



Transport Telematics - Systemic View

Editor

Tomáš Zelinka:

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All the authors are lecturers of the Czech Technical University Prague, Faculty of the Transportation Sciences (CTU, FTS). This book is accepted as a textbook for the ITS joint degree master studies program offered by the CTU, FTS together with Technical University Wien, Austria and Linköping University, Sweden.

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PREFACE

Intelligent transport systems (ITS) link information technologies with transport engineering. The ITS objective is to achieve principal transport, travel and forwarding processes services improvement within the existing transport infrastructure. ITS services cover requirements from an individual local case up to the complex wide area solutions with wide scale of services complexity. The telematics services are an integral part of the ITS. They do not represent the only telecommunications solutions, but they are tightly connected with a wide variety of transportation services. “Intelligent” services with the ability to support the relevant environment of the complex system structures are provided. Consequently, this discipline is closely linked with managerial and legal topics due to their ability to principally influence the system behavior.

There are numerous books and publication proceedings on the topic of ITS or transport telematics available but their approach and scope is different from ours. Typically, they describe the impact of ITS systems on traffic management e.g. real-time traffic management, planning of commercial vehicle operations, environmental management, etc. or they present parts of ITS solutions in big detail: e.g. electronic fare management, car navigation systems, fleet management, digital maps, strategies to reduce transport congestions, etc. In this book we introduce a very new system-oriented approach to the ITS design, operation and evaluation with respect to all predefined performance indicators like reliability, safety, security, integrity, etc.

Systems Theory represents a significant theoretical background for any professional undertaking within the branch of ITS. There are several approaches to elaborating this kind of theory, however, for engineering purposes such as the ITS the classical approach called General Theory of Systems (GTS) is usually accepted as the most beneficial. The Systems science within its application areas means resolving tasks. Efficient handling of the systems ideas implies functional knowledge of a wide range of specific mathematical tools.

The ITS applications require wireless seamless secure communications solutions with selectable level of services quality and mostly also with a wide-area coverage. Even though publically available wireless services usually provide reasonable coverage under acceptable cost conditions, most of the public providers do not offer any data service with the guaranteed quality. The principal improvement of the service quality can be reached by the selection of the best possible alternatives from the set of currently identified available services. Efficient decision processes must be adopted to reach the relevant service quality guarantee. Success of such approach relies on profound understanding of applied technologies and their performance described by the performance indicators.

Critical system properties are represented by security aspects. The difference between security and safety must be well understood. Safety assures that a life-critical system behaves as needed even when certain elements fail. Security is a condition that results from the establishment and maintenance of protective measures that ensure a state of inviolability from hostile acts or influences. Due to the fact that the human being has been a part of a system, security must be understood as a complex of measures leading to the survival of human beings in the system under the influence of an external hostile environment or any other influences. Analysis of potential threats and other security vulnerabilities specific for the telematic system represents the rest of this area. The behavior of a system consists of interactions among elements and it is to be assumed that these interactions have to be undisturbed, i.e. to be secure.

The ITS solutions resolve interactions between systems of a dissimilar nature. The differences can be in its nature, the types of these systems or in the role a particular human subject plays in such an

interaction. The functional reliability has to be considered as an important factor specifying the practical applicability of any real system. The ITS system requires to be designed with high functional reliability. The original approach is based on understanding that reliable systems have to be constructed from adequately reliable parts. Such approach can, however, lead to unrealistic and extremely expensive solutions. Besides the usage of solely reliable components the method of life-time minimization of system functional sensitivity to system parameter changes has been applied. The newest approach developed and used only quite recently has been based on the concept of the so-called prediction diagnostics.

This book addresses scientists, R&D specialists and transport systems designers, as well as students. While the articles were written by experts that are actively involved in the discussed areas research, our intention was to present the texts at a level suitable for a general science and R&D audience. Each article contains a list of references as a point of entry to the comprehensive resources.

The preparation of this publication involved generous support from an extended specialist team and we would like to express our sincere thanks to each one of our colleagues.

Editor

About Authors



Miroslav SVÍTEK

Czech Technical University in Prague, Faculty of Transportations Sciences

Chapter:

- Advanced Design of Intelligent transport systems

Professor Miroslav Svítek was born in Rakovník, Czech Republic, in 1969. He graduated in radioelectronics from Czech Technical University in Prague, in 1992. In 1996, he received the Ph.D. degree in radioelectronics at Faculty of Electrical Engineering, Czech Technical University in Prague. Since 2002, he has been associated professor in engineering informatics at Faculty of Transportation Sciences, Czech Technical University in Prague. Since 2005, he has been nominated as the extraordinary professor in applied informatics at Faculty of Natural Sciences, University of Matej Bel in Banská Bystrica, Slovak Republic. Since 2008, he has been full professor in engineering informatics at Faculty of Transportation Sciences, Czech Technical University in Prague and Honorary professor at Universidad Autónoma de Bucaramanga in Colombia. He is currently teaching courses and doing research in theoretical telematics, intelligent transport systems, quantum system theory and quantum informatics. Miroslav Svítek is president of Association of transport telematics of the Czech and Slovak Republic (it covers more than 70 public and private organization), Dean of Faculty of Transportation Sciences and Head of Department of Control Engineering and Telematics, Czech Technical University in Prague. He is author or co-author of more than 200 scientific papers and 6 monographs.



Zdeněk VOTRUBA

Czech Technical University in Prague, Faculty of Transportations Sciences

Chapter:

- Systems Theory applied in Intelligent Transport Systems

Professor Zdeněk Votruba born in Prague, April 22, 1942.

Graduated at the Faculty of Electrical Engineering of the Czech Technical University in Prague in 1964.

Carried out his postgraduate studies in Computer Research Institute, Prague (VÚMS) and at the Faculty of Mathematics and Physics of the Charles University, Prague, respectively; PhD degree in Applied Physics received in 1975.

In the seventies studied postgraduate course of applied mathematics at CTU in Prague and seminar on informatics and computer architectures at VÚMS.

In the period of 1966-1993 worked with VÚMS as a researcher (1966-1976), scientist (1976-1983), director of technological dept. (1983-1990) and technical director respectively (1990-1993). Interested in measurement and instrumentation technologies, computer peripherals, HMI, in the research of thin magnetic films and Computer Systems. Involved in managing of the complex technological projects (e.g. bipolar gate arrays, testers).

In 1990-1993 participated in the transformation of an “eastern-style”. Research Institute into the group of market-oriented private companies.

In one of them, VUMS-EPOS was active in 1994-5 in the post of managing director. Involved in consultancy services, both for domestic (state administration) and international bodies.

- In 1996 joined Czech Technical University in Prague, Faculty of Transportation Sciences.
- In 2000 gained the scientific – pedagogical degree of Associate Professor in the scientific branch “Engineering Informatics”.
- In the period of 2000-2008 he was in the posts of the head of Dept. of Control and Telematics and vice - dean of Faculty.
- Since 2005 full professor of Engineering Informatics in Transportation and Telecommunication; Czech Technical University in Prague, Faculty of Transportation Sci.
- Reads Lectures in Systems Science and Electronics.
- Carries - out research in the fields of Systems Science, HMI, Telematics and Reliability.

Further activities:

In seventies: teaching in postgraduate courses at CTU in Prague, Faculty of Electrical Engineering,

1980-1990: Seminars, consultancy and research at the Charles University, Faculty of Mathematics and Physics.

Awards:

Gold and Silver Felber's Medals of CTU in Prague; Perner's Medal of Jan Perner University in Pardubice

Membership in professional communities / bodies:

- Union of Czech and Slovak Mathematicians and Physicists
- IEEE (USA)
- Scientific Council of the Faculty of Transportation Sciences
- Grant Agency of the Czech Republic
- Evaluating Committee of the Ministry of Transport, Czech Republic
- Branch Council of Engineering Informatics CTU in Prague, Faculty of Transportation Sciences.
- Cybernetic Society of the Czech Republic



Tomas ZELINKA.

Czech Technical University in Prague, Faculty of Transportations Sciences

Chapter:

- Preface
- Telecommunications systems for ITS solutions

Professor Tomas Zelinka - Informatics - CTU in Prague, Ph.D. (CSc.) - experimental physics in the Czechoslovak Academy of Sciences, mgr. (Ing.) - Cybernetics and computer sciences at the Czech Technical University Praha, FEL

2005 – Czech Technical University in Prague, Faculty of Transportations Sciences

- Lectures: basic and advances lectures in area of the telecommunications sciences, legal issues of telecommunications, new trends in telecommunications applied in the Intelligent Transport Systems (ITS),
- R&D: theoretical background of specific telecommunications solutions dedicated for the ITS, vehicles Electronic Fee Collection (EFC) and related Value Added Services (VAS), On Board Units architecture, system security etc.

1993 – 2005 Communications business

- Development of the new products, the business development e.g. in area of alternative global voice and data communications in the Czech Republic and the other countries of the CEEMEA region
- EuroTel/Nextel/Global One (Sprint Int., France Telecom, Deutsche Telekom)
- External lecturer and mentor at the FTS of the CTU in Prague

1976 – 1993 Geophysical Institute of the Czechoslovak Academy of Sciences

- Experimental laboratory and observatory methods in geophysics, studies of the variations and drift of the Earth magnetic field, data communication solutions within international and national observatory system,
- Computer modeling of the magnetic material structures with on-line experimental identification, laboratory study of the magnetic properties of rocks,

1972 – 1976 Industrial R&D

- Automatic control systems for the technological processes – CNC, Data communications and computer based control in technological processes.



Václav JIROVSKÝ

Czech Technical University in Prague, Faculty of Transportations Sciences

Chapter:

- Telematics System Security

Professor Václav Jirovský had graduated at Czech Technical University, Prague (CTU), Czech Republic, in radioelectronics. In his Ph.D. thesis he introduced application of theory of homogeneous structures in different areas of electronic and especially in the computer modeling. Later he joined the Regional University Computing Center where he led department of Research and Development. His team had developed a new system for the city transport monitoring and control for Prague City Transport Corporation (PCT), based on combination of radio navigation and microwave communication. For short time he had entered the position of Executive Director for Development in the PCT, but after successful completion of the project he went back to

academia taking senior scientist position at Department of Software Engineering at Faculty of Mathematics and Physics, Charles University, Prague. In 1991 he had received position in Research and Development department of Advanced Computer Applications, Inc. in Newtown, Pennsylvania, U.S.A. finally becoming a director for R&D in the company. He left the company at 1998 joining his original team at Charles University. During years 2001/2002 he accepted position of Executive Director for Technology at Czech Telecom Corporation, lately returning back to Charles University as Associated Professor of Computer Sciences. In the year 2008 he changed position to the Czech Technical University, Faculty of Transportation Sciences, taking chair of Department of Security Technologies and Engineering. In 2007, as a member of Expert Group of the Minister of Transportation of the Czech Republic, he designed a new concept of hybrid system for electronic tolling services. His design of hybrid toll system anticipate ISO/CEN standard for European Electronic Tolling Service and had been evaluated by standardization group as the nearest implementation of EETS.



Mirko NOVÁK

Czech Technical University in Prague, Faculty of Transportations Sciences

Chapter:

- Prediction diagnostics for system reliability

Professor Mirko Novak was born on September 29, 1930 in Prague, Czechoslovakia.

In 1956 he joined the Institute of Radioengineering and Electronics of the Czechoslovak Academy of Sciences in Prague, where was the head of the Department of System Theory.

In 1965 and 1966 he has been the visiting professor of the Department of Electrical Engineering of New York University.

- In 1975 he has founded a new Institute of Computer Science of the Czechoslovak Academy of Sciences. He has been in the position of the director of this Institute for almost 15 years. Since 1965 he is the senior member of the Institute of Electrical and Electronic Engineers, Inc. and in 1988 he becomes the Corresponding member of the Czechoslovak Academy of Sciences.
- His present research interest in the field of neural networks is mainly in the theory of sensitivity and tolerances of neural networks and of their applications for signal processing, time series prediction and system reliability improvement. He is also interested in internal information systems of living bodies and of cells and in the field of the human subject – artificial, namely transportation system interaction reliability. Prof. Dr. Mirko Novák has written more than 150 research reports, about 110 scientific papers, has presented about 200 contributions on scientific conferences, colloquia and seminars and has published almost 30 scientific books in Czech, English and Russian, total - about 500 scientific presentations.

At the end of 1994 he was one of the founders of the Joint Laboratory of System Reliability between the Czech Technical University, Prague, Faculty of Transportation Sciences and the Institute of Computer Science of the Academy of Sciences, Czech Republic.

In 1999 he joined the activity of the workgroup for Neuroinformatics of the Global Science Forum OECD and took part in the preparing of the world research program in neuroinformatics. Since 2000 he is the full professor at the CTU, Faculty of Transportation sciences. He was to 2010 the chairman of the Czech National Node for Neuroinformatics and the Czech representative in INCF (International Neuroinformatic Coordination Facility) of GSF OECD.

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Index Terms

Access network
Access wireless mobile solutions
Accident
Accuracy
activation threats,
Adaptive decision processes
Alliance Control
Alternative Behavior
Antecedent
antijamming
Artificial Intelligence
Artificial systems
AS
ASN.1
ATM
ATM Architecture
Attack by Enterprise
Attack by Foreign Power
Attack by Government
Attack by Hacker
Attack by Service Charger
Attack by Service Provider
Attack by User
Attack on OBU
Attack on OBU Data
Attack on Sensor
Authentication
Availability
Backbone networks
back-door
Base station
Basic Encoding Rules (BER)
basic threats,
Behavior
BER (Bit Error Rate)
Block Cipher
Bluetooth
CALM
CAT
Catastrophe theory
CDMA
Cellular Layer
classes separability
Communication
Communication architecture
complementary information
complementation functions
Components
constant jamming
consumer privacy
Continuity
core business
CoS
Cost-benefit analyze (CBA)
Cryptographic Checksum
cryptography
CSD
CSD measurement results
CWDM
Cybernetics
data privacy
deceptive jamming
Decomposition
Delay
denial of service
Design centering
Distinguished Encoding Rules (DER)
DOTEK
DSRC
DSRC 5.8
DSRC 5.9 - WAVE
DTMF
Duplex
DWDM
Economic impact
EDGE measurement results
Electronic Toll Collection (ETC)
Elementary catastrophe
Elements
encrypted packet,
Environmental functions
ERTICO
ETHERNET
Expectation-Maximisation (EM) algorithm
Exposure
extended Kalman filtering
fail safe
Failure risk
Failure risks analysis
false alert
Feedback
Feistel Networks
first generation of handover
Flow Network Task
frequency hopping spread spectrum
Functional architecture
Functional blocks
Galileo
Generalized DOTEK architecture
Genetic Code
Global Navigation Satellite Systems (GNSS)
GNSS
Goals
GPRS
GPRS measurement results
GPS

GSM
GSM data services
Half duplex
handoff
handover
Hazard criteria
Hazards
heterogeneous IEEE 802 networks
Heterogeneous systems
hierarchy of services area coverage
HMI (Human Machine Interface)
Homeostasis
Homogenization
Homogenous systems
HSCSD
HSCSD measurement results
Hybrid systems
HYPER-ring
Hysteresis
IBS
Identification
Identity
IEEE 802.11a
IEEE 802.11b
IEEE 802.11e
IEEE 802.11g
IEEE 802.11i
IEEE 802.11n
IEEE 802.11p
IEEE 802.11r
IEEE 802.15
IEEE 802.15.1
IEEE 802.15.3
IEEE 802.15.4
IEEE 802.16d
IEEE 802.16e
IEEE 802.1q
IEEE 802.21 Reference Model
IEEE 802.21 standard
IEEE 802.3
Ill designed system
Independent variables
Information architecture
Information Power
Initiator
Integration
Integrity
intelligent routing
Intelligent Transport Systems (ITS)
Interaction
Interaction coupling
Interface
Internal Rate of Return (IRR)
Interoperability
IP

IP addressing
ISO 21210
ITS
ITS architecture
ITS data registry
ITS databases
ITS effectiveness
ITS market packages
ITS Performance Parameters
ITS requirements
ITS standards
ITS system model
ITS technological platform
jamming
Kalman filtering algorithm
kernel function
Keyless hash function
Language
Laplace density function
Laplace kernel
Life curve
Life-time
LTE
M from N
M5
MAC
MAN
masquerading
mass market
medical privacy
Mobilní WiMax
Model
MPLS
MTBF (Mean Time Between Failure)
MTTR
Multi mode optical fibre
Multi-path access
multipath regime
Natural hazard
Natural systems
Net Present Value (NPV)
OBU (Out Board Unit)
Optimization
Organisation architecture
organization security,
Packed Encoding Rules (PER)
Packet/Frames Loss
PAN
Parallel behavior
Parameter synchronization
Parts
password
Path
PBT
PDH

performance
 personal security
 Physical architecture
 Physical Layer
 political privacy
 Prediction diagnostic
 Prediction diagnostic
 Prediction diagnostic in multi-parameter systems
 Prediction diagnostic methodology
 proactive measure,
 Probability
 product security
 Production wreck
 Profitability Index (NPV/I)
 Protocol synchronization
 Public Key Cryptography
 public providers
 public telecommunications
 QoS
 quality
 Radial sprouting
 random jamming
 reactive jamming,
 reactive measure,
 Reference architecture
 Regions of acceptability
 Relations
 Reliability
 Restoration procedure
 right detection
 Risk analysis
 Risk criteria
 RM OSI
 Routing
 RSTP
 RTD (Round Trip Delay)
 Safety
 SAT
 SDH
 SDH architecture
 second generation of handover
 Security
 Security
 security models
 Service Activation Time
 Service availability
 services performance
 Simplex
 Single mode optical fibre
 SLA
 SMS
 social engineering
 Societal Destabilization
 Soft systems analysis techniques
 Soft Systems Methodologies (SSM)

Soft Systems Tasks
 SONET
 STP
 Stream Cipher
 Structural tasks
 Subsequent Elements
 subsystem
 System
 System alliances
 System Approach
 System functions
 System parameters
 system reliability
 System reliability theory
 system safety
 system security
 System structures
 System Vulnerability
 Systems
 Systems Architecture
 Systems Reliability
 Systems uncertainty
 TCP
 TCP/IP
 TCP/IP architecture
 Technological hazard
 Telecommunications performance indicators
 telematic system
 Terminator
 The Data encryption Standard
 Theory of Systems Alliances
 Time
 Time synchronization
 Trans-European Network for Transport (TEN-T)
 Transport Telematics
 Transposition Cipher
 Trojan horse
 UMTS
 underlying threats.
 Unified modeling language (UML)
 UTP
 UWB
 Vigenère
 VPN
 Vulnerability
 WAN
 WDM
 Well designed system
 WiFi
 WiFi (IEEE 802.11) measurement results
 WiMax – IEEE 802.16
 WiMax (IEEE 802.16d) measurement results
 Winner takes all
 Yield
 ZigBee