Traffic Load Analysis of Data Communication Networks for KNICS

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Abstracts

Based on the systems and devices which are being developed in the KNICS project, the data communication network (DCN) which is an essential element for the interfaces among the I&C systems, is designed. The traffic load for each network is calculated at the expected maximum traffic condition. The result shows that the utilizations of all networks satisfy the design requirements.

1. Introduction

As shown in figure 1, the KNICS consists of control systems, protection systems, monitoring systems, information processing and display systems and these are classified with the function and safety classification. In the KNICS all systems are linked with inter- and intra- communication networks,[1] therefore the performance of DCN is a key element in the KNICS design. The KNICS DCN, consisting of several types of communication networks, is designed to support the maximum data traffic under all plant operating conditions and its performance is confirmed by the traffic load analysis. The traffic load analysis is performed referring the commercial technology on topology, protocol and transmission architecture for each network.[2,3] Also the design requirements applicable to the nuclear power plant are considered. In the analysis, the serial communication and hardwired are excluded.

2. Classification and function of KNICS DCN

The DCN for inter-system consists of as follows;

1) IPN : provides the interfaces between IPS with displays in the MCR and other I&C systems such as protection, control and monitoring systems
2) QIAN : provides interfaces between QIAS and safety-related systems including the displays for indication and alarm.
3) CN : provides interfaces among all control systems and between control systems and information systems.
4) PAIN, PBIN, PCIN, PDIN : provide interfaces among protection systems and between protection systems and information systems including operator modules and soft-controllers.

3. Transmission architecture of KNICS DCN

The basic transmission architecture of KNICS DCN is shown as table 1.

Table 1) Basic Transmission Architecture of KNICS DCN

	Type	Access Method	Topology	Frame Format	Transmission Service
IPN	100 Mbps Fast Ethernet	CSMA/CD	Bus	Overhead : 26 Bytes Length : 46-1500 Bytes	
QIAN, PAIN, PBIN, PCIN, PDIN	Profibus -FMS	Token-Passing	Physical :Bus Logical :Ring	Overhead : 9 Bytes Data Length : 1-246 Bytes	SDA, SDN, SRD, CSRD
CN	Token - Ethernet	Token-Passing	Ring	Overhead : 33 Bytes Data Length (Min) : 72 Bytes	

4. Performance of KNICS DCN

The bases for the performance calculation are summarized as follows;
The data analysis margin of 20% is assumed with the exception of CN (40%), the maximum propagation delay is 5 usec (1 km), the overhead for application layer is 40 bytes (based on TCP/IP) except Profibus-FMS (50% of lower layer), the expansion capability is 30%. The transmission cycle are 100 msec for protection network (PAIN~PDIN) and CN and 500 msec for IPN and QIAN.

The evaluation factors for performance analysis are a transmission delay time and a utilization. The evaluation criteria for the performance of each network considering the transmission delay time and the network type are as follows;
1) IPN: transmission delay time < 500 msec, network utilization < 20%.
2) QIAN: transmission delay time < 500 msec, network utilization < 40%.
3) PAIN/PBIN/PCIN/PDIN, CN: transmission delay time < 100 msec, network utilization < 40%.

The factors considered and the procedures for the performance calculation of each network are as follows;

1) IPN: (1)calculation of raw data load for each link, (2)addition of analysis margin of 20%, (3)fragmentation of

data frame exceeding 1500 bytes, (4)addition of pad in data frame less than 46 bytes, (5)addition of 26 bytes for overhead in data frame, (6)addition of 96 bits for dead time, (7)addition of 40 bytes for TCP/IP overhead, (8)calculation of transmission delay time for each frame, (9)calculation of total transmission delay time and transmission capability (bps), (10)addition of 30% for expansion, (11)calculation of network utilization considering transmission cycle time.

2) QIAN, PAIN/PBIN/PCIN/PDIN: (1)calculation of raw data load for each link, (2)addition of analysis margin of 20%, (3)fragmentation of data frame exceeding 256 bytes, (4)addition of pad in data frame less than 1 bytes, (5)addition of 9 bytes for overhead in data frame, (6)calculation of transmission delay time for each frame(frame size*bit time), (7)addition of 96 bits time for dead time, (8)addition of propagation delay time (1km=5usec), (9)addition of 33 bits time for token synch. time, (10)addition of 3 bits time for token examination, (11)addition of 24 bits time for frame examination, (12)addition of propagation delay for token, (13)calculation of FDL transmission delay time, (14)addition of FMS overhead of 50%, (15)calculation of total transmission capability (bps), (16)addition of expansion of 30%, (17)calculation of network utilization considering transmission cycle time.

3) CN: (1)calculation of raw data load for each link, (2) addition of analysis margin of 40%, (3)addition of 33 bytes for overhead in data frame, (4)fragmentation of data frame exceeding 72 bytes, (5)calculation of transmission delay time for each frame, (6)addition of 96 bits time for dead time, (7)addition of 29 usec for frame generation, (8)addition of transmission delay time for token (72 bytes), (9)addition of 4 usec for recognition of token frame, (10)addition of 5 usec for token generation, (11)addition of 200 nsec for transceiver delay, (12)addition of propagation delay time (1km=5 usec), (13)addition of TCP/IP overhead (40 bytes), (14)calculation of total transmission time and capability (bps), (15)addition of expansion of 30%, (16)calculation of network utilization considering transmission cycle time (100 msec).

5. Results and Conclusions

As shown in table 2, the results of traffic load analysis for KNICS DCN show that all of the networks designed in KNICS meet the performance requirements.

Acknowledgements

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References

[1] S. Hur et al, "Design concepts of KNICS", The 3rd KNS-KIEE Joint Workshop on I&C Technology, Nov., 2003
[2] Normative Parts of Profibus-FMS, -DP, -PA according to the European Standard, EN 50 170, Volume 2
[3] Local Area Network Performance, Gilbert Held

Table 2) Results of the traffic load analysis for KNICS DCN

	IPN	QIAN	CN	PAIN (PBIN)	PCIN (PDIN)
Total Node #	85	25	35	8	6
Total Link #	102	24	252	10	9
Total Raw Data Point #	305,819	24,924	11,951	2,436	906
Total Raw Data Size (bits)	4,148,553	132,340	40,508	14,320	8,620
Transmission Delay Time (msec)	55.83	22.88	15.19	8.76	6.12
Network Utilization	14.52%	5.95%	19.75%	11.40%	7.96%

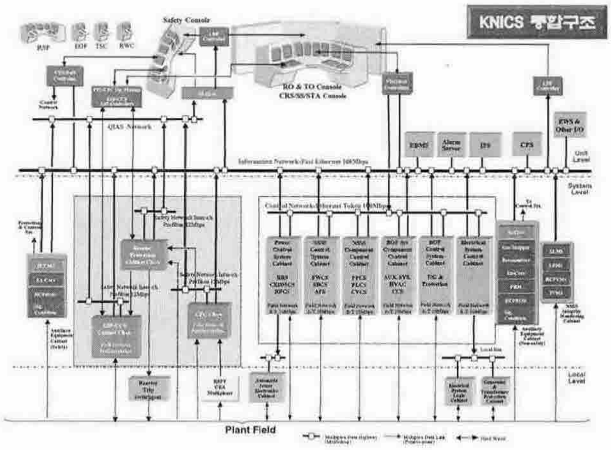

Fig. 1 Architecture of KNICS