

Preface

The subject of the book is to present systematized research, development and implementation of green information technologies engineering (green IT engineering), and green IT principles into components, networks, and complex systems (software, programmable and hardware components, communications, cloud and IoT-based systems, IT-infrastructures) and to describe energy-/cost-efficient and safe applications in industry and human domains.

green IT engineering is a special kind of engineering based on energy saving and effective information technologies. It could be represented in a form of services tended to improve energy efficiency, safety, and environmental performance of industrial processes and products.

This monograph is “de-facto” a Volume 2 to the first book “Green IT Engineering: Concepts, Models, Complex Systems Architectures,” published by Springer in the beginning of 2017.

All contributions were discussed at the international TEMPUS-project GreenCo’s workshops and seminars (UK, Italy, Portugal, Sweden, Ukraine) during 2013–2016 years and 1–5th Workshops on green and safe computing (GreenSCom) in Russia, Slovakia, and Ukraine.

This second monograph with the same first part of the title “Green IT Engineering” aims to motivate researchers and engineers from different IT domains to assumption and propagation of green values in complex.

The book has a chapter-oriented structure according to green IT “vertical” from components to complex industry systems and infrastructure. The chapters are prepared according to general paradigm and unified scheme of content, and step by step describe elements of green IT engineering taxonomy logically adding one of other.

In terms of structure, the 16 chapters of the book, presented by authors from Greece, Malasia, Russia, Slovakia, Ukraine, and UK, are grouped into four parts: (1) Green Internet of Things, Cloud Computing, and Data Mining: Methodology, Algorithms, and Tools; (2) Green Mobile and Embedded Control Systems: Power Consumption, Security, and Safety Issues; (3) Green Logic and FPGA Design: Synthesis, Fault-Tolerance, and Experiments; and (4) Green IT for Industry and Smart Grid: Models and Implementation.

The chapters have been thought out and grouped to provide an easy introduction to the topics that are addressed, including the most relevant references, so that anyone interested in them can start their introduction to the topic through these references. At the same time, all of them correspond to different aspects of work in progress being carried out in various research groups throughout the world and, therefore, provide information on the state of the art of some of these topics.

Part I “Green Internet of Things, Cloud Computing and Data Mining: Methodology, Algorithms and Tools,” includes five chapter:

Chapter “[Vedic Mathematics as Fast Algorithms in Green Computing for Internet of Things](#),” by V. Sklyar, describes an approach to improve energy efficiency of low power devices for Internet of Things (IoT). The proposed approach is based on using of fast computation algorithms like Vedic Mathematic. IoT architecture for experiments with different applications and features is proposed and described. The Device Layer of this architecture is based on Arduino platform. A measurement of power consumption of Device Layer in conditions of constant power supply voltage can be done with Hall effect sensors which are able to measure a current. Dependencies of operation cycle time and consumed device memory from computations algorithms and variables types are experimentally investigated.

N. Doukas, in Chapter “[Technologies for Greener Internet of Things Systems](#),” considers two paradigms “Internet of Things” and “Big Data,” which are correlated, since Internet of Things applications are beneficial when there are “a lot of things,” and hence, the amount of data classifies as “Big Data.” The Internet of Things information processing paradigm is one of the rare occasions where the demand for green computing systems does not compete with the need for performance. The volumes of data that need to be processed are overwhelming to such an extent that approaches which use unlimited amounts of power, for processing, storage and the associated hardware cooling, are simply not feasible. At the same time, remotely operating components that form the distributed processing network, such as smart mobile devices or remote interconnected sensors, need to be green if they are to be viable. The chapter focuses on algorithmic developments that make the real-time collection, summarization, analysis, and decision making based on streaming data less energy consuming.

In Chapter “[Secure, Green Implementation of Modular Arithmetic Operations for IoT and Cloud Applications](#),” N.G. Bardis considers the methods for securely performing the calculations required for fundamental modular arithmetic operations, namely multiplication and exponentiation using mobile, embedded, remote, or distant computational resources, that offer the possibility for green information processing system development. These methods are targeted to the distributed paradigms of cloud computing resources and Internet of Things applications. They provide security by avoiding the disclosure to the cloud resource of either the data or the user secret key. Simultaneously, environmental effects of processing are minimized by the simplifications of the operations and by transferring demanding calculations to energy-efficient data centers. The developed modular multiplication algorithm provides faster execution on low complexity hardware in comparison

with the existing algorithms and is oriented toward the variable value of the modulus, especially with the software implementation on microcontrollers and smart cards whose architectures include a small number of bits.

V. Hahanov, E. Litvinova, and S. Chumachenko, in Chapter “[Green Cyber Physical Computing as Sustainable Development Model](#),” consider the green cyber culture of micro, macro, cosmological, and virtual computing, which formulates, explains, and predicts the current processes and phenomena monitoring and control technology in the physical and virtual space. The verbal and structural definitions of the main types of computing based on current trend evolution of planet cyber ecosystem and the universal model of MAT-computing, which leverages three components (memory, address, transactions) to create a computational structure in technologically acceptable matter environment, are represented. Special attention paid to computing model, which defines the structure of quasi-optimal digital monitoring and cloud control of scalable technical, biological, social, and virtual processes.

In Chapter “[Data Acquisition for Environmental and Humanitarian Crisis Management](#),” E. Dontas, F. Toufexis, N. Bardis, and N. Doukas consider a systematic crisis and disaster management process that involves Big Data analytics with principal goal to minimize the negative impact or consequences of crises and disasters, thus protecting societal and natural environment. green IT engineering principles are translated as a need to analyze data in order to detect early warnings of evolving environmental effects. Big Data analytics in the context of crisis management involves efficient solutions in four fundamental aspects of the related technology: data volume, data velocity, data variety, and data value. This chapter aims to present appropriate solutions in all aspects of distributed data analysis of social media data so as to define the enabling technologies for high-performance decision support for the purpose of crisis management.

Part II “Green Mobile and Embedded Control Systems: Power Consumption, Security and Safety Issues” includes four chapters:

In Chapter “[Influence of Software Optimization on Energy Consumption of Embedded Systems](#),” A. Chemeris, D. Lazorenko, and S. Sushko show that program optimization has the positive influence on power consumption. The system-level optimization has the greatest effect on potential power consumption gains. The chapter is focused on the transformations of program loops as the point where the most of computational load exists. The loop fusion algorithm for programs optimization is presented, and its influence to the power consumption is discussed. The experiment results show that the loop fusion optimization may decrease the current consumption by more than 20%. The authors propose the loop fusion method for high-level language code-to-code transformations and demonstrate its efficiency in terms of power consumption.

S.N.D.M. Azmi, A.-L. Kor, C. Pattinson, and N. Bujang, in Chapter “[Energy Efficiency of 4th Gen Intel® Core™ Processor Versus 3rd Gen Intel® Core™ Processor](#),” compare the energy efficiency between two generations’ Intel processors: the 4th Gen Intel® Core™ Processor and 3rd Gen Intel® Core™ Processor. The chapter also surveys the technologies that provide better energy performance

for both of the processors. The results obtained from the experiment show that the 4th Gen Intel® Core™ Processor is more energy-efficient than the 3rd Gen Intel® Core™ Processor.

D. Maevsky, E. Maevskaya, E. Stetsuyk, and L. Shapa, in Chapter “[Malicious Software Effect on the Mobile Devices Power Consumption](#),” propose the method of indirect detection of malicious software, which cannot be recognized as a computer virus since it does not include the program codes realizing the virus multiplication and infection of other devices. The computer programs, which provide malefactors with the data, concerning the usage of an infected mobile device, can be referred to malicious software. The proposed method is based on a hypothesis of power consumption increasing in a mobile device after its being infected by malicious software. The experiment results demonstrate the correctness of the hypothesis and show that after the input of malicious software, the smart-phone power consumption increases. The proposed method can be used for any mobile devices running under the control of any operating systems.

In Chapter “[Rational Intellectualization of the Aircraft Control: Resources-Saving Safety Improvement](#),” A. Kulik presents a substantiation for the necessity of improving the aircraft flight safety due to reducing the flight costs by using green technology and intellectualizing the technologies that provide diagnosis and recovery of control systems operability. Special attention paid to the typical reasons for operability failure of three aircraft types: airplanes, unmanned aerial vehicles, and spacecraft. A new approach standing on the diagnosis-based control principle and providing for operability of aircraft control systems is suggested. The usage of the principle requires supplementing intelligent control functions: diagnosis and recovery of operability. An example of forming the algorithm for sensor operability recovery in the heading channel of a flying model is presented.

Part III “Green Logic and FPGA Design: Synthesis, Fault-Tolerance and Experiments” includes three chapters:

Chapter “[Resource and Energy Optimization Oriented Development of FPGA-Based Adaptive Logical Networks for Classification Problem](#)” (authors: A.V. Palagin, V.M. Opanasenko, S.L. Kryvyi) deals with the development of new digital FPGA-based devices with a high degree of reconfigurability by dynamic adjustment of architecture and structures that can improve the efficiency of reconfigurable devices and systems according to the optimal criteria of hardware resources and power consumption, which are decisive for the green IT engineering. Authors focus on the class of facilities in relation to implementation of “reconfigurable computing” technology. It is showed that in the dynamic logical structure devices, the dynamically changing configuration depends on the specific solving problem by transmitting information about any given current configuration. As a basic structure for construction of such devices, authors consider adaptive logical networks (ALN), designed for solving of a wide class of problems by means of directly implementing algorithms and by direct mapping of the input data into output data.

In Chapter “[Green Experiments with FPGA](#),” A. Drozd, J. Drozd, S. Antoshchuk, V. Antonyuk, K. Zashcholkin, M. Drozd, and O. Titomir examine experimentally the opportunity of the modern CAD and feature of FPGA for

development of the power-efficient digital components of computer systems. Authors discuss (a) the preliminary estimation of energy consumption in the project implemented in Altera FPGA; (b) the assessment of energy consumption distribution between parts of the project circuit by control of signals activity; (c) influence of the partial failure of circuits of the general signals on energy consumption of the FPGA circuit; (d) monitoring of the general signals in the circuit according to its energy consumption; and (e) a problem of the glitches caused by signal races with parasitic transitions leading to essential power losses. The program model developed for an assessment of glitches in the iterative array multiplier shows repeated exceeding of number of parasitic transitions in comparison with the number of functional ones. The matrix parallelism which is widely used in the FPGA circuits is the cornerstone of the problem of glitches. Experiments with FPGA show solution to this problem by simplification of array structures in use of additional and natural pipelining and in execution of the truncated operations.

S. Tyurin, in Chapter “[Green Logic: Green LUT FPGA Concepts, Models and Evaluations](#),” focuses on the correlation between green computing and FPGA computing, which largely determined by millions so-called LUTs. The chapter considers the concept of green LUT FPGA in three main green logic areas: (a) Double LUT, which computes two functions simultaneously through the using of inactive transmission transistors LUTs subtree; (b) LUT—decoder with possibility to calculate a system of the logic functions and proposed technique can significantly reduce hardware complexity and power consumption taking into account the use of millions logic elements; and (c) DNF-LUT, which allows the calculations of the logic systems in Disjunctive Normal Form (DNF) and else more significantly reduces the complexity of the large number variables LUT. The models of the proposed concepts were explored in the NI Multisim 10 by National Instruments Electronics Workbench Group. The chapter analyzes the green LUT assessments and formulates the conclusions about the effectiveness of the proposed solutions for the green computing.

Part IV “Green IT for Industry and Smart Grid: Models and Implementation” includes four chapters:

V. Pavlenko, I. Shostak, A. Sobchak, O. Morozova, and M. Danova, in Chapter “[The Concept of Virtual Manufacturing Enterprise Operation as a Green Complex System](#),” focuses on the idea of virtual enterprise (VE) creation, deployment, and functioning support through the use of green IT concept. The green IT is regarded as a complex of innovative techniques and processes used in material production and based on the principles of sustainable development. The VE requires the implementation of the green IT concept because the vast majority of business processes on VE are based on information search, collection, storage, delivery, and dissemination. The authors describe informational support for the main life cycle (LC) stages of the VE from the standpoint of the green IT that decreases the

environmental stress during the VE operation. Authors also discuss (a) the evaluation of economic efficiency of the proposed approach for managing VE LC within green IT concept; (b) a spiral model, which allows to make quick and flexible management decisions according to investment into further upgrades and continue production; (c) evaluation results, which deal with increasing integrated resource production efficiency and decreasing economic risks and damage caused to the environment during production.

In Chapter “[Green-IT Approach to Design and Optimization of Thermoacoustic Waste Heat Utilization Plant Based on Soft Computing](#),” Y. Kondratenko, V. Korobko, O. Korobko, G. Kondratenko, and O. Kozlov consider the intelligent digital system for control of thermoacoustic plant with providing optimal working conditions for increasing its efficiency. Authors synthesize the fuzzy controllers of Mamdani and Sugeno types for the created control system. Fuzzy controllers are compared with a traditional PD controller in terms of their operation speed and accuracy. Special attention is paid to green IT approach for the design of embedded fuzzy systems by the optimization of fuzzy controllers based on the different types and parameters of linguistic terms for input and output signals as well as on minimization of fuzzy rule quantity in the preliminary synthesized fuzzy rule bases. The results of comparative analysis of initial and optimized fuzzy controllers are discussed in detail.

G. Kuchuk, A. Kovalenko, V. Kharchenko, and A. Shamraev, in the Chapter “[Resource-Oriented Approaches to Implementation of Traffic Control Technologies in Safety-Critical I&C Systems](#),” consider appropriate approaches intended to solve the problem of traffic control in safety-critical I&C systems in order to reduce data flows’ transmission time. Proposed method of rapid identification of traffic parameters on the basis of the current samples for timely detection of traffic anomalies allows reducing time of traffic main parameter identification by 15–20%. For the prediction of fractal traffic, authors propose an approach, which based on certain properties of fractal processes, including self-similarity and linearity of autocorrelation function. Simulation results proved that proposed approach allowed reducing power consumption during appearance anomalies in traffic behavior, compared to standard approaches, by approximately 20%.

In Chapter “[Markov Models of Smart Grid Digital Substations Availability: Multi-level Degradation and Recovery of Power Resources Issues](#),” the authors H. Fesenko, V. Kharchenko, E. Brezhnev, E. Zaitseva, and V. Levashenko consider the merging unit (MU) as one of the most important components of smart grid digital substation, which is a recovered multi-state system (RMSS). Authors analyze existing approaches to RMSS assessment based on Markov models, degradation levels for MU, and degradation diagrams. The main feature of the proposed Markov models is consideration of testing and recovery errors caused by problems of checking coverage and faults of checking means. Finally, authors formulate recommendations based on the research results for improving maintenance policy and availability of the MU.

The chapters selected for this book (Volume 2, Green IT Engineering) provide an overview of some problems in the area of green IT engineering and the

approaches and techniques that relevant research groups within this area are employing to try to solve them. We would like to express our appreciation to all authors for their contributions as well as to reviewers for their timely and interesting comments and suggestions. We certainly look forward to working with all contributors again.

Kharkiv, Ukraine
Mykolaiv, Ukraine
Warsaw, Poland
December 2016

Prof. Dr. Sc. Vyacheslav Kharchenko
Prof. Dr. Sc. Yuriy Kondratenko
Prof. Dr. Sc. Janusz Kacprzyk

Green IT Engineering: Components, Networks and
Systems Implementation

Kharchenko, V.; Kondratenko, Y.; Kacprzyk, J. (Eds.)

2017, XIV, 355 p. 147 illus., 82 illus. in color., Hardcover

ISBN: 978-3-319-55594-2