Data Packet Backtracking in Digital System Network

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1. Introduction

Most power plant systems are undergoing a transition from analog to digital.

Unlike analog systems, digital equipment delivers most of the control, measurement, and information signals using networks.

In the control system, the soundness and response time of information and measurement signals are very important. Therefore, it is considered very important when designing a system.

In the Operation & Maintenance (O&M) phase, network delays occur due to signal delays and process delays, despite being perfectly designed.

Data packet backtracking is needed to identify the cause of network delays and to find vulnerabilities to improve the system and analyze the cause.

In this paper, I will describe the experiences of backtracking of digital systems excluding safety class.

2. Network Environment and Backtracking of Data Packets

This chapter describes the power plant's non-safety network environment, and describes the environment configuration for data packet backtracking.

2.1 Network Configuration

In digital system, embedded systems or programmable logic controllers (PLCs) are responsible for measuring and controlling field signals, and servers and switches arbitrate network data. The following figure is a simplified diagram of the information network and control network of the Korean-type APR1400. [1]

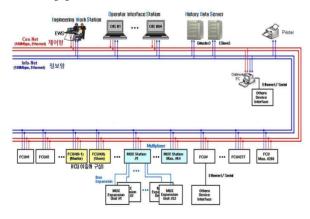


Fig. 1. Non-Safety network structure

The foreign-type APR1400 consists of a control network and an information network.

2.2 Data Packet Data and Environment in Networks

The more data you have, the better. In particular, it is good to have information about the packet. And it's even better if you have network routing information.

However, it is difficult to find this information in the field. This is because a lot of information is not disclosed due to the intellectual property rights of the design / production company.

To trace a packet back, you need to figure out the specific pattern of the packet. If there is a lot of encryption in the packet, it will not be possible to trace it.

Fortunately, the power plant is made up of closed networks, so it is highly unlikely that data packets will be encrypted.

In addition, there is a high possibility of not encrypting raw data that can place a load on the CPU (Central Processing Unit) due to restrictions such as response time, which are very sensitive to signal delay.

2.3 Analysis Devices Composition

Network data is divided into transmission / reception (TX / RX), but half-duplex is used instead of full-duplex. Therefore, it is necessary to utilize equipment that can acquire data separately by transmitting/receiving or mirroring data. In addition, computers must be used to acquire and analyze data packets.

2.3.1 Data Packet Acquisition Device

- 1) TAP device : Continuously monitors packets transmitted on the network
- 2) Intelligent Hub: Analyzes and controls all data in the network management system (for packet aggregation and synchronization of switch and TAP device)
- 3) Two (2) computers for packet acquisition and analysis with wireshark (open source packet analysis program) installed

2.3.2 Configuration for data packet acquisition

As shown in the following figure, TAP and Intelligent HUB are installed in an existing system. In addition, the Switch mirrors a specific port for data packet acquisition.

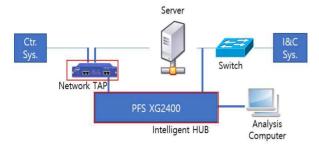


Fig. 2. Data packet measurement devices composition

2.4 Data pattern analysis method

2.4.1 Wireshark data acquisition

Data acquired through mirroring of the switch and data acquired with the TAP device are synchronized through the Intelligent Hub to generate a log file pcap file with Wireshark and converted to a cvs file for analysis.

0,360r = 172,16,0173 cr i	p,addr == 172,16.8,17				🛛 🗀 🔹 Expression –
Time	Source	Destnation	Protocol	Length Into	
2888 13.987488	1	1	TCP	398 9010 + 9010 [PSH, ACK] Seq=4817 Ack+1561 Win=64183 Len=344	
2871 13.993176	1	1	TCP	158 9010 → 9010 [PSH, 4CK] Seq=1561 Ack=5161 Win=8192 Len=104	
2879 13.993186	1	1	TCP	398 9010 + 9010 [PSH, ACK] Seq=5161 Ack=1665 Win=64599 Len=344	
2929 13.995318	1	1	TCP	158 9010 + 9010 [PSH, ACK] Seq=1561 Ack=5161 Win=8192 Len=104	
2934 13.995324	1	1	TCP	398 9018 → 9010 [PSH, ACK] Seq=5161 Ack=1665 Win=64079 Len=344	
2984 14.195662	1	1	TCP	68 9818 - 9818 [ACK] Seq=1665 Ack=5585 Win+8192 Len=8	
3812 14.197798	1	1	TCP	68 9018 → 9018 [ACK] Seq=1665 Ack+5505 Win+8192 Len=0	
3058 14.986510	1	1	TCP	158 9010 + 9010 [PSH, ACK] Seq=1665 Ack+5505 Win+8192 Len+104	
					1
Ethernet II, Src: W Internet Protocol V	Westingh_00:00: Version 4, Src:		Dst: IntelCo	r_6e:c6:10 (00:1b:21:6e:c6:10) 85, Ack: 345, Len: 0	
00 1h 21 Co. cf	18 18 8/ 77 8	8 68 4+ 68 68 45 68 -	In w11-	F-	

Fig. 3. Wireshark acquisition data

2.4.2 Search for a specific pattern

Extract specific patterns from manual or system

2.4.3 Packet time comparison in a specific section

Time delay interval estimation and cause analysis through comparison of the log time of data packets for the control system, server, and specific point of the field systems

2.4.4 Packet Acquisition Constraints

- Although there is no time delay for TAP device, Switch, and Intelligent Hub in theory, it is difficult to completely exclude them (almost no effect)
- 2) In order to record and synchronize a specific control signal (operator's operation or automatic operation), it is necessary to review by adding an offset to the time record

3. The Data Packet Traceback Results

As a result of tracking a specific pattern, the data packet satisfies within the response time requirement, and a slight difference occurs due to wire delay or delays such as TAP, HUB, and Switch.

INDE -	R						R	- Time	· From	- To	
1	FFFF F	FF1 FFFF	FFFF	FFFF F	FFFF FF	FF	FFF1 FFFF FFFF FFFF FFFF FFFF FFFF	01_33_29_56470	6		
- 2	2 FFFF F	FF1 FFFF	FFFF	FFFF F	FFFF FF	FF	FFF1 FFFF FFFF FFFF FFFF FFFF FFFF	01_33_29_56470	8		
1	3			_				01_33_30_14414	4 1		1
4	\$							01_33_30_14443	33 1		.73
	5							01_33_30_14448	31 1		1
6	5							01 33 30 14448	32 1		1
	7							01_33_30_14448	33 1		1
8	3							01 33 30 14448			1
Time	9_564706	From		To		Ms •				Diff OW +	DiffMTP -
1_33_2	9_564708					1				0.570436	-0.000001
01_33_29	9_564708	1	3	1	3	1	FFFF FFF1 FFFF FFFF FFFF FFFF FFFF FFF	FRF FFFF FFFF FFFF FFF	F FFFF	0.579436	
1_33_29 1_33_30 1_33_30	9_564708	1 1	7	1**** 1' 1'	3	1	ELEE ELET ELEE ELEE ELEE ELEE ELEE ELEE	FFF FFFF FFFF FFFF FFF	F FFFF		0.000289
01_33_29 01_33_30 01_33_30 01_33_30	9_564708 0_144144 0_144433	1 1 1 1	3 7 1	1 1 1 1	3	1 3 1	FFFF FFF1 FFFF FFFF FFFF FFFF FFFF FFF	FEF FFFF FFFF FFFF FFF	F FFFF	0.579725	0.000285
01_33_29 01_33_30 01_33_30 01_33_30 01_33_30 01_33_30	9_564708 0_144144 0_144433 0_144481	1 1 1 1		1 1 1 1 1 1	3	1 3 1 1	ELEE ELET ELEE ELEE ELEE ELEE ELEE ELEE	FFF FFFF FFFF FFFF FFF	F FFFF	0.579725 0.579773	0.000285
01_33_29 01_33_30 01_33_30 01_33_30 01_33_30 01_33_30 01_33_30	9_564708 0_144144 0_144433 0_144481 0_144482	1 1 1 1 1	7 1 5 9		3	1 3 1 1 1 1	FFFF FFF1 FFFF FFFF FFFF FFFF FFFF FFF	FFF FFFF FFFF FFFF FFFF	F FFFF	0.579725 0.579773 0.579774	0.000289 -0.000001 -0.000001 -0.000001 -0.000001
01_33_2 01_33_3 01_33_3 01_33_3 01_33_3 01_33_3 01_33_3 01_33_3	9_564708 0_144144 0_144433 0_144481 0_144482 0_144483				3	1	4666 6667 6666 6666 6666 6666 6661 6			0.579725 0.579773 0.579774 0.579775	-0.000001 0.000285 -0.000000 -0.000000 -0.000000 -0.000000 0.0000374

Fig. 4. Comparison result of standard input/output time of data pattern

	•	Time	From	· To	• M:	s - D	DIFIMITP + RESULT # SEQ1 + DESCIPTION
FF&F FFFF FFFF FFFF FF&F FFFF FFFF	FFF1 FFFF FFFF FFFF FFFF FFFF FFFF	03_16_54_524865				1	LC
FF8F FFFF FFFF FFFF FF8F FFFF FFFF	FFF1 FFFF FFFF FFFF FFFF FFFF FFFF	03_16_54_524865					LC
		03_16_55_365608	17	8 1	1	1	2.001301 E)CRC_TIME 1833857316 9010 -> 9010 Seq=22361 Ack=73961
		03_16_55_365981	17	4 1	1	1	2.00167 E)CRC_TIME 1833785974 9010 -> 9010 Seq=22257 Ack=73617
		03_16_55_366548	17	5 1	1	1	2.000488 E)CRC_TIME 1835209415 9010 -> 9010 Seq=21737 Ack=71897
		03_16_55_367317	17	0 1	1	1	2.000384 E)CRC_TIME 1834818873 9010 -> 9010 Seq=21945 Ack=72585
		03_16_55_367406	17	3 1	1	1	2.000477 E)CRC_TIME 1834888283 9010 -> 9010 Seg=22153 Ack=73273
		03_16_55_368559	17	9 1	1	1	2.000423 E)CRC_TIME 1835270547 9010 -> 9010 Seq=22569 Ack=74649

Fig. 5. Time Error due to measurement devices and wire delay (within 0.1 μ s)

4. Conclusions

Backtracking data packets in a network requires a lot of time and effort, especially when not knowing the packet information.

During the O&M phase, many errors and unexpected situations occur. In digital power plants, it is very difficult to determine the cause.

Backtracking of network data packets will be a very important method for analyzing the unexpected causes of power plants.

The method proposed in this paper is expected to be very helpful in proving the integrity of networks and systems and analyzing the cause of unexpected malfunctions.

REFERENCES

[1] M. G. Min, Verification of failover effects from distributed control system communication networks in digitalized nuclear power plants, NET-49-5-11, 2017