International Carpathian Control Conference ICCC' 2002
MALENOVICE, CZECH REPUBLIC
May 27-30, 2002

APPLICATION OF LANWORKS NETWORKS FOR INTRINSICALLY SAFE CONTROL OF MINING ROPE TRANSPORT SYSTEMS

Sebastian CZYRWIK[1], Jacek FERUŚ[2], Adam HEYDUK[3], Michał LANGHAMMER[4] Kazimierz MIŚKIEWICZ[5] and Krystian SZEBESTA[6]
[3,5]Institute of Electrical Engineering and Automation in Mining
Silesian Technical University in Gliwice
Gliwice, Poland, kmiskiew@zeus.polsl.gliwice.pl
[1,2,4,6] Manufacture-Commercial-Service Enterprice ATUT Ltd.
Katowice, Poland ul. Sosnowa 25

Abstract: LonWorks technology is a complete platform for implementing networked control system. ATUT networks is an intrinsically safe extension of LonWorks technology that allows us to develop control, signalling and communication systems for methane mines. Each node of the ATUT networks consists of Neuron processor and transformer coupled transiver for twisted pair 78 kbps data rates as well as interfaces depending on node type.

The paper presents the design of control system of mining suspended and floor railways using the ATUT-NET network. The communication protocol used has been applied as well as examination results of time relationship while transmitting the signals between nodes.

Key words: Mining rope transport, Intrisically safe system, LonWorks, LonTalk.

1 Introduction

The special feature of control and signalling systems arranged in mining workings is widespread arrangement and high requirements as regards the reliability.

The problem of proper transmission of signals has special significance. Because of limitation in cable expenses it seems advisable to use a serial transmission, which allows transmission of larger amount of information using one pair of wires by means of proper protocol of interface access [Decotignie 1988, Decotignie 1993].

Taking into consideration the cost reduction as well as software reliability increase it is advisable to use the network protocols that were implemented in mass-produced integrated circuits.

One of network protocol which meets the above mentioned requirements is LonTalk protocol developed by Echelon [Hoskie 1996, Raji 1994]. This protocol was implemented in specialised NeuronChip integrated circuits being the set of three processors: application processor, network processor and medium access processor [LonWorks 1997].

2 ATUT-NET network based on LonWorks network.

On the basis of NeuronChip MC143120 integrated circuits as well as transivers ATUT-NET network was developed in ATUT Co. Ltd. [Szebesta 1999]. ATUT-NET network is provided to construct the mining intrinsically safe control, signalling and communication systems. The separate network nodes are connected with 6-core bus cable.

The bus provides performance of the following tasks:

- transmission of power supplying the separate devices (voltage 15V) preserving intrinsically safe systems.
- transmission of analogue audio signals (voice for loudspeaking communication, acoustic warning signals, verbal messages generated by the system)
- hardware implementation of safety circuit (a serial circuit of closed contacts),
- transmission of digital data – used, among others to transmit information on switches condition, panels, identification of events, software interlock.

Necessity to meet the intrinsically safe condition as well as power of intrinsically safe supply units requires to divide the ATUT-NET network into separate supply zones.

Every segment is supplied only from one supply unit and audio and interlocking cores of adjacent zones are separated galvanically in a special node called analogue separator. Connecting the supply units in parallel is forbidden due to intrinsic safety conditions.

The following nodes can co-operate in ATUT-NET network:

- **CUKS-1** control-signalling device provided with 6 control inputs used to supervise the bi-stable information (switched on/switched off type) as well as four outputs used, for instance, to control the information panel.
- **CUKS-2** control panel provided with 12-key keyboard and five-digit seven-segment display, which performs the function of operator's panel providing the control of state of any devices connected to the network.
- **CUKS-3** universal loudspeaking signalling device providing simplex communication, broadcasting of verbal messages, warning signals as well as co-operation with safety circuit connected in series.
- **CUKS-4** universal synoptic panels mapping the operation state of other devices connected to ATUT-NET network by means of LEDs, seven-segment displays or LCDs
- **CUKS-5** operator's desk

3 The control systems of SSLKSP-1A floor and suspended railways as an example of ATUT-NET application. [ATUT 2001]

SSLKSP-1A system consist of the nodes set of ATUT-NET network connected with bus line. The basic element of SSLKSP-1A system is CUKS-5 digital control device which fulfils the role of railways operator. It co-operates with HNK1, HNK2, HNK3, NK 100H, Ecker as well as Goelner drives. The control of railways operation is provided using the sensors as follows:

- ride direction lever position sensors (ahead, backwards),
- sensor of exceeding the admissible tension of rope,
- pressure sensors (pressure charging, control, operation pressure)
- confirmation of actuating the motor,
- confirmation of brake releasing,
- zero position sensor of hydraulic pump,
- operation pressure sensor of tension station,
- oil temperature sensor,
- motor cooling fluid flow sensor

A pulse generator is coupled with the shaft of railway drive. Counting the pulses being correlated with direction of railway motion allows mapping the present position and velocity of the car on railway route as well as displaying these magnitudes on dispatcher's desk.

The block diagram of SSLKSP-1A system is presented in Fig. 1. The separate ATUT-NET network nodes are located along the railways route as CUKS-1 and CUKS-3 devices, which perform the functions as follows:

- controlling the transparents "STOP", "PERSONNEL RIDE", "GOODS TRANSPORT" on the basis of information obtained from operator's desk,
- inspection of limit switches conditions, railway position correction connector as well as interlocking connectors located in every device.
- loudspeaking communication along the whole railway route
- broadcasting the verbal messages on system operation along the whole railway route.

4 Simplified time analysis of ATUT-NET network protocol

NeuronChip processors used in ATUT-NET networks apply LonTalk protocol to exchange information. This is p-persistent CMSA protocol. In ATUT-NET network the MASTER-SLAVE protocol was used as a superior one in relation to LonTalk protocole. Operator's desk constitutes the MASTER node which sends periodically the queries to separate nodes and obtains information on inputs state of inquired nodes. The MASTER SLAVE protocol simplifies the time delays analysis in a network [Kwiecień]. There are three basic sources of this delays:

- NeuroChip sequence operation (updating programme of inputs and outputs conditions is executed in time loop – no using the interruptions)

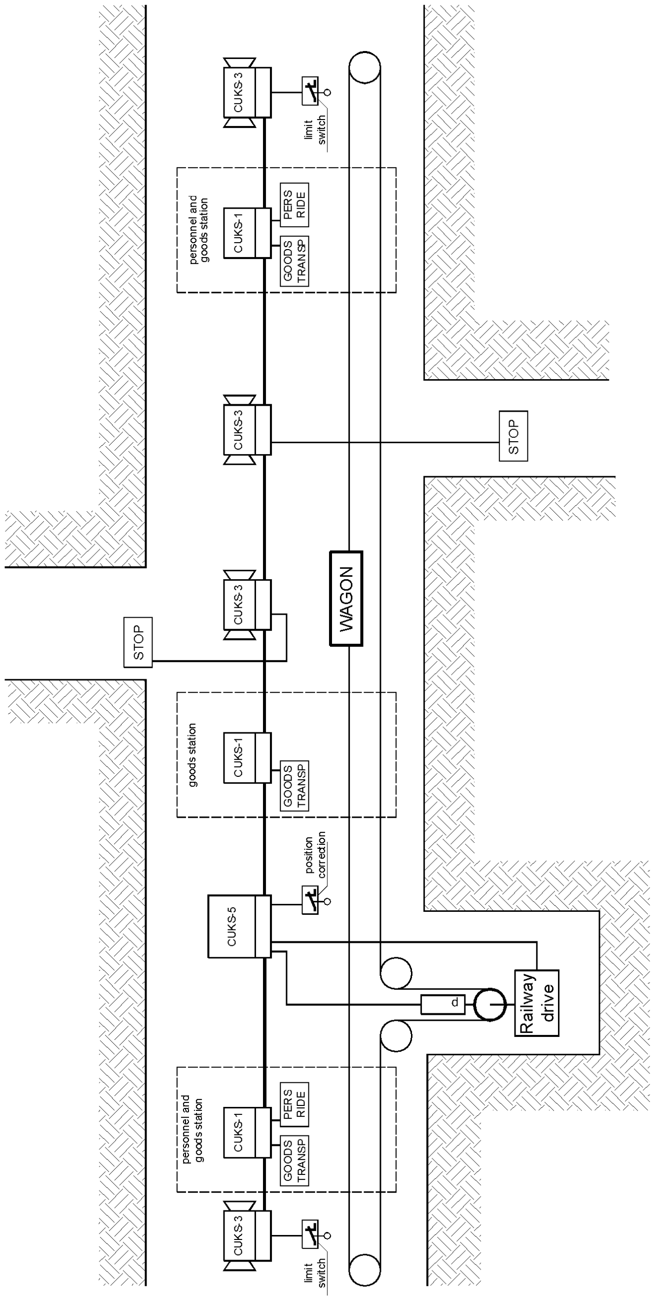

Figure 1 The simplified block diagram of control system of SSLKSP-1A suspended and floor railways

- delays in transmission and processing the information between three processors included in NeuroChip,
- delays correlated with signal transmission,
  - transmission time connected with transmission speed and frame length,
  - propagation time connected with line length,
  - medium access time connected with p-persistent CSMA protocol.

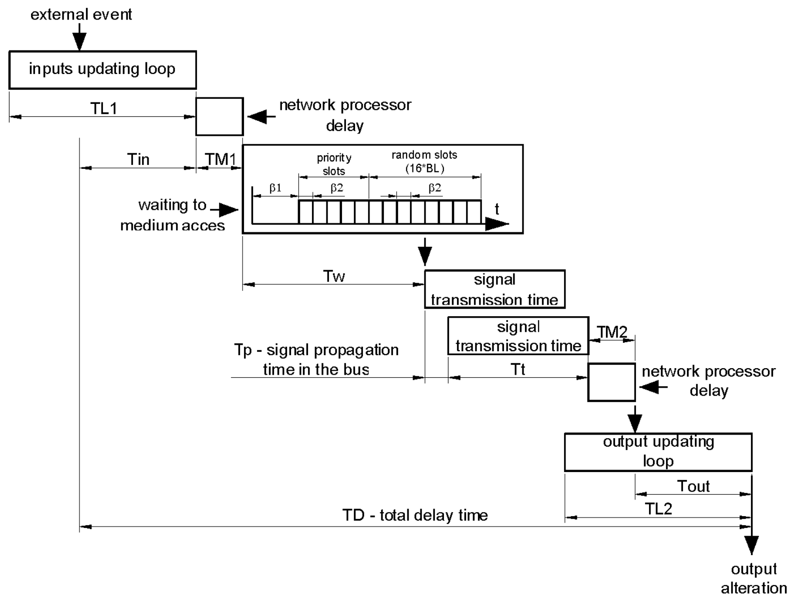

Fig. 2 Time delay components in LonWork network

Table 1: List of statistical parameters of TD delay components

Delay component	Designation	Average value	Standard deviation	Distribution
Input updating loop	Tin	$TL1/2$	$TL1/\sqrt{12}$	uniform
Network processor delay	TM1	TM1	0	
Waiting time to access the medium	Tw	$\beta 1+np\cdot\beta 2+\frac{\beta 2\cdot(1+p)}{2\cdot p}$	$\frac{\beta 2\cdot\sqrt{1-p^2}}{p\sqrt{12}}$	uniform
Transmission time	Tt	Tt	0	
Propagation time	Tp	<15 µs (up to 3 km)	0	
Network processor delay	TM2	TM2	0	
Outputs updating loop	Tout	$TL1/2$	$TL1/\sqrt{12}$	uniform

NOTE: p-parameter of p-persistent CSMA protocol. Inverse of p parameter is a random number of β2 slots, np – number of priority slots.

These components including the proper designations are schematically presented in Fig. 2. Table 1 presents parameters list of separate components of delay such as average value, standard deviation as well as their probability distribution. The delay analysis results has been verified experimentally using the LonWork physical network model including A and B nodes provided with the same application programme.

The $Tr1=Tm1+Tw$ sum was estimated by means of statistic analysis of measured delay between input signal alteration of A nodes and the beginning of a frame in a bus. The $Tr2=Tt+Tp+TM2+Tout$ sum was estimated by means of statistic analysis of measured delay between the beginning of the frame in the bus and signal alteration on output of B node.

Statistical parameters of measurement results of separate delay components in LonWork network model are presented in Table 2. In SSLKSP-1A system the measured delays of interlocking signal transmission between nodes equal approximately 100 ms. Longer times of inputs and outputs updating loops of nodes that contain SSLKSP-1A software is the reason of longer delay time.

Table 2: Statistic analysis results of delay times for transmission between two nodes.

Delay	Average value, ms	Standard deviation, ms	Minimum value , ms	Maximum value, ms
Tin	2.3	1.2	0.2	4.4
Tr1	6.1	0.8	4.6	7.6
Tr2	8.2	1.3	6.2	10.4
TD	16.5	1.9	12.2	21.6

Acknowledgments

This work is supported by grant from KBN (Scientific Research Committee)

References

LonWorks Technology Device Data Book Rev.3 Motorola Inc. 1997

Decotignie J.D, Pleinevaux P.: Time Critical Communication Networks: FieldBuses. IEEE Network Magazine Vol.2 No. 3, May 1988

Decotignie J.D., Pleineveaux P.: A survey on industrial communication networks. Annales des Telecommunications. Vol. 48 No. 9-10, 1993

Hoske M.T.: LonWorks Expands Positions as Universal Network Solution. Control Engineering, May 1996

Raji R.S. Smart networks for control IEEE Spectrum, June 1994.

Szebesta K., Czyrwik S., Langhammer , Miśkiewicz K.: Zastosowanie sieci LonWorks w kopalnianych układach sterowania i sygnalizacji. Mechanizacja i Automatyzacja Górnictwa, 8-9/1999.

Kwiecień A.: Analiza przepływu informnacji w komputerowych sieciach przemysłowych. Pracownia Komputerowa Jacka Skalbmierskiego. Gliwice 1999.

Przedsiębiorstwo Produkcyjno Handlowo Usługowe ATUT Sp o.o.: System Sterowania Liniowych Kolejek Spągowych i Podwieszanych SSLKSP-1A. Dokumentacja Techniczno Ruchowa. Katowice Czerwiec 2001.