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A Novel Method to Identify and Recover the Fault Nodes over 5G Wireless Sensor Network Environment

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***Abstract*—The significance of communication networks is growing in tandem with the proliferation of communication technologies. Present methods for maintaining 5G Wireless Sensor Networks are still restricted to routine maintenance and post-maintenance tasks. They lack a comprehensive function for monitoring the network's status, are unable to assess the network's health, and are difficult to maintain before the 5G-based WSNs seriously degrade. 5G Wireless Sensor Network faults can only be resolved by highly trained technicians due to low maintenance efficiency. As a result, errors cannot be detected or located promptly or accurately, leading to forced repairs that incur the expense of new network cables. First, the article lays forth the basics of network fault analysis. Then, it uses deep learning to simulate communication network problem diagnosis. Lastly, the experimental section compares various methodologies and analyses the findings of fault location. The results of the simulation demonstrate that the suggested approach mitigates the created model's flaws to a certain degree while simultaneously enhancing the network fault detection model's accuracy, universality, and robustness. A novel approach to autonomous placement, the Fault Node Recovery Protocol is described in this study. It is implemented in 5G mobile communications to detect faulty data according to wireless sensor network standards, and it is made to fix the problems with conventional techniques, such poor positioning precision and lengthy running time. The automated localization model for 5G mobile communication fault data, constructed using the suggested FNRP approach, is presented in this work. By comparing it to the standard Adhoc On-Demand Distance Vector Routing protocol, we can see how well the suggested system performs.**

Keywords*—Fault Node Detection, 5G, Wireless Sensor Network, WSN, Recovery Protocol, FNRP, AdHoc, On-Demand, Distance Vector Routing, AODV

I. INTRODUCTION

Industrial automation, smart manufacturing, oil and gas, and many more fields have found new uses for the latest developments in wireless communications as well as computing, such as the Internet of Things (IoT), mobile edge computing along with 5G wireless networks. Recently, there has been a surge of interest from both academics and business in finding ways to use 5G and MEC for industrial IoT (IIoT), since this aligns with the goals of future smart manufacturing systems and business 4.0 [1].

Wireless technologies provide a number of issues, including reliability, efficiency, and time constraints, that the IIoT finds particularly interesting in the context of industrial automation, production, as well as regulation systems [2]. For instance, real-time defect detection and diagnostics systems ensure data collection, transmission, and processing; they are a typical type of mission-critical industrial automation applications. Traditional wireless networking methods are severely inadequate when it comes to keeping data transmission latency on the millisecond scale. Due to security and performance problems, a lack of best operational practices or Internet of Things initiatives, and the complexity of factory environments, using wireless technologies for automated processes have proven to be a challenging task [11].

In heterogeneous networks, cellular networks will thrive in the future. Various radio and architectural technologies make up these networks. In contrast, these networks as well as the internet of things are becoming more complicated every day due to the expansion of services and technology [3]. A fresh approach to managing these networks is essential for operators to thrive in the modern, cutthroat business environment. The standard method for accomplishing this is through the use of self-organizing networks (SONs). Autonomy, self-repair, and self-improvement are the three main components of SON architecture [4]. There are several steps involved in creating a self-regulating network, such as the initial design, any necessary updates, and development. As IP-based, flat-architecture LTE networks proliferate, it will be necessary for various network endpoints, including base receivers, nodes, along with transmitter stations, to configure associated parameters [12]. The following figure Fig.1 shows the illustration of a factory cell.

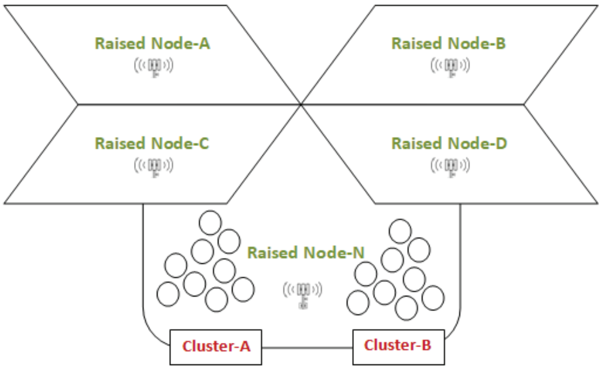

Fig. 1. Illustration of a Factory Cell

The popularity of self-healing networks has grown in tandem with the complexities of cellular networks. But compared to other fields, this one has a far lower rate of published research and papers. Through automated detection and cause identification, these networks can handle system failures and problems. The self-optimizing network then determines, based on the current state of the network, the traffic, and the services utilized by users, which network parameters require resetting and assign them values. Traditional communication networks are ill-equipped to handle the increased bandwidth and speed demands of the modern Internet as a result of technological advancements in the field. Thus, 5G mobile networks are applicable. The enormous transmission bandwidth, rapid node movement speed, and severe signal drift that characterize 5G mobile networks have made pinpointing the actual data defects in 5G mobile communication a hot subject in the 5G research community [5].

II. RELATED STUDY

The shift from a "post-maintenance" to a "pre-prevention" mentality is necessary in operation and maintenance in light of the advent of 5G networks and the enormous amounts of data they generate [6]. A defect in the present timestamp is one of the criteria that determine whether a problem arises in the subsequent timestamp in a wireless network, and the fault also has cause and propagation. While current approaches for fault prediction focus on the temporal and inter-measure relationships of KPIs, they fail to account for the crucial causal connections of cellular network problems. Determining the fault causal dependence in cellular networks remains a tough task. In order to address these issues, we provide a new paradigm for predicting wireless cell failures, which takes causal dependence into account. The first step is to construct an undirected graph using the base station's graphical representation of key performance indicators and information about faults. We next provide the graphical model that can be used to understand the causal connection among fault codes at asynchronous time stamps and the dependency relationship that contains various KPIs at synchronous timestamps. Lastly, we maximized the correlation among parameters during training by utilizing the graphical model's attention mechanism. Using fault datasets of actual wireless cells, we perform comprehensive prediction tests on fault code (i.e., the kind of fault that happens) and fault events (i.e., if a fault occurs) tasks. The experimental findings demonstrate that our framing technique outperforms the conventional methods of fault prediction and is state-of-the-art [6].

The most current iteration of mobile networks in the field of wireless communication is known as Fifth Generation Technology [7]. Presented in this study [7] are assessments within the domain of mobile communication technology. With the support of next-gen mobile networks, a number of obstacles were overcome in each iteration. 5G offers a high-speed internet service to everyone, anytime, wherever, unlike any of the previous mobile networks. The new capabilities of 5G, including as the ability to link and operate devices, objects, and machines, make it somewhat distinct. With the 5G mobile system's varying degrees of performance and capabilities, new user experiences and business connections will be possible. Knowing where the business may take use of 5G is, hence, crucial. Millimeter wave, massive multiple-input as well as multiple-output, tiny cells, mobile edge computing (MEC), beamforming, various antenna technologies, etc., are just a few of the many topics covered in depth in this research paper. The primary purpose of this article is to review the current state of 5G mobile system research and to outline some of the most recent advancements in this area [7].

The mobile industry is hard at work creating and getting ready to launch 5G networks [8]. Internet of Things (IoT) as well as other intelligent automation applications is seeing explosive development, propelled in large part by the increasing availability of 5G networks. Internet of Things, artificial intelligence (AI), autonomous vehicles, virtual reality (VR), blockchain, and any number of other innovations in intelligent automation will require 5G's ultra-fast connections and minimal latency. A new age of technological opportunity has begun with the arrival of 5G, which is more than simply a generational leap. The purpose of this article is to review the existing literature on the topic and look at the ways in which 5G might simplify or enable intelligent automation in various industries. Reviewing the key enabling technologies, trends, and challenges of 5G revolutionary networks, this paper examines their applications in different manufacturing industries and highlights their role in shaping the era of limitless connectivity, intelligent automation, as well as business digitization. It also emphasizes the significance of these networks and their revolutionary nature [8]. It also reviews the evolution and development of previous generations of mobile wireless technology.

5G deployments are already complicated enough without adding the complexity introduced by 5G's feature-rich design, which makes its performance extremely conditional and depends on a wide variety of critical parameters, each of which has its own distinct values and traits [9]. This study builds a novel machine learning-based modular approach to tackle the complexity of 5G network performance variations caused by architectural and service variables (5GPA). The goals are to streamline the feature-selection process for various deployments, improve the performance of 5G networks, and solve problems that arise during the planning and design stages in accordance with requirements prior to 5G deployment. A correlation among the 5GPA components and overall performance is determined by implementing the model and using the results. Furthermore, 5G performance forecasts are based on unobserved components as well as values of interest using a simulated dataset. In order to verify the model's dependability, we compare the expected and actual outcomes within the framework of service quality standards. In terms of mean absolute error, mean squared error, as well as root mean squared error, the findings show a low error rate of 7.60e−03, 1.18e−04, and 8.77e−03, respectively, indicating a high degree of accuracy (with an average of 95%).

Complex data processing and rapid communication exchanges are necessary for the next generation of smart city vehicle applications, such as assisted self-driving [10]. Taking a page out of 5G's playbook—the edge-computing paradigm—and moving computation, storage, and networking closer to the users—the edge of the network—would be a practical way to meet these demands. The efficiency of the vehicle applications is closely related to the correct positioning of the spatially overlaid edge nodes (EN). But there's a cost-effectiveness issue with deploying edge nodes on the sides of roadways. The effective and economical deployment of a small number of edge nodes in a city setting is the focus of this work. In order to rank the possible sites for edge node placement, we take into account both the vehicle traffic distribution and the structural features of the road network, which are measured utilizing complex-network based centrality metrics. Afterwards, we offer a dynamic programming–based solution to the edge node deployment problem by recasting it as a 0–1 knapsack problem, a traditional NP problem. We provide definitive evidence that our suggested strategy produces a workable solution to the specified problem by testing it in a city setting with actual traffic [10].

III. Methodology

Recent developments in embedded computing and wireless transmission have made wireless sensor networks capable of delivering a wide range of previously indicated applications. Many different kinds of control and monitoring applications have found widespread usage in wireless sensor networks. These include traffic monitoring, industrial sensing, and environmental surveillance. For environmental monitoring, industrial sensing, as well as traffic control, WSNs comprise vast numbers of tiny, low-power wireless sensors. Wireless sensor networks (WSNs) consist of large numbers of tiny, low-power devices that are often sent from dispersed, poorly-organized locations. Always collecting and processing data from the actual environment, several ubiquitous apps provide detailed information about any identified conditions or events.

We build and propose the Fault Node Recovery Protocol (FNRP) as an automated positioning method for 5G mobile communication defect data to address the issues with low positioning accuracy as well as poor positioning security that are present in conventional techniques of Ad hoc On-Demand Distance Vector Routing (AODV). Building a model that can complete the first steps of a model's building utilizing publicly accessible statistical data and little input from experts is the primary goal of this essay. Reducing the model's reliance on people and eliminating the impacts of human mistake both improve the model's accuracy. The second and third parts of this paper go over the primary and secondary sources, respectively. If there is an issue in a certain location, you can find out about it by consulting these three network mode sources of information. Also, this system is capable of identifying the sources of cellular network faults utilizing three distinct data kinds and information fusion techniques. Following an introduction to the indicators used for qualitative network condition evaluation and the kinds of problems that impact their values, the second section delves into an examination of the efficiency of the support system, the primary data source. In order to determine what went wrong, the findings are examined. The third part of the report presents additional evidence that a problem exists in a certain region. The following figure Fig.2 shows the paper's comprehensive outline of the research.

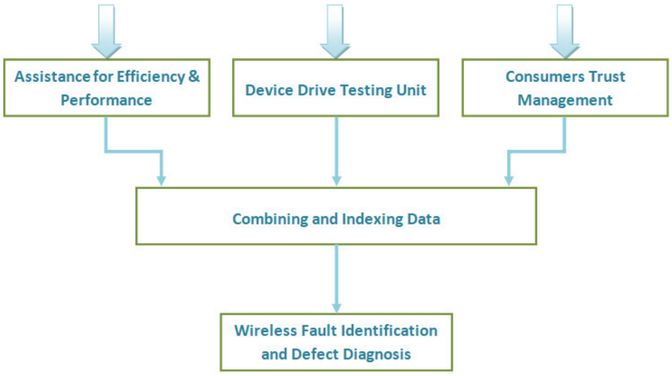

Fig. 2. Comprehensive Outline of the Research

Distributed computing, of which cloud computing is a subset, involves breaking down large data processing programs into smaller ones and then running the resulting algorithms across a network of computers. Grid computing, another name for cloud computing, is able to process large amounts of data quickly. This research presents a data automated positioning technique that may get precise positioning results by utilizing cloud computing technologies. For 5G mobile communication networks data automatic positioning research, two types of nodes—beacons and anchors—are required. Beacons and anchors primarily use distance or angle to measure unknown nodes, while 5G mobile communication research requires three or more position interactions to determine the coordinate places of each defect.

(i) Granularity: Sliced can accommodate other online services' and other user groups' requirements. But while slicing, the issues that require fixing are the quantity of slices as well as the technique of cutting. Not only are slicing units too tiny to be easily managed and deployed, but they also could not be big enough to offer adequate flexibility for some kinds of networks.

(ii) Flexibility: Slices work similarly to 4G policy control structure in that they offer real-time performance if they are very adaptable. But slicing is too adaptable, and there's a little uptick in both the expense and danger of network administration. After all, network management isn't complete without thinking about dependability and stability. Furthermore, new service launches take time and a lot of research and planning on the part of businesses.

(iii) Resource Distribution: Network slicing technology adds complexity to network operations. Quickly configuring network resources according to client demands and providing flexible, highly compatible services are two of the most important skills for operators to have. Congestion will occur in the network if resources are not configured in a timely manner.

(iv) Isolation: The technology used to slice networks must allow for the separation of different parts of the network. Other components' functionality can be compromised if the slab isn't adequately insulated.

The following figure Fig.3 shows the 5G mobile communication signal reception procedure.

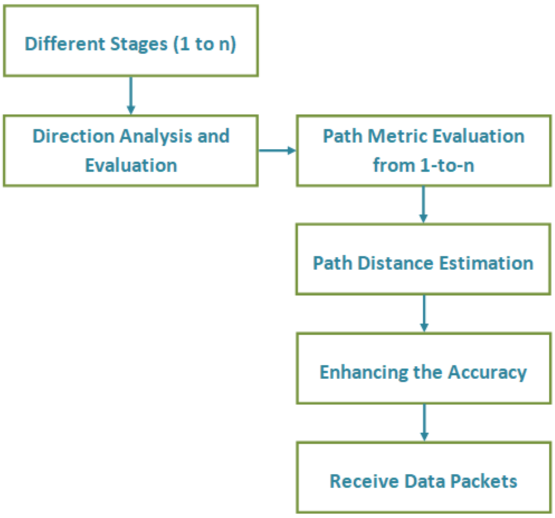

Fig. 3. 5G Mobile Communication Signal Reception Procedures

IV. Results and Discussions

The Fault Node Recovery Protocol (FNRP) method is employed to learn sample data collected from the actual 5G WSN network environment in accordance with specified criteria. This is all a part of the recommended network fault detection and diagnostic strategy in this section. After the function has been selected, the algorithm is applied and regardless of the form of the network. It is now much simpler to gather vast volumes of labeled analogue data from any place because to the 5G wireless sensor network. The use of real data is what is done in order to assess the diagnostic model for the problem. Constructing a model for the purpose of fault identification and diagnostics is yet another application of the virtual data obtained from the resistance network. For the purpose of providing a more convincing demonstration of the algorithm's capacity to produce reliable virtual data, the fault diagnosis model presented in this chapter employs AODV in addition to other typical routing algorithm models for verification activities. The first step in this section involves training and testing a number of defect diagnosis models by making use of simulation data and actual data obtained before and after job screening, respectively. When considering the amount of time required finding and diagnosing flaws in 5G wireless sensor networks (WSN), another alternative is to consider the fact that, following function screening, the input parameters of the training model are decreased, and the learning time is also reduced proportionately. When compared to troubleshooting without filtering functionality, the approach described in this chapter takes significantly less time to diagnose problems with 5G wireless sensor networks (WSNs) once feature filtering has been applied. Due to the fact that it is both accurate and timely, the FNRP model that was suggested has been chosen to serve as the final fault detection and diagnostic model for 5G wireless sensor networks in this chapter. FNRP is able to effectively pinpoint problem areas despite feature information loss or false positives, all thanks to its remarkable stability. The findings of this study demonstrate that the model suggested in this study is able to pinpoint the position of the defect with greater precision when dealing with feature sets that contain additional dimensions.

The below figure Fig-4 shows the results of a cross-validation between the suggested Fault Node Recovery Protocol (FNRP) and the conventional AODV protocol, which measures the time it takes for a network to recover from a fault. The information is presented in a descriptive way in Table-1.

TABLE I. COMMUNICATION DELAY W.R.T FAULT NODES

S.No.	Nodes	AODV (s)	FNRP (s)
1.	10	15	3
2.	20	17	8
3.	30	21	9
4.	40	23	12
5.	50	25	16
6.	60	27	19
7.	70	31	22
8.	80	36	25
9.	90	39	28
10.	100	41	31

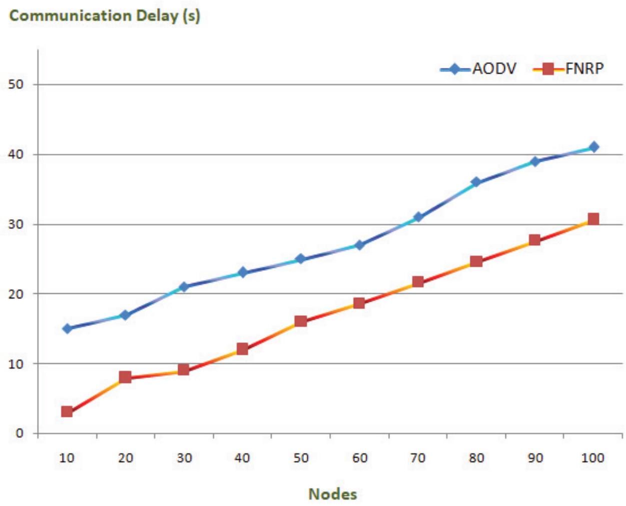

Fig. 4. Communication Delay w.r.t Fault Nodes

The effectiveness of the suggested technique, FNRP, is evaluated by comparing it to the standard routing protocol, AODV, as shown in the following figure Fig-5, which displays fault node detection efficiency. The next table, Table-2, provides a descriptive representation of the same.

TABLE II. FAULT NODE IDENTIFICATION EFFICIENCY

S.No.	Nodes	AODV (%)	FNRP (%)
1.	10	89.26	97.54
2.	20	89.34	97.39
3.	30	89.17	97.52
4.	40	89.52	97.86
5.	50	89.63	97.81
6.	60	89.09	97.38
7.	70	89.37	97.72
8.	80	89.38	97.84
9.	90	89.39	97.86
10.	100	89.40	97.89

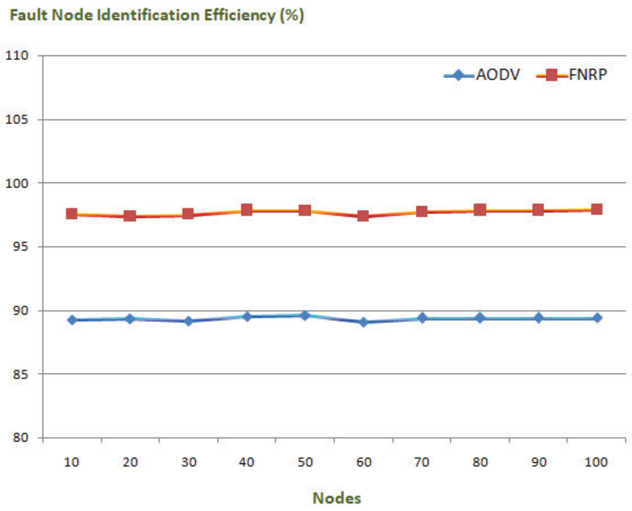

Fig. 5. Fault Node Identification Efficiency

The below figure Fig-6 shows the results of a cross-validation between the suggested FNRP method and the standard routing protocol AODV, which measures the accuracy of fault node identification. This allows us to assess the efficacy of the suggested approach. The same is illustrated in a detailed way in Table 3.

TABLE III. ACCURACY ANALYSIS

S.No.	Nodes	AODV (%)	FNRP (%)
1.	10	91.64	95.89
2.	20	91.26	95.67
3.	30	91.08	95.49
4.	40	91.47	95.71
5.	50	91.19	95.76
6.	60	91.12	95.49
7.	70	91.05	95.72
8.	80	90.98	95.59
9.	90	90.91	95.57
10.	100	90.85	95.55

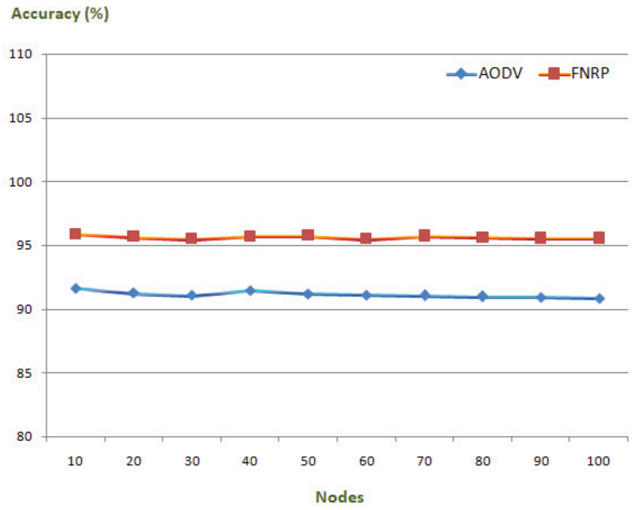

Fig. 6. Accuracy Analysis

V. CONCLUSION

A 5G wireless communication system fault information autonomous position identification technique that is based on wireless sensor network environment and the respective protocols are suggested in this work. This method is named the Fault Node Recovery Protocol (FNRP), and it is intended to alleviate the difficulties that are currently present in the traditional way of defect data automatic location. From both the theoretical and experimental perspectives, the following findings may be demonstrated to be correct. When it comes to placing significant amounts of defect data, this approach possesses a high level of positioning efficiency and positioning accuracy. To be more specific, when compared to the location method that is based on point line features, the location efficiency is significantly improved, and the shortest time it takes to locate something is only fifty seconds. When compared to the location method that is based on improved programme spectrum, the accuracy of the location is substantially enhanced, and the highest possible location failure is only two and a half percent. Furthermore, the location approach that has been provided, which is based on a 5G wireless sensor network, has the potential to better satisfy the criteria of faulty data automated localization for 5G wireless mobile communication. Within the scope of the next research endeavors, the simulation platform and the theories that are associated with it will undergo more enhancements, and the practicability of the placement approach will be increased.

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