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H. Wang
P. Wang
H. Yang
Chongqing University of
Posts and Telecommunications

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Joint Deterministic Scheduling Requirements for Industrial Field/Backhaul Networks
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Abstract

This document analyzes the requirements of joint deterministic scheduling in industrial field/backhaul networks. The requirements include six aspects: determinacy, time synchronization, compatibility, scalability, scheduling cost and unified management.

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1. Introduction

Industrial network includes many types of industrial field networks, such as the three industrial wireless network standards: ISA100.11a[IEC62734], WirelessHART[IEC62591] and WIA-PA[IEC62601]. Most industrial field networks are in a middle or small size, and the network coverage is constant, for example, a field network usually covers a production area of a plant. Therefore, there is a need for industrial backhaul network that makes data flow from an industrial field network to other field networks, or transmits data access to Manufacturing Execution System (MES) or Enterprise Resource Planning (ERP). Thus, a new network architecture, the deterministic industrial field/backhaul network, is proposed in this draft. Some questions of deterministic have been described in the draft [I-D.finn-detnet-problem-statement], and the architecture and application have been illustrated in [I-D.finn-detnet-architecture] and [I-D.bas-usecase-detnet] separately.

The proposed network architecture is mainly applied to industrial production environment, which has strong demands on packet loss ratio of network data, low jitter and determinacy and so on. The backhaul network is a heterogeneous network including field wireless networks and wired networks. Industrial backhaul network contains a centralized controller, thus it can schedule the network resources of bandwidth and cache. However, some industrial field networks such as ISA100.11a, WirelessHART, have their own system manager and management mode. At the same time, there is no system manager for some types of networks. Thus, it is an issue remained to study about how to implement a joint scheduling under a complex industrial networks environment.

2. Network Structure

Figure 1 shows a typical deterministic industrial field/backhaul networks structure. The field network is ISA100.11a, which is a standard of international industrial wireless network. ISA100.11a employs Time Division Multiple Access (TDMA) mechanism to realize the network time-slot, and provide a deterministic guarantee for sensor data. Data derived from the field networks is access to industrial backhaul networks. In the last, sensor data either transmits to another industrial field networks, or to the internet applications or the enterprise information management system like MES/ERP.

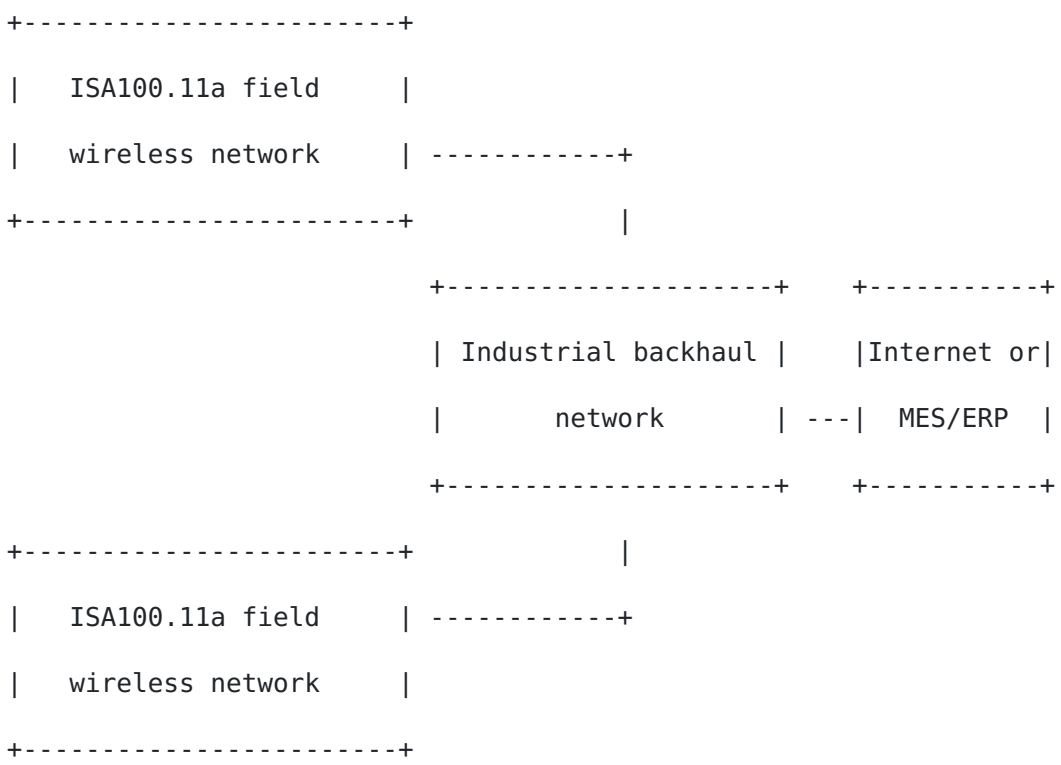

Figure 1. Typical network structure

Thus, in the above network structure, field network nodes deployed in a plant can communicate with the field network nodes deployed in another plant through the industrial backhaul network. At the same time, the internet or information management system can manage the sensor nodes of the field network remotely through the industrial backhaul network.

3. Joint Scheduling Requirements

3.1. Determinacy

The data, which generates from industrial field network, is directly used to monitor industrial production process, so the requirement of data deterministic transmission is very significant, and data needs to arrive at its destination in a certain time. Industrial field/backhaul network is also a kind of network that is mainly used in the process of industrial production, so it also requires to meet the demands of data determinism in the joint scheduling.

3.2. Time Synchronization

Because the industrial field/backhaul network is a data aggregation network, and needs scheduling method to ensure deterministic transmission for data stream. Thus, industrial field/backhaul network requires high time synchronization accuracy among all network devices. The accuracy of time synchronization should be held from the range of 10ns to 10ms according to different network applications. Presently, the existing time synchronization protocols include IEEE 1588 and IEEE 802.1 AS, which are raised by Time Sensitive Networking (TSN) Task Group.

3.3. Compatibility

Industrial field network and backhaul network both comprise different types of networks. Industrial field networks such as ISA100.11a, WirelessHART usually contains built-in system management, which can allocate network communication resources to data stream, while some field networks have no system manager. Although industrial backhaul network is able to control the network with central controller, some mechanisms and interfaces are necessary when conducting joint scheduling to keep compatibility with industrial field/backhaul network.

3.4. Scalability

Generally, the field network data cannot be transmitted across network. While in the deterministic industrial field/backhaul network, the characteristic of cross-networks should be supported. Therefore, the scalability of data transmission should be ensured during joint scheduling process.

3.5. Scheduling Cost

The joint scheduling of industrial field/backhaul networks refers to different networks, when the network manager calculates the scheduling results, it should satisfy a low scheduling cost, such as low computation time, and otherwise it will bring extra delay to the transmission of data stream.

3.6. Unified Management

Most industrial wireless networks have their own network manager. Network manager is able to configure the time slots and channels of field networks. Meanwhile, some backhaul networks also have their independent management units and protocols. For hybrid industrial field/backhaul networks, data stream usually departs from a filed

network, and arrives at another field network by passing through backhaul network. It is an important issue to realize the unified management of cross-network data stream in multiple heterogeneous networks by combining every separate network manager.

4. Security Considerations

5. IANA Considerations

This memo includes no request to IANA.

6. References

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6.2. Informative References

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Authors' Addresses

Heng Wang
Chongqing University of Posts and Telecommunications
2 Chongwen Road
Chongqing, 400065
China

Phone: (86)-23-6248-7845
Email: wangheng@cqupt.edu.cn

Ping Wang
Chongqing University of Posts and Telecommunications
2 Chongwen Road
Chongqing, 400065
China

Phone: (86)-23-6246-1061
Email: wangping@cqupt.edu.cn

Hang Yang
Chongqing University of Posts and Telecommunications
2 Chongwen Road
Chongqing, 400065
China

Phone: (86)-23-6246-1061
Email: 18716322620@163.com