

Classification of Anomalies in Telecommunication Network KPI Time Series

Korantin Bordeau-Aubert ^{*}, Justin Whatley [†], Sylvain Nadeau [†], Tristan Glatard ^{*}, Brigitte Jaumard ^{*}

^{*}Department of Computer Science and Software Engineering, Concordia University, Montreal, Quebec, Canada.

[†] EXFO Inc., Montreal, QC, Canada.

Abstract—The increasing complexity and scale of telecommunication networks have led to a growing interest in automated anomaly detection systems. However, the classification of anomalies detected on network Key Performance Indicators (KPI) has received less attention, resulting in a lack of information about anomaly characteristics and classification processes. To address this gap, this paper proposes a modular anomaly classification framework. The framework assumes separate entities for the anomaly classifier and the detector, allowing for a distinct treatment of anomaly detection and classification tasks on time series. The objectives of this study are (1) to develop a time series simulator that generates synthetic time series resembling real-world network KPI behavior, (2) to build a detection model to identify anomalies in the time series, (3) to build classification models that accurately categorize detected anomalies into predefined classes (4) to evaluate the classification framework performance on simulated and real-world network KPI time series. This study has demonstrated the good performance of the anomaly classification models trained on simulated anomalies when applied to real-world network time series data.

I. INTRODUCTION

ANOMALY detection in network KPI time series has gained significant attention in recent years due to the increasing complexity and scale of the systems. Communication networks generate massive amounts of time series data capturing various activities and behaviors. The detection of anomalies in time series data is crucial in traffic analysis and performance monitoring or Key Performance Indicators (KPI). Compared to anomaly detection, classification of anomalies detected on network KPI has received relatively less attention in research, giving less information on the anomalies characteristics and classification processes. Exploiting classification techniques to identify and categorize anomalies within network KPI time series data remains an open area for exploration. Further research is needed to find new approaches and methodologies to accurately detect and classify anomalies, enhancing network KPI monitoring capabilities.

This article addresses the problem of effectively simulating anomalies on KPI and assessing anomaly classification models on both simulated and real-world time series datasets. In this paper, we separate the detector and classifiers as two parts within the anomaly classification framework. The detector identifies the anomalies in the time series while the classifiers categorize the time series into their corresponding classes or types. This separation allows for a modular approach between the detection and the classification.

This paper introduces an anomaly classification framework. This framework includes a network KPI time series simulator,

a detection model, classification models. The detection and classification models are evaluated on both simulated and real-world time series datasets. The simulator generates simulated time series with anomalies to mimic real-world network KPI systems. This simulator provides time series to train and test the detection and classification models. The detection model is built to identify the anomalies within the simulated and real-world time series. Additionally, we aim to build classification models to accurately classify the anomalies in their respective classes. Finally, we evaluate the performance and generalization capabilities of these classification models by testing them on both simulated datasets, generated by our time series simulator, and real datasets, obtained from network KPI.

The paper is organized as follows. Section II provides a comprehensive review of existing literature on network KPI anomaly definition, anomaly classification models, and evaluation methodologies. Section III presents our method for the anomaly classification framework, detailing the simulation, the detection and classification models. Finally, Section IV presents the experimental setup, including the datasets used and the performance of the models on both simulated and real-world time series datasets, followed by concluding remarks in Section V.

II. BACKGROUND

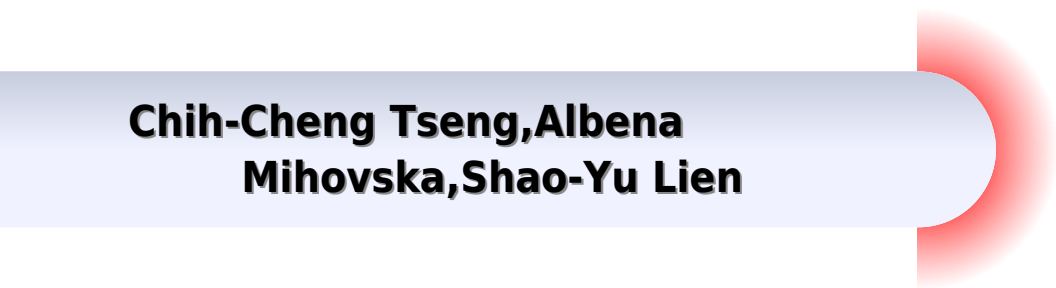
This background section aims to provide an overview of the key concepts, methodologies, and advancements in the field of network anomaly definition, simulation, detection, and classification.

Defining anomalies is the first step in the creation of a simulator and classification model. Network KPI anomalies encompasses a wide range of definitions and interpretations, reflecting the diverse nature of anomalies that can occur in network systems. Choi *et al.* [1] identified 3 major anomaly types in time series: point, contextual, and collective anomalies. Point anomalies refer to a data point or sequence that exhibits a sudden and significant deviation from the normal range. These anomalies are typically caused by sensor errors or abnormal system operations and are detected by comparing values against predefined upper and lower control limits. Contextual anomalies present a challenge for detection as they do not deviate from the normal range based on predefined limits. This type of anomaly is characterized by a group of points that do not contains extreme values and modify the

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Understanding Telecommunications Networks Andy Valdar, 2006-11-15 This book provides a broad introduction to all aspects of modern telecommunications networks covering the principles of operation of the technology and the way that networks using this technology are structured The main focus is on those technologies in use today and the next generation networks NGN and how they will be implemented

Optical Code Division Multiple Access Communication Networks Hongxi Yin, David J. Richardson, 2009-03-15 Optical code division multiple access OCDMA communication network technology will play an important role in future optical networks such as optical access and metropolitan area networks OCDMA technology can also be applied to implement optical signal multiplexing and label switching on backbone networks Optical Code Division Multiple Access Communication Networks Theory and Applications introduces the code theory of OCDMA the methods and technologies of OCDMA encoding and decoding the theory and methods of analyzing OCDMA systems with various receiver models and realizing multiple class services with different bit rates and QoS In addition OCDMA network architectures protocols and applications are discussed in detail The up to date theoretical and experimental results on OCDMA systems and networks are also reported A large number of encoding decoding examples and many analysis and simulation results of code and system performances are given It is a valuable text and or reference book for postgraduates majoring in telecommunication and photonics to obtain a well knit theoretical foundation and for engineers in R D and management of optical communications Dr Yin is an Associate Professor of the School of Electronics Engineering and Computer Science at Peking University China and was a Visiting Research Fellow of Optoelectronics Research Centre ORC at University of Southampton UK Dr Richardson is a Professor for optical communications and Deputy Director of ORC at University of Southampton UK and is responsible for much of the ORC s fiber related activities

Papers Presented at the Ninth Annual European Fibre Optic Communications and Local Area Network Conference/Efoc/Lan 91/Eln-91/E9912Pr, 1991

Software Agents for Future Communication Systems Alex Hayzelden, John Bigham, 2012-12-06 Agent technology has recently become one of the most vibrant and fastest growing areas in information technology And advanced digital communication is a central enabling technology for the coming information society So software agents and their exploitation for future communication systems are attracting particular attention from the research and development community as well as from economic and user communities interested in everyday private and professional digital communication applications This monograph like anthology is the first systematic introduction to software agents and future communication systems Fifteen coherently written chapters by leading software agent researchers provide complementary coverage of the relevant issues Multi agent systems and mobile agent approaches are presented in a well balanced way and applied to most important topics in future communication systems In addition the volume editors have provided a detailed introductory survey chapters

Multiwavelength Optical LANs Georgios I. Papadimitriou, Paraskevas

A. Tsimoulas, Mohammed S. Obaidat, Andreas S. Pomportsis, 2005-08-19 During the last thirty years or so it has been widely recognised in the research community that the key transmission medium seeming capable of serving both the ever growing demand for bandwidth and the unceasing need for new services is optical fibre In this context Wavelength Division Multiplexing WDM is the most popular technique for introducing concurrency among multiple user transmissions into the network and thus exploiting the huge amount of fibre bandwidth available under the severe limitations imposed by electronics speed on the maximum network access rate This book extensively covers an important research area in optical networking enabling readers to fully understand the concepts of optical LANs and learn details of architecture issues and control protocols Through its careful focus on the local area the book covers the major architectural topological and protocol issues regarding optical Local Area Networks LANs today Considering that constant advances on optical component technology make all optical WDM LANs all the more feasible for a wide commercial deployment the book investigates thoroughly the crucial latter topic i e the Media Access Control MAC protocols that should be used Besides introducing a noteworthy part of the vast literature on such protocols and providing some helpful distinguishing key protocol characteristics the book is also innovative in focusing on a recent significant class of promising protocols whose operation is based on network feedback information In this way these adaptive protocols for optical LANs achieve an overall higher performance in comparison with many other non adaptive schemes Multiwavelength Optical LANs Enables readers to understand the concepts of optical LANs and learn details of architecture issues and control protocols Focuses on the major architectural topological and protocol issues regarding optical local area networks Presents the important class of adaptive protocols for optical LANs No Optical systems network developers or engineers and scientists working in optical networking should be without this book The well considered approach also makes this recommended reading for undergraduate and graduate computer science computer electrical and telecommunications engineering students Space-time Array Communications Jason Wee Peng Ng, 2007 Space time array communications have gained a great deal of interest in recent years Its superior performance in practical multipath propagation environments has established it as a core aspect in next generation mobile networks as well as several portable wireless communication systems In fact the employment of the sensor array component has already been provided for in the current UMTS standard and there is presently a major thrust to make space time processing an important part of 3G 4G networks This book hence attempts to bridge the knowledge gap looking at the integration of two emerging technologies from an array manifold perspective space time array processing and spread spectrum multiple access communications It covers a range of novel multiuser channel estimation and reception techniques which is designed to provide mitigations of the various associated channel impairments in accordance to its environmental context For convenience of the readers the book is written in a self contained modular format with its mathematical frameworks and tools readily extendable to other research domains Optical and Wireless Communications Sushank

Chaudhary, Amir Parnianifard, Abhishek Sharma, 2025-05-09 This edited volume brings together diverse perspectives on machine learning and AI applications in optical and wireless systems offering a structured and comprehensive resource for researchers and professionals It explores advancements driven by 5G IoT and the increasing demand for high speed reliable communication Covering optical fiber systems wireless networks and AI driven optimizations the book provides insights into real world applications impacting telecommunications healthcare and transportation The contributing authors discuss key topics such as signal processing techniques optimization algorithms and deep learning models applied to optical and wireless networks The volume also highlights emerging challenges security concerns and future trends in AI powered communication systems This resource is essential for professionals in electrical and computer engineering telecommunications and computer science helping them stay ahead in these rapidly evolving technologies **Molecular Communication** Tadashi

Nakano, Andrew W. Eckford, Tokuko Haraguchi, 2013-09-12 This comprehensive guide by pioneers in the field brings together for the first time everything a new researcher graduate student or industry practitioner needs to get started in molecular communication Written with accessibility in mind it requires little background knowledge and provides a detailed introduction to the relevant aspects of biology and information theory as well as coverage of practical systems The authors start by describing biological nanomachines the basics of biological molecular communication and the microorganisms that use it They then proceed to engineered molecular communication and the molecular communication paradigm with mathematical models of various types of molecular communication and a description of the information and communication theory of molecular communication Finally the practical aspects of designing molecular communication systems are presented including a review of the key applications Ideal for engineers and biologists looking to get up to speed on the current practice in this growing field **Optical WDM Networks** Jun Zheng, Hussein T. Mouftah, 2004-08-04 The essential

guide to the state of the art in WDM and its vast networking potential As a result of its huge transmission capacity and countless other advantages fiber optics has fostered a bandwidth revolution addressing the constantly growing demand for increased bandwidth Within this burgeoning area Wavelength Division Multiplexing WDM has emerged as a breakthrough technology for exploiting the capacity of optical fibers Today WDM is deployed by many network providers for point to point transmission but there is strong momentum to develop it as a full fledged networking technology in its own right The telecommunications industry network service providers and research communities worldwide are paying close attention Optical WDM Networks presents an easy to follow introduction to basic concepts key issues effective solutions and state of the art technologies for wavelength routed WDM networks Responding to the need for resources focused on the networking potential of WDM the book is organized in terms of the most important networking aspects such as Network control architecture Routing and wavelength assignment Virtual topology design and reconfiguration Distributed lightpath control and management Optical layer protection and restoration IP over WDM Trends for the future in optical networks Each

chapter includes examples and problems that illustrate and offer practical application of concepts as well as extensive references for further reading This is an essential resource for professionals and students in electrical engineering computer engineering and computer science as well as network engineers designers planners operators and managers who seek a backbone of knowledge in optical networks

The Road to B5G/6G Mobile Communication Networks: Technologies and Applications Chih-Cheng Tseng,Albena Mihovska,Shao-Yu Lien,2025-10-22 This book provides essential resources for industry academia and research professionals for understanding the potential evolving roadmap of Beyond 5G B5G and 6G technologies and their diverse applications In the critical era of the evolution of the 5G mobile communication networks wireless mobile communication technologies have already pivoted toward the next stages Beyond 5G B5G and the upcoming Sixth Generation 6G This book is an insightful collection that explores cutting edge technologies and applications guiding the paths toward B5G and 6G mobile communication networks Divided into two parts Technologies and Applications the book covers a broad spectrum of advancements or the future of mobile systems The focus of Part I Technologies and advanced techniques to B5G 6G is AI enhanced language learning applications and the use of graph convolutional networks for channel and power allocation in device to device communication It also explores machine learning methods for beam selection and unsupervised learning approaches in mobile network management Topics such as frequency resource allocation in satellite communication high frequency mmWave analysis using clustering methods and deep learning for network traffic prediction are highlighted Furthermore innovative concepts like area sweep coverage hardware implementations for signal processing and centralized radio access networks C RAN are discussed providing a glimpse into future dynamic radio resource allocation schemes Part II Applications addresses emerging trends such as quantum machine learning and the transformative potential of the Tactile Internet in enhancing healing and self actualization It also explores real time system communication efficiencies showcasing the practical impacts of these advancements

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Table of Contents Telecommunication Networks Iee Telecommunications Series No 36

1. Understanding the eBook Telecommunication Networks Iee Telecommunications Series No 36
 - The Rise of Digital Reading Telecommunication Networks Iee Telecommunications Series No 36
 - Advantages of eBooks Over Traditional Books
2. Identifying Telecommunication Networks Iee Telecommunications Series No 36
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Telecommunication Networks Iee Telecommunications Series No 36
 - User-Friendly Interface
4. Exploring eBook Recommendations from Telecommunication Networks Iee Telecommunications Series No 36
 - Personalized Recommendations
 - Telecommunication Networks Iee Telecommunications Series No 36 User Reviews and Ratings
 - Telecommunication Networks Iee Telecommunications Series No 36 and Bestseller Lists

5. Accessing Telecommunication Networks Iee Telecommunications Series No 36 Free and Paid eBooks
 - Telecommunication Networks Iee Telecommunications Series No 36 Public Domain eBooks
 - Telecommunication Networks Iee Telecommunications Series No 36 eBook Subscription Services
 - Telecommunication Networks Iee Telecommunications Series No 36 Budget-Friendly Options
6. Navigating Telecommunication Networks Iee Telecommunications Series No 36 eBook Formats
 - ePub, PDF, MOBI, and More
 - Telecommunication Networks Iee Telecommunications Series No 36 Compatibility with Devices
 - Telecommunication Networks Iee Telecommunications Series No 36 Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Telecommunication Networks Iee Telecommunications Series No 36
 - Highlighting and Note-Taking Telecommunication Networks Iee Telecommunications Series No 36
 - Interactive Elements Telecommunication Networks Iee Telecommunications Series No 36
8. Staying Engaged with Telecommunication Networks Iee Telecommunications Series No 36
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Telecommunication Networks Iee Telecommunications Series No 36
9. Balancing eBooks and Physical Books Telecommunication Networks Iee Telecommunications Series No 36
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Telecommunication Networks Iee Telecommunications Series No 36
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Telecommunication Networks Iee Telecommunications Series No 36
 - Setting Reading Goals Telecommunication Networks Iee Telecommunications Series No 36
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Telecommunication Networks Iee Telecommunications Series No 36
 - Fact-Checking eBook Content of Telecommunication Networks Iee Telecommunications Series No 36
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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