

Classification of Anomalies in Telecommunication Network KPI Time Series

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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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Fundamentals of 6G Communications and Networking Xingqin Lin, Jun Zhang, Yuanwei Liu, Joongheon Kim, 2023-12-11 This book begins with a historical overview of the evolution of mobile technologies and addresses two key questions why do we need 6G and what will 6G be The remaining chapters of this book are organized into three parts Part I covers the foundation of an end to end 6G system by presenting 6G vision driving forces key performance indicators and societal requirements on digital inclusion sustainability and intelligence Part II presents key radio technology components for the 6G communications to deliver extreme performance including new radio access technologies at high frequencies joint communications and sensing AI driven air interface among others Part III describes key enablers for intelligent 6G networking including network disaggregation edge computing data driven management and orchestration network security and trustworthiness among others This book is relevant to researchers professionals and academics working in 5G 6G and beyond

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

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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

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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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