Studies in Systems, Decision and Control 533

Peter S. Sapaty

Spatial Networking in the United Physical, Virtual, and Mental World

Springer

Studies in Systems, Decision and Control

Volume 533

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Peter S. Sapaty
Institute of Mathematical Machines
and Systems
National Academy of Sciences of Ukraine
Kyiv, Ukraine

ISSN 2198-4182 ISSN 2198-4190 (electronic)
Studies in Systems, Decision and Control
ISBN 978-3-031-62153-6 ISBN 978-3-031-62154-3 (eBook)
https://doi.org/10.1007/978-3-031-62154-3

To global consciousness, wisdom, and peace desperately needed to protect the whole world from growing conflicts and wars, which are painfully witnessed especially after working for a long time in very different countries with good cooperation and friends in all of them

Preface

The ideas of this book originate from the WAVE approach which allowed us, more than half a century ago, to implement citywide heterogeneous computer networks and solve distributed problems on them in a simple, flexible, and mobile way, well before the Internet. The invented system organization and management paradigm evolved into Spatial Grasp Technology (SGT) resulting in a European Patent and nine previous books oriented on concrete applications in social and defence systems, security, crises management, gestalt theory, collective robotics, space research, and many others. SGT and its basic Spatial Grasp Language (SGL) allow us to directly exist, move, and operate in physical, virtual, and mental spaces by creating holistic recursive substances self-evolving, self-propagating, and self-matching the distributed worlds. The obtained solutions often exhibit high system integrity, awareness, and even a sort of consciousness.

Many applications and results of the previous works and publications were dealing with graph and network problems and solutions which were extremely important in the researched areas. The current book chooses graphs and networks as the primary and global research objectives after reviewing numerous and very different types and areas of networking. These include transport networks, communication networks, social networks, military networks, economic networks, production networks, evaluation networks, distribution networks, virtual networks, neural networks, psychological networks, criminal networks, etc. We also investigated many existing works on graph and network theory, graph data structures, network and graph algorithms and operations, graph pattern matching, distributed networks, maximum flow in networks, and others, including very important network centrality features.

The main goal of this book is the investigation of applicability of SGT and SGL for the development of higher level infrastructures effectively combining and integrating very different types of networking under the same practical and unified approach, and also the application of the networking approach in very new areas like the creation of artificial organoids and brain research. By the results obtained in the book, the whole world under SGT can be hypothetically and symbolically considered as organized in the following interacting levels: spiritual and mental levels providing global security, integrity, awareness and consciousness, middle networking level materializing from

the mental level, and real physical-virtual world controlled and managed by the networking models and cultures.

In our strong belief, the book can help develop advanced social, economic, cultural, educational, and political infrastructures capable of providing and supporting both local and global development, evolution, prosperity, and security within any terrestrial and celestial environments.

Kyiv, Ukraine Peter S. Sapaty
April 2024

Acknowledgments

Special thanks go to my good colleagues, friends, and their organizations for the lasting support and active discussions of the ideas of this book:

John Page, University of New South Wales, Australia
Steve Lambacher, Aoyama Gakuin University, Tokyo, Japan
Kohei Arai, Saga University, Saga Prefecture, Japan
Bob Nugent, Catholic University of America, Washington D.C.
James White, Vice President of General Magic, retired, Hawaii, USA
Thomas Ditzinger, Editor of Springer books, Germany
Gabriella Williams, Editor, IT—Security, Networking and Communication, Taylor & Francis, UK
Svitlana Tymchyk, Nataliia Karevina, and Yevheniia Petruk, Editorial team of Mathematical Machines and Systems journal, National Academy of Sciences of Ukraine.

Kyiv, Ukraine
June 20, 2024

Peter S. Sapaty

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About the Author

Dr. Peter S. Sapaty Chief Research Scientist, Ukrainian Academy of Sciences, has been with networked systems for more than five decades. Outside of Ukraine, he worked in former Czechoslovakia (now Slovak Republic), Germany, the UK, Canada, and Japan as a group leader, Alexander von Humboldt researcher, and invited and visiting professor. He launched and chaired the SIG on Mobile Cooperative Technologies in Distributed Interactive Simulation project in the US, and invented a distributed control technology that resulted in a European patent and books with Wiley, Springer, Emerald, and Taylor & Francis. He has published more than 280 papers on distributed systems, and has been included in the Marquis Who's Who in the World and Cambridge Outstanding Intellectuals of the 21st Century. Peter also works with several international scientific journals as their editorial board member.

Chapter 1
Introduction

1.1 Networking World and the Global Approach Needed

We are witnessing rapidly growing popularity and activity in the use of networking models and solutions for solving numerous problems in many specific areas. As a universal model and approach, networks can be also used for solving complex problems simultaneously covering very different domains. The main goal of this book is to investigate and propose universal networking techniques and solutions simultaneously covering different areas with united solutions in them, using for this the patented and revealed in many previous publications Spatial Grasp Model and Technology (SGT). The book reviews, analyzes, and classifies the current use of networks in many physical, virtual and mental areas, psychological and psychiatric including. It briefs SGT and its main features, details of Spatial Grasp Language (SGL) and its networked implementation, which can operate without central resources and cover arbitrary large areas. It describes fundamental network operations in SGL which can be performed in parallel and fully distributed mode, including those discovering and analyzing main features of graphs and networks, using active self-matching networking patterns, and providing holistic united solutions in the combined worlds. The book has a special chapter using SGT for modeling organoids and organoid cultures, which are important in medicine and brain research.

The rest of this Introduction chapter is organized as follows. Section 1.2 reviews a number of other books analyzed, compared, used for, and stimulated this book project. Section 1.3 briefs key ideas and features of the Spatial Grasp Model and Technology on which solutions presented in the book are based. Section 1.4 provides summary of other book chapters. References contain literature sources used in the book.

P. S. Sapaty, *Spatial Networking in the United Physical, Virtual, and Mental World*,
Studies in Systems, Decision and Control 533,
https://doi.org/10.1007/978-3-031-62154-3_1

1.2 Other Books Analyzed, Compared, and Used for This Book Project

As this publication was planned as a book, we first looked through some other books published in this and related areas, to learn how they are organized, of which volume, when published, how may relate to the current book proposal, and so on. The following books were investigated in this way and summarized as follows.

The Physical and Virtual Space of the Consulting Room: Room-object Spaces [1]. Examines the role of space and objects in the psychoanalytic process, explores spatialization as simultaneously being a psychological projection of meaning and physically acting upon environment.

Virtual Reality for Physical and Motor Rehabilitation [2]. Reviews two decades of progress in virtual reality for physical and motor rehabilitation, offers research on the capacity of VR to evaluate, address, and reduce motor skill limitations.

The Pilates Method of Physical and Mental Conditioning [3]. A unique system of physical and mental exercise, which stresses control and centering of the body, precise movement, smoothness of motion, proper breathing, and relaxation.

Innovation System Frontiers: Cluster Networks and Global Value [4]. Using interdependencies between key economies analyses systems that cross national borders, shows that technological complexity is an important factor in the formation of production networks.

Foreign Direct Investment and Corporate Networking: A Framework for Spatial Analysis of Investment Conditions [5]. Examines foreign direct investment from spatial perspective and considers how knowledge, regional synergies, economic integration, corporate strategies and networking affect patterns of investment.

Spatial Multidimensional Cooperative Transmission Theories and Key Technologies [6]. Introduces theory and technologies of multi-antenna system, describes spatial multi-dimensional cooperative transmission in the ground-based, air-based and space-based communication systems.

Spatial Network Big Databases: Queries and Storage Methods [7]. Provides a collection of concepts, algorithms, and techniques that effectively harness the power of spatial network big data, investigates scalable graph-based query processing strategies.

Managing Airline Networks: Design, Integration and Innovative Technologies [8]. Discusses the impact of network management on airline resource planning and performance, examines the interplay between network management and adjacent functions.

Optimal Operation of Active Distribution Networks: Congestion Management, Voltage Control and Service Restoration [9]. Provides case studies, modern implementations and supporting flowcharts and code, along with current research in congestion management, service restoration and voltage control of active distribution networks.

Network Psychometrics with R: A Guide for Behavioral and Social Scientists [10]. Provides a comprehensive overview and guide to theoretical foundations of network

psychometrics, infers network topology, estimates network parameters from different sources of data.

Centrality Metrics for Complex Network Analysis: Emerging Research and Opportunities [11]. Research findings on centrality metrics and their broader applications for different categories of networks, including wireless sensor networks, curriculum networks, social networks, etc.

Centrality in Strategic Transportation Network Design: An Application to Less-than-truckload Networks [12]. Describes the appearance of a network by transportation network centrality, develops a strategic approach to transportation network design by conceptualizing transportation network centrality.

Crime and Networks [13]. Showcases the use of social networks in the analysis and understanding of various forms of crime, applies to criminology many conceptual and methodological options from social network analysis.

Models of Madness: Psychological, Social and Biological Approaches to Psychosis [14]. Challenges beliefs that madness can be explained without reference to social causes, updates the research showing that hallucinations, delusions etc. are best understood as reactions to adverse life events.

Brain Network Dysfunction in Neuropsychiatric Illness: Methods, Applications, and Implications [15]. Provides a synthesis of the uses of multiple analytic methods applied to neuroimaging data, to seek understanding of the neurobiological bases of psychiatric illnesses.

Human Pluripotent Stem Cell Derived Organoid Models [16]. Highlights recent and emerging advances that describe organoid differentiation protocols for the different organ systems that implement organoids as tools to understand complexity and maturation, high content drug screening, disease modeling, development and evolution.

Brain Organoid Research [17]. Explores multiple methods and approaches used to generate human brain and neuroretinal organoids to address fundamental questions in human brain research.

Organoid Bioengineering—Advances, Applications and Challenges [18]. Organoids are three-dimensional miniature tissue mimics established from embryonic stem cells, human pluripotent stem cells, adult stem cells, and cancer cells. These 3D organoids serve as a valuable tool for fundamental research, disease modeling, drug screening and discovery, and regenerative medicine.

1.3 Basics of the Spatial Grasp Model and Technology

This Spatial Grasp paradigm has been chosen to investigate its applicability as a possible universal approach and technique that could cover very different networking areas and provide important united solutions. Only main technology ideas are summarized below, more can be found in Chaps. 3–5, the related patent and previous books [19–28], latest journal papers [29–36], also previous publications (only few mentioned due to their number and period covered) [37–92].

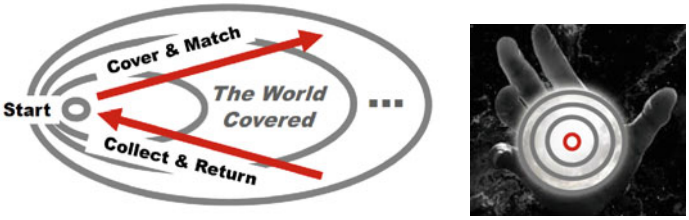

Fig. 1.1 Parallel wavelike world coverage under Spatial Grasp Model

Within Spatial Grasp Model and Technology (SGT), a high-level operational scenario expressed in recursive Spatial Grasp Language (SGL), starting in any world point *propagates, covers, and matches the distributed environment in parallel wavelike mode*, as symbolically shown in Fig. 1.1. Such propagation can result in returning and analyzing the reached states and data, which may be arbitrarily remote, or used for launching more waves.

The SGL allows for organizing *direct space presence and operations* with unlimited power and parallelism. Its universal recursive organization, with operational scenarios called ***grasp***, can be expressed just by a single formula:

$$\textbf{\textit{grasp}} \rightarrow \textbf{\textit{constant}} \,|\textbf{\textit{variable}}|\, \textbf{\textit{rule}}\, (\{\textbf{\textit{grasp}}, \})$$

The ***rule*** expresses certain action, control, description or context accompanied with operands, which can be any *grasps* too. The rules, starting in certain points, can organize navigation of the world sequentially, in parallel, or any combinations thereof. They can result in the same application points or cause movement to other world points with obtained results left there or returned. The ***SGL interpreter*** consists of specialized modules serving multiple SGL scenarios or their parts happened to be inside this interpreter, also organizing exchanges with other interpreters for distributed SGL solutions. Communicating SGL interpreters can be in arbitrary number of copies, representing ***powerful spatial engines*** *operating without central resources or control*, as in Fig. 1.2. They can effectively work with ***spatial graph and network data*** of any volumes and distributions. Details of SGT are explained in the subsequent Chaps. 3–5.

1.4 Summary of Other Book Chapters

Chapter 2: The Use of Networks in Physical, Virtual, and Mental Domains

The rapidly growing use of networks in various areas of human activity strongly encouraged this book preparation. This chapter reviews, analyzes and classifies many existing publications on the use of networks in very different areas, like

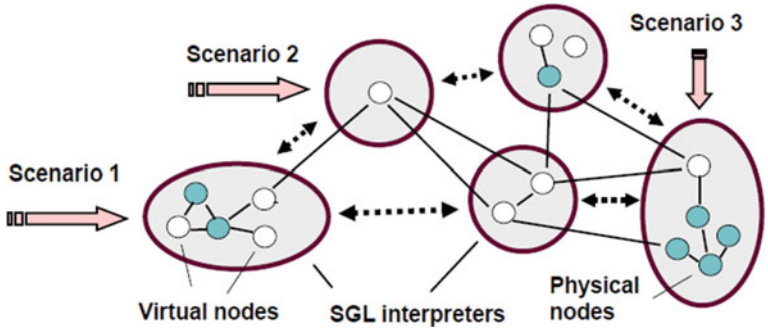

Fig. 1.2 SGL distributed networked interpretation

transport networks, communication networks, social networks, battle and military networks, economic networks, distribution networks, virtual networks, neural networks, psychological networks, and criminal networks. It summarizes existing publications on network analysis and network management too. Then briefs the developed Spatial Grasp Model and Technology (SGT) as a potential global paradigm capable to support, integrate, and manage the reviewed and other heterogeneous networking systems, which is investigated in detail in the subsequent chapters.

Chapter 3: Spatial Grasp Model and Technology Basics

The chapter briefs recursive Spatial Grasp Model and Technology (SGT) which is self-evolving, self-migrating, and self-matching in distributed environments. It describes technology's general issues, Spatial Grasp Language (SGL) features, its top summary, control states, and how SGL scenarios evolve in distributed spaces. Explains details of the networked SGL implementation, SGL interpreter overall organization and its spatial tracking system effectively supporting distributed system integrity, management, and control, altogether allowing SGL interpretation network behave as a universal and powerful spatial engine. Also compares SGT with traditional mobile agents approach based on quite different principles, which were also used by SGT predecessor two decades earlier. Selected references reflect more than half a century publications on this spatial paradigm.

Chapter 4: Spatial Grasp Language (SGL)

The Chapter offers Spatial Grasp Language details which may be particularly useful for better understanding of many practical examples in the subsequent chapters. It first briefs the Spatial Grasp Model and Technology where SGL is its basic language, providing summary of its syntax and main constructs. Then describes different types of SGL constants and variables with their features, spatial distribution and possible movement, also full repertoire of SGL rules with their semantics

and practical use, which include type, usage, movement, creation, echoing, verification, assignment, advancement, branching, transference, exchange, timing, qualification, and grasping. Elementary examples of programming in SGL are provided, also references to existing SGL publications and its previous versions called WAVE.

Chapter 5: Organization and Components of SGL Interpreter

The Chapter explains how Spatial Grasp Technology (SGT) can be implemented with communicating Spatial Grasp Language (SGL) interpreter copies embedded into any existing systems, internet including, representing altogether powerful networked engines capable of solving any problems in distributed environments. After briefing SGT and SGL, the Chapter describes main processors and data structures of the interpreter, including its track-based control mechanisms. As both backbone and nerve system, its self-optimizing spatial track system supports hierarchical command and control and remote data and code access, also supervises spatial variables and merges distributed control states and data for decisions and processing at higher organizational levels. With this holistic spatial vision, distributed SGL interpreter can effectively operate without any central control.

Chapter 6: Basic Network Operations in Different Worlds Under SGT

Inheriting the analysis of networking in many areas provided in Chap. 2, this chapter investigates and classifies existing works on main network and graph operations. After briefing the Spatial Grasp Technology and its Spatial Grasp Language (SGL) described in Chaps. 3–5, it presents detailed SGL solutions for network creation, modification, path finding, spanning and shortest path trees, strong and weak components, graph pattern matching, also flows in networks. The latter includes well known Ford Fulkerson method with its solution in SGL which is much simpler and shorter than traditional implementations in Java and C. The networking solutions in SGL can operate on arbitrary large and complex networks, and in highly parallel and fully distributed mode.

Chapter 7: Network Centrality Solutions in SGL

After summarizing the investigated use of networks in many areas of human activity in the previous chapters and briefing the developed Spatial Grasp Technology and its Spatial Grasp Language (SGL), the chapter investigates, evaluates, and models one of the most important features of graphs and networks called Centrality, with its variants Degree Centrality, Closeness Centrality, Betweenness Centrality, and Eigen Vector Centrality. Detailed, efficient, and extremely compact SGL scenarios for solving these centrality problems on a chosen network topology are provided and discussed, being also integral, highly parallel, and fully distributed. They can operate on arbitrary complex and large network structures and evolve in time and space without any central resources.

Chapter 8: Examples of Networking Solutions in Combined Worlds

The chapter investigates applicability of Spatial Grasp Technology (SGT) and its and Spatial Grasp Language (SGL) for development of higher-level social infrastructures effectively integrating very different types of networking. It provides practical examples of combined networking solutions in SGL integrating product development networks expressing design and production of different type of goods, product assessment and request networks describing communities interested in the same or different products, and networks of product delivery to important and registered consumers, with distribution of resultant products via optimal transportation infrastructures. Summary of these combined networking solutions is exhibited too. Deep integration of heterogeneous distributed systems can be organized naturally within global integrity, awareness and consciousness capabilities of SGT.

Chapter 9: Active Spatial Patterns in SGL Versus Traditional Algorithms

Pattern is everything around us; it can represent world's regularity, human-made design, a model, plan or diagram, standard way of modeling, acting and thinking, a distinctive style or form, a combination of qualities and tendencies, etc. The chapter reviews existing works on patterns and pattern languages, considers creating regular patterns and patterns of concrete objects in SGL, offers pattern-based practical solutions for managing transport column, collecting zone coordinates, and tracking mobile objects. It then provides pattern recognition and pattern matching examples in SGL with different types of patterns, explains how SGL can be considered as a real pattern language, concluding with the confirmed effectiveness of SGL and SGT for working with patterns in different areas.

Chapter 10: Networks as Models of Organoid Cultures and Brain Research

This special chapter relates to the concept of organoids, the simplified versions of organs produced artificially, which are of growing importance for disease prediction, prevention, and brain research. Investigates capabilities of creation and evolution of organoid models by Spatial Grasp Technology (SGT) described in the previous chapters. Analyzes and classifies latest organoid-related publications, shows expression in SGL of growing organoid models for cell growth, division, replication, worm movement, killer cell operation, and full organoid creation. It reviews other organoid developments of potential interest to SGT like mini-brains in robotics, organoids with brain waves, and organoids in outer space. Confirms applicability of the developed spatial paradigm to express and simulate cells growth up to the whole organoids.

Chapter 11: Conclusions

The book investigated applicability of Spatial Grasp paradigm for solving networking problems in very different areas. It allows us to directly move and operate in physical, virtual and mental spaces in a clear and compact mode, radically differing from traditional algorithmic thinking but rather creating flexible holistic and intelligent substances self-evolving, self-propagating, self-covering and self-matching the distributed worlds together with solving complex problems in them. By results

obtained in the book and discussed in previous publications on this paradigm, the whole world can be symbolically considered as integrating spiritual and mental level providing global awareness and consciousness, middle networking level which materializes from the mental level, and real physical-virtual world controlled from above and inside by networking models.

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