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COMPUTER NETWORK SYSTEMS FOR RAILWAY TRANSPORT CONTROL AND MANAGEMENT

In the paper new system approach to computer systems based on computer network solutions for railway transport applications is presented. The basic network architectures with communication standards for dissipated management and control is an introduction to the hierarchical multi-level control structure according to theory of control and railway control classification. The several implementations of dissipated computer systems are characterised with respect to standardisation and safety aspects. The new technical solutions applied the fibre optics and radio transmission may be discussed corresponding to European Railway Traffic Management System (ERTMS). In the conclusions the actual problems and trends in computer network systems for railway transport applications are expressed.

SIECI KOMPUTEROWE W STEROWANIU I ZARZĄDZANIU TRANSPORTEM KOLEJOWYM

W referacie przedstawiono systemowe podejście do systemów komputerowych opartych na sieciach komputerowych w zastosowaniach transportu kolejowego. Po omówieniu podstawowych konfiguracji i standardów komunikacyjnych stosowanych w rozproszonych systemach sterowania przedstawiono koncepcję hierarchicznego, wielopoziomowego sterowania zgodnego z teorią sterowania oraz z klasyfikacją przyjętą w sterowaniu ruchem kolejowym. Scharakteryzowano różne realizacje rozproszonych systemów sterowania zwracając uwagę na standaryzację oraz bezpieczeństwo. Wprowadzanie nowych rozwiązań opartych na transmisji światłowodowej i radiowej przedstawiono na bazie założeń Europejskiego Systemu Zarządzania Transportem Kolejowym (ERTMS). We wnioskach poruszono problemy związane ze stosowaniem sieci komputerowych w zarządzaniu transportem kolejowym oraz aktualne tendencje rozwojowe.

1. INTRODUCTION

The computer networks as a support of computer systems for railway transport and management have been implemented from twenty years. We may distinguish typical classification with respect to distance and volume of transmitted information:

- µLAN with near connections via local or external buses and interfaces
- LAN corresponding to ETHERNET, RS 232 and 485 (or similar standards)
- MAN related to X25 and Frame Relay communication

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- WAN applying new information technology with fibre optics and radio transmission.

The net topology depends from given application:

- Bus configuration in typical fail safe architecture including redundancy and self testing
- Ring configuration used always for transmission in remote control and dispatcher systems
- Star configuration connected with information and ticket systems and supervisory systems for train and freights.

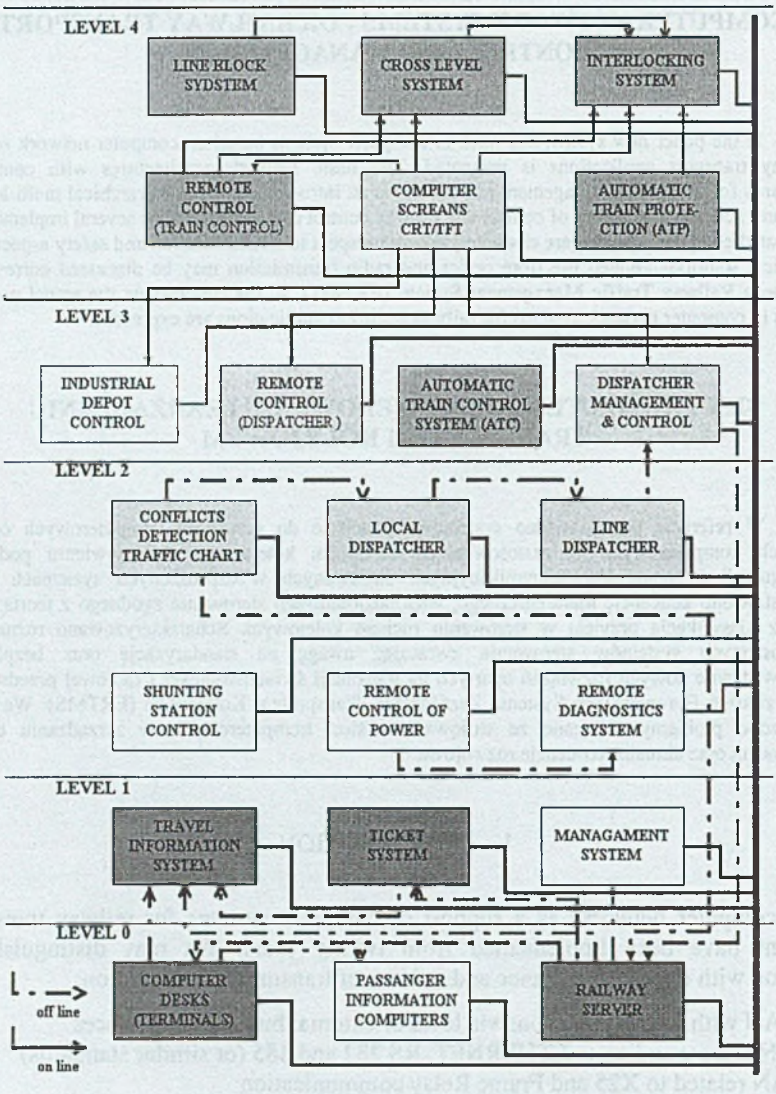


Fig.1. Dissipated computer networked railway control and management system

From historical point of view the first computer networks in railway control applications are configured for safety purposes [2] such SIMIS (Siemens) or EBILOCK (ABB Signal) applying the special solutions of bus interfaces. Next we can observe introduction of industrial net standards such RS 232 into coupled controllers in Level Protectioned Control Systems [3], [4], or modem transmission Industrial Ethernet in Line Dispatcher [1] systems produced for example by ABB. Now railway computer systems use the fast radio transmission based on GSM+ two way standard and integrates with fast high rate optical network for efficient railway traffic management.

2. THE HIERARCHICAL APPROACH TO RAILWAY MANAGEMENT

From several years we can observe integration of many computer systems in the form from Fig.1. To each system communicating with other systems the safety level from 0 to 4 is assigned (Table I). It means that safety of transmission in each level must be considered with respect to existing standards (CENELEC), [6],[7] recommendations (UIC) [2] and requirements (national railway administrations) [8].

Table 1

Systems Classification in Railway Control and Management

	Required integrity of safety	Consequences of system fault	Characteristics of system	Type of system
4	Very high	Lost of human life	To prevent the train collision and derailment	Fail-safe system
3	High	Injuries or illness	To identify the train integrity or characteristics	High integrity system
2	Medium	Environmental pollution	To manage the railway traffic	Safety involved system
1	Low	Loss or damage of property	To inform the passenger	Low integrity system
0	Non-safety related	Loss of non-safety related information	To manage the railway	Non-safety related system

Safety critical systems — Safety essential systems

The standardisation committee CENELEC suggests the following assumptions about reliability of computer systems applied in railway signalling and management. Corresponding to assumption that the ratio between safety integrity levels may be as 100:1, the common failure rates (regarding system level including transmission) for subsystems are:

- System Integrity Level 4 - 10^{-9} h^{-1}
- System Integrity Level 3 - 10^{-7} h^{-1}
- System Integrity Level 2 - 10^{-5} h^{-1}
- System Integrity Level 1 - 10^{-3} h^{-1}

The computer systems may be analysed from hierarchical point of view typical to theory of control. Such approach is shown on the Fig.2.

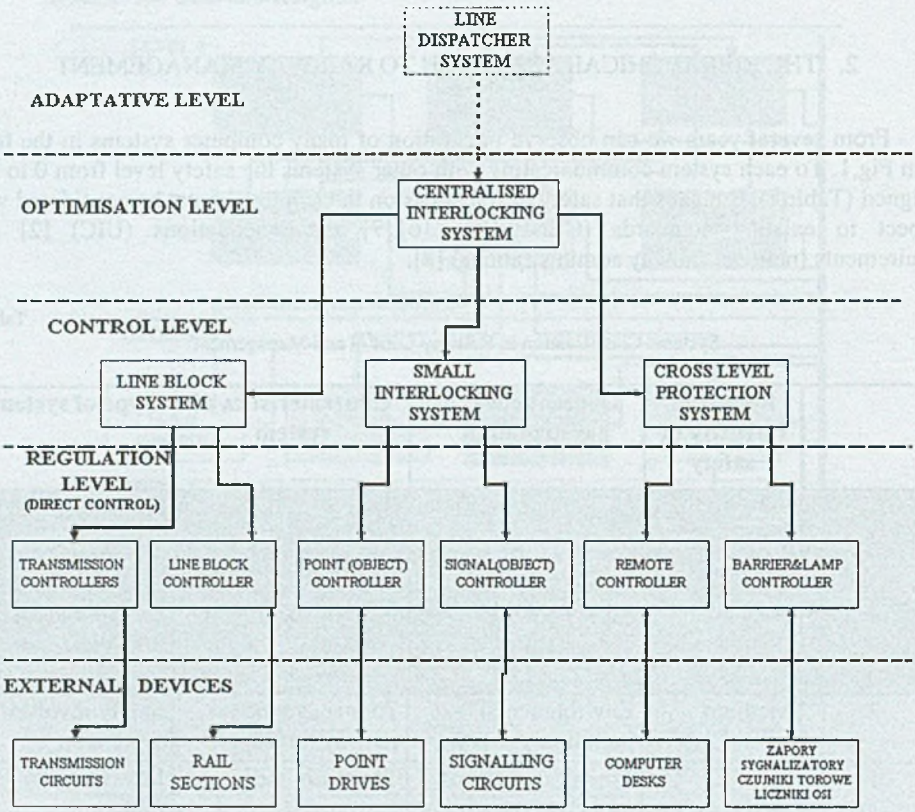


Fig.2. Hierarchical approach to computer networks in control and management

3. COMPUTER NETWORKS AND DISSIPATED SYSTEMS

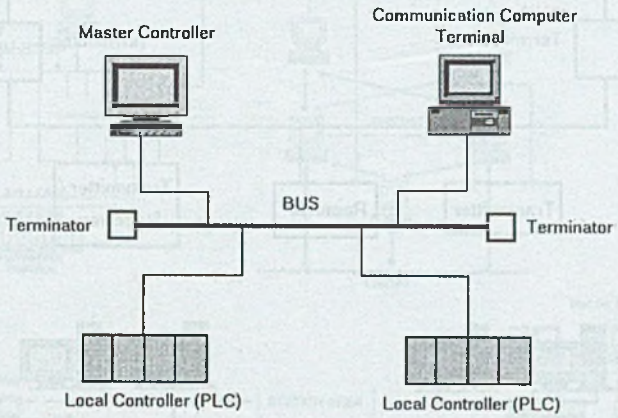
For µLAN structures (redundancy and self-testing) the bus topology (including double and triple bus connections) is used. The Fig.3.a. shows the schematic structures of multiple computers in interlocking controllers.

Some network techniques are very convenient for safety applications in transport systems. On the Fig.3.b the FDDI (Fibre Distributed Data Interface) structure is presented. This standard of fail safe computer connections elaborated by ANSI before 1990 assures the transmission (synchronous or asynchronous) to 100 Mb/s in to several thousands meters distance. The FDDI applies the Dual Ring topology based on copper cables or fibre optics (with optical laser switch), in the case of computer fault the efficient by-pass is realised.

The typical realisation of WAN communication systems for management and control purposes (dispatcher control and remote control) applies RS 485 standard (PROFIBUS) from Fig.4.a. This standard is convenient for remote control and remote supervision.

Another WAN realisation, Frame Relay standard (Fig.4.b), is typical solution for non-safety relation (level 0) or not safety essential (level 1 or partially 2) applications.

a)



b)

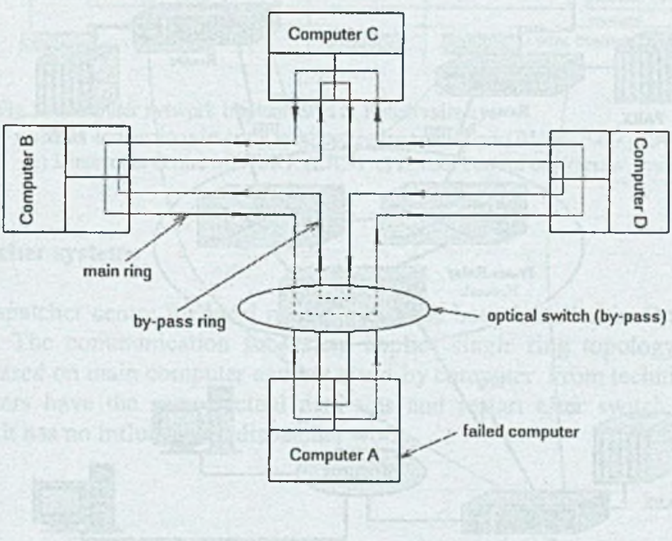


Fig.3. The bus topologies of railway computer network
a) µLAN in interlocking fail safe computers
b) FDDI structure as a fail-safe support for computer LAN solutions

This standard use (like previous X.25 standard) package transmission with error correction protocols (FCS) and virtual circuits between users. This standard is a base of modern network KOLPAK-T applying the fibre optics and copper cables for fast transmission in both synchronous and asynchronous modes.

In this chapter some practical solutions of computer networks in railway management and control applications is presented. These technical solutions reflect the actual state of telematics including newest achievements of information technology in Polish railways.

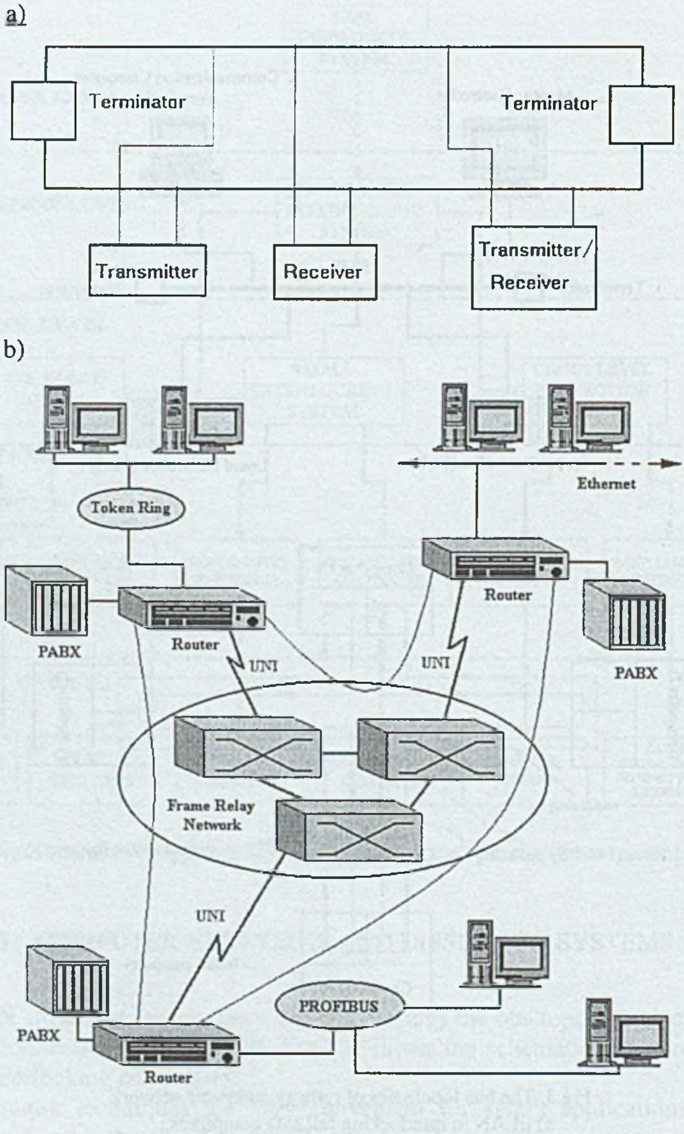


Fig.4. The WAN realisation, a) RS 485 scheme, b) Frame Relay structure

Redundant systems

The bus connections in duplex structures presented on the Fig.5a . The double CAN bus connection assure the fail safe operation, with complex monitoring and fault recovery is realised in program way. This solution is elaborated by Scheidt&Bachmann for cross level protection system, and is a base of fail safe control in other systems [2],[4]. The implementation assures the checking of all bus signals, synchronisation and diagnostics of faulty modules.

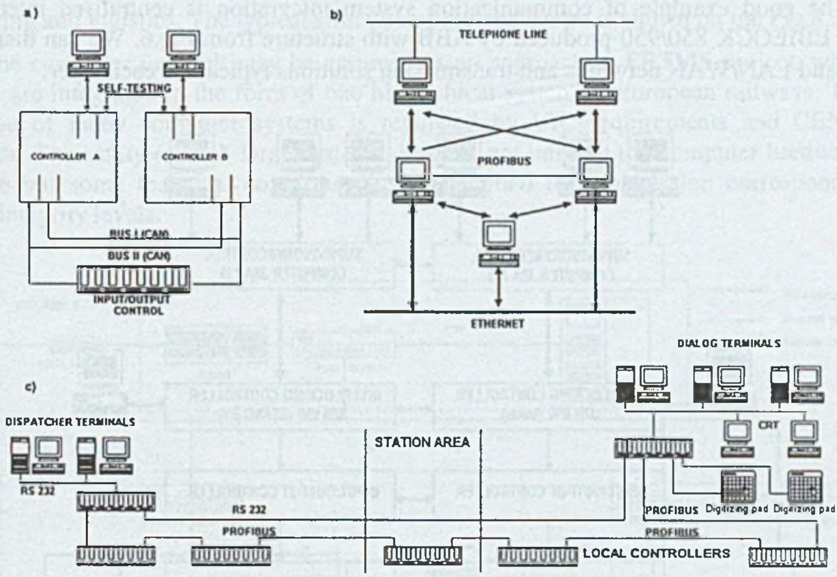


Fig.5. Computer network implemented in Polish railways
a) Bus connections in cross level protectioncontrollers (BUES 2000(μLAN))
b) Dispatcher centre of WSKR (LAN) c) remote control of Warsaw Underground (WAN)

Dispatcher systems

The dispatcher centre for local management has been installed in Cracow in the form from Fig.5b. The communication subsystem applies single ring topology [1], the duplex structure is based on main computer and hot stand-by computer. From technical point of view both computers have the same, actual data sets and restart after switch caused by main computer fault has no influence on dispatcher work.

Remote control systems

The remote control system applying the RS 485 (PROFIBUS) standard is implemented in Warsaw Underground [1], (Fig.5c). It is realisation typical to distributed industrial systems. Both cable distances and transmission rates is sufficient for management of trains from one point of dispatcher centre.

Centralised systems

The good example of communication system integration is centralised interlocking system EBILOCK 850/950 produced by ABB with structure from Fig.6. We can distinguish μLAN and LAN/WAN networks and transmission solutions typical for each layer.

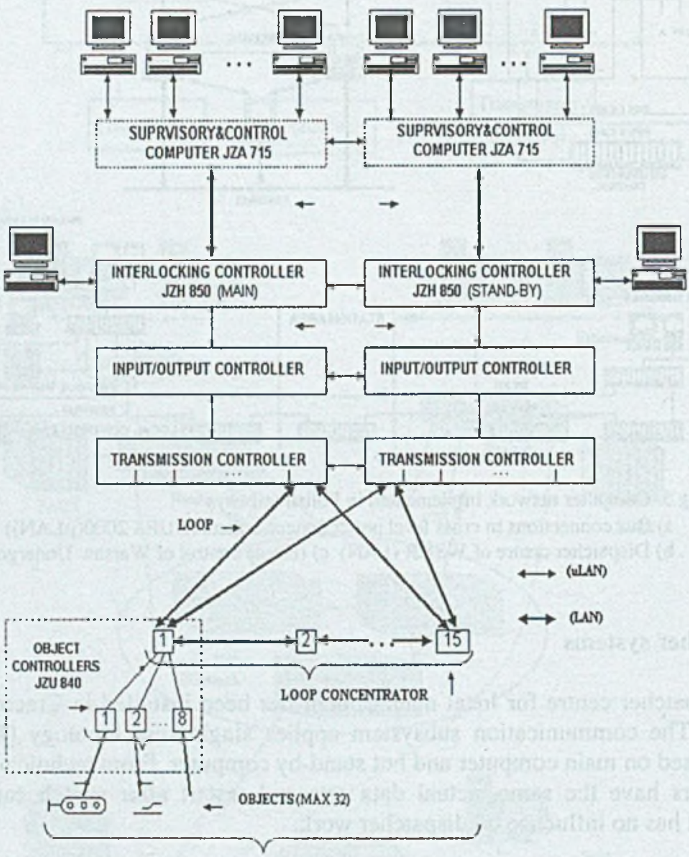


Fig.6. The centralised interlocking with computer network hierarchy

4. CONCLUSIONS

The railway management system may be treated as a large computer network integrating typical computer controllers dedicated to different functions on the distinguished levels corresponding to hierarchical multilevel approach. Such techniques combine different net technologies related to μLAN, LAN and WAN structures. The railway computer networks apply different technologies: copper cables fibre optics and radio transmission (GSM-R). The new standard, Frame Relay (KOLPAK-T) is very convenient for railway traffic management. The transmission parameters are sufficient for information and ticket systems, freight monitoring and logistics. The typical structure of logistic centre is shown on the Fig.8.

The computer network may be assumed as an approach to ERTMS project, where all systems are integrated in the form of one hierarchical system of European railways. The co-operation of many computer systems is regulated by UIC requirements and CENELEC standards. The safety of such large systems depends not only on the computer hardware and software but some technical solutions must be applied to transmission corresponding to system integrity levels.

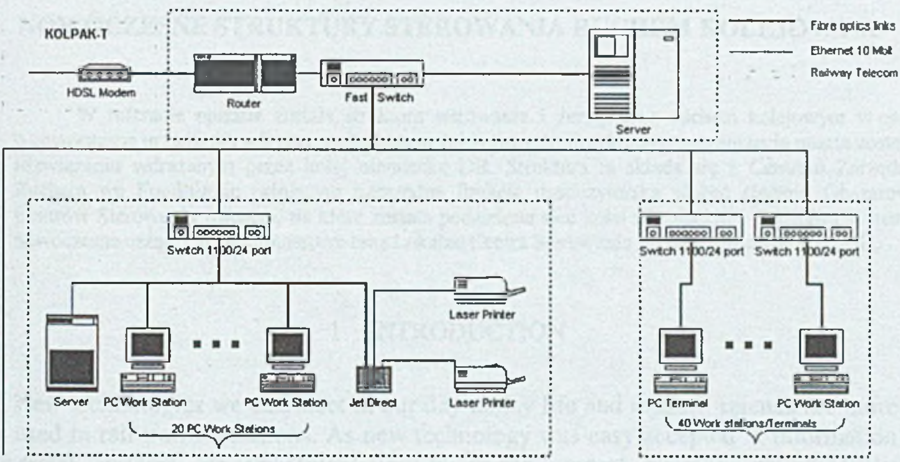


Fig.7. The logistic centre structure

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