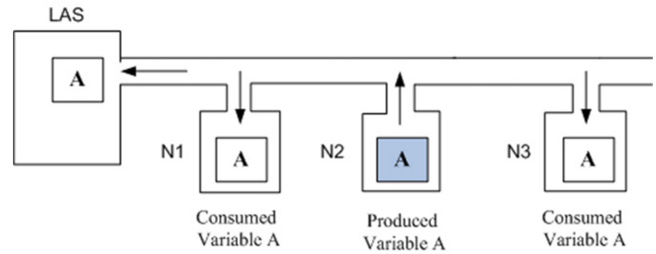

Fig. 1. Data exchange between nodes by means of Produced/Consumed variable exchange.

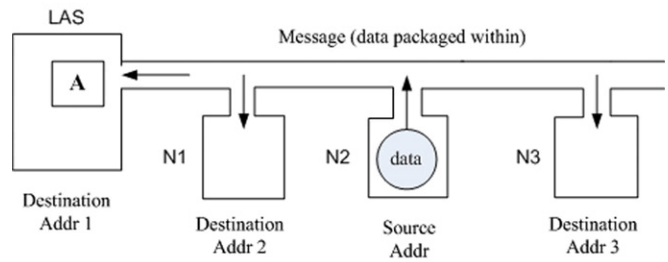

Fig. 2. Data exchange between peer nodes by means of message transmission.

Variable exchange is a more effective way for communication among nodes over WorldFIP network, by which data transmission from 1 node to n nodes simultaneously can be achieved. In a data transmission cycle, all nodes requiring the data of the same produced variable can obtain the value of the data as consumed variables. Addressing is used in message transmission to implement data exchange between any two peer nodes. The data can be transmitted in m cycles of message transmission if required by m nodes, which makes it less efficient than variable exchange in communication performance [1,18]. The two basic patterns supported by WorldFIP protocol are shown in Figs. 1 and 2.

Patterns for data exchange between nodes are related closely to the type of communication controller used in nodes. Two types of communication controller, including FULLFIP2 and MICROFIP chips [19,20], are widely used in WorldFIP network. FULLFIP2 supports periodical/non-periodical variables exchange and messages transmission with direct addressing and can be used to implement scheduling of communication over the fieldbus. FULLFIP2 provides interface between data link layer and application layer and user. By contrast, MICROFIP cannot serve as bus communication scheduler. It is often applied to elementary nodes, which have no bus schedule function. MICROFIP supports periodical/non-periodical variables exchange between LAS, elementary nodes and direct addressing messages transmission. Generally, FULLFIP2 is used in LAS while MICROFIP is used in elementary nodes in practice [1,19,20].

As far as functions are concerned, MICROFIP and FULLFIP2 are quite different in terms of data communication over WorldFIP network. Limited by the number of identifiers, network nodes with the chip MICROFIP as their communication controller cannot exchange data directly. Namely, direct data exchange between peer nodes, just as described in the basic pattern of variable exchange, cannot be achieved if MICROFIP chips are applied to them. Instead, it is achievable with FULLFIP2 chips [21,22]. However, cost of nodes with FULLFIP2 chips is much higher than that with MICROFIP chips. In practice, MICROFIP chips are more widely used in design of elementary nodes, which can lower the cost of system to great extent.

Based on the basic communication ways supported in WorldFIP protocol, here we propose two kinds of pattern in data exchange between nodes with MICROFIP chips, which can be described as follows: