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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