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An Optimal Algorithm for Feature Activation Based on Cell Value Scoring in the Field of Wireless Communication

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Abstract. With the increasingly strict assessment of regional mobile operators' wireless indicator by the wireless communication group, and the need for corresponding licenses and activation fees for the advanced feature algorithms provided by the vendor, regional mobile operators are in urgent need of optimizing a cost - controllable and scenario - based rapid deployment plan for the above - mentioned advanced feature algorithms due to cost control. This paper uses the methods of data analysis and comparative experiments to analyze and study the Key Performance Index (KPI) data of cells provided by regional mobile operators, and proposes an optimal algorithm for feature activation based on cell value scoring. This algorithm aims to solve the problem of how to select cells for deployment when mobile operators deploy specific feature algorithms. The algorithm can balance operating costs and network performance, and help mobile operators make optimal deployment decisions based on data. Based on the experimental KPI data, this algorithm can achieve an approximately optimal effect in terms of improving the Low-Speed network performance, and has a lower time complexity compared with the traditional combination algorithm.

Keywords: Wireless Communication, Wireless Indicators, Cell Value Scoring, Performance Gain

1. Introduction

Improving user-perceived speed is key for 5G mobile operators to retain users, boost competitiveness, reduce complaints, and achieve sustainable growth [1-3]. Wireless indicators like Low-Speed Ratio (K_1) and cell throughput, critical for user perception, directly determine network smoothness and stability [4-6].

Regional operators need to deploy vendor A's licensed, paid feature X to meet assessment metrics but cannot roll it out network-wide due to costs. Typically, temporary authorization allows X deployment across all cells to capture K_1 before and after deployment. Existing algorithm 1 selects cells by ranking K_1 gains post-X, ignoring inter-cell wireless performance interactions and yielding suboptimal total gains. Algorithm 2 identifies optimal M-cell sets from N authorized cells by calculating K_1 gains for all combinations, but its high time complexity hinders quick responses. This paper focuses on feature X, aiming to efficiently select optimal cells for operators. It proposes a cell value scoring-based algorithm, validated against the two existing ones via performance gains, time

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complexity, and applicability to demonstrate its effectiveness and superiority. It helps operators balance performance and costs under budget constraints, driving industry progress; it offers scalable, referable optimization insights for researchers.

2. An optimal algorithm for feature activation based on cell value scoring

2.1. An optimal algorithm based on cell value scoring

2.1.1. Data sources and indicator definitions

The data used in this algorithm mainly comes from the wireless indicator K_1 data collected before and after the deployment of feature X, after vendor A obtained a temporary authorization permit for applying feature X in the cells of a mobile operator in a certain city. Specifically, it includes:

A. Basic information of the cell, such as the cell wireless network identifier and the deployment time point of feature X [7];

B. Wireless indicator data collected before and after the deployment of feature X, mainly including the number of cell users, the number of sample points in the speed distribution interval of the cell uplink Ue Equipment Throughput (i.e., UE Throughput) and the cell downlink UE Throughput [8-10];

C. Uplink Low-Speed threshold (cell uplink UE Throughput <= 2Mbps) and downlink Low-Speed threshold (cell downlink UE Throughput <= 5Mbps);

These data can be obtained through the mobile operator's network management system or the monitoring platform of vendor. The accuracy and integrity of the data are the keys to ensuring the effective operation of the algorithm. This paper takes the wireless assessment indicator K_1 = "uplink - downlink Low-Speed Ratio (%)" (hereinafter referred to as the Low-Speed Ratio indicator) of the mobile operator as the optimization target, and carries out a comparative analysis before and after the deployment of the feature algorithm X.

2.1.2. The principle of the optimal algorithm based on cell value scoring

The core principle of the optimal algorithm based on cell value scoring is to comprehensively consider the gain of the wireless indicator K1 after the deployment of feature X in the cell and the contribution of the cell to the overall network performance to determine the value score of the cell. The gain of the wireless indicator K_1 reflects the degree of improvement in the performance of the cell itself after the deployment of feature X, while the contribution to the entire network reflects the importance of the cell in the network. By calculating the value score of the cell, it is possible to more comprehensively evaluate the performance of deploying feature X in the cell. Therefore, when selecting a cell for deployment, not only can the selected cell have a good performance improvement, but also the performance of the entire network can be maximally improved.

2.1.3. The process of the optimal algorithm based on cell value scoring

A. Input the number of cells N, KPI indicator K_1 of each cell before and after feature deployment

B. Calculate the indicator K_1 and its gain G_o of all N cells after deploying feature X

C. For i = 1 to N do:

(1) Exclude cell C_i from the N cells, and then calculate the gain G_i of the indicator K_1 after deploying feature X for the remaining (N - 1) cells;

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(2) Calculate the value score of cell C_i : $V_{Ci} = \frac{G_i - G_o}{G_o} \times 10$

D. Sort V_{Ci} in descending order of value to obtain the value ranking list L_v

E. For j = 1 to N do:

Take the first j cells from L_v , and calculate the indicator K_1 and its gain G_j of these j cells after deploying feature X

F. Return Lists R_M of combinations of M cells and their corresponding gain results

2.2. Analysis of the results of the optimal algorithm based on cell value scoring

2.2.1. Comparison of the Low-Speed Ratio K_1 of the cells selected by this algorithm before and after feature X deployment

Verify the improvement effect of feature X on the Low-Speed performance of cells by comparing the Low-Speed Ratio indicator K_1 of cells before and after deploying feature X.

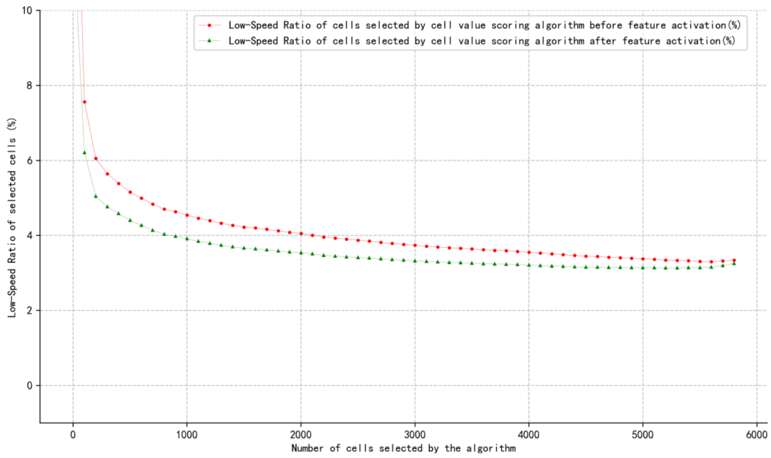

Figure 1. Comparison chart of the Low-Speed Ratio before and after feature activation for cells selected by the cell value scoring algorithm

As can be seen from Figure 1, after deploying feature X, regardless of the number of cells selected, the overall Low-Speed Ratio K_1 of the selected cells has decreased significantly. This indicates that feature X can effectively decrease the Low-Speed Ratio of cells.

2.2.2. Comparison of Low-Speed Ratio K_1 of cells after deployment between this algorithm and conventional algorithm 1

Compare the Low-Speed Ratios K_1 of the cells selected by the algorithm in this paper and the conventional algorithm 1 (algorithm based on the Low-Speed Ratio gain of cells) after feature X is enabled.

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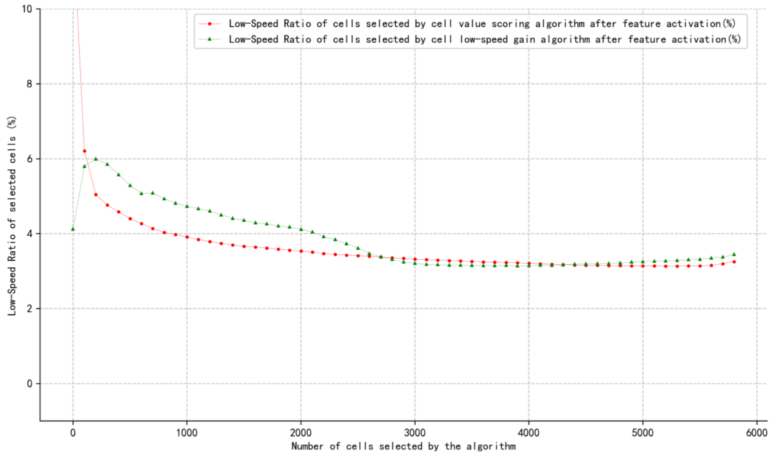

Figure 2. Comparison chart of the Low-Speed Ratio of the cells selected by the algorithm in this paper and conventional algorithm 1 after feature X is enabled

As can be seen from Figure 2, when the number of deployed cells is the same, in most cases, the Low-Speed Ratio of the cells selected by the algorithm in this paper is lower than that of conventional algorithm 1.

Compare the absolute gains of the Low-Speed Ratio K_1 of the cells selected by the two algorithms after feature X is enabled.

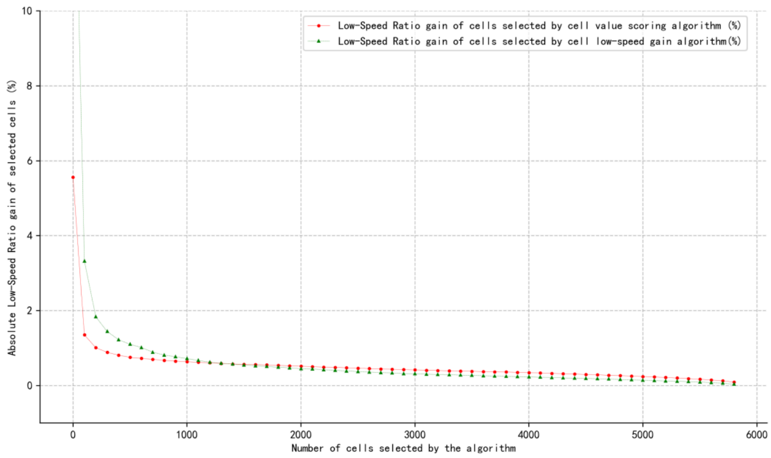

Figure 3. Comparison chart of the absolute gain of the low-speed ratio of the cells selected by the algorithm in this paper and conventional algorithm 1 after feature X is enabled

As can be seen from Figure 3, when the number of deployed cells is less than 1000, the absolute gain of the Low-Speed Ratio K_1 of conventional algorithm 1 is higher than the algorithm in this paper. However, as the number of deployed cells further increases, the absolute gain of the Low-Speed Ratio K_1 of the algorithm in this paper will exceed that of conventional algorithm 1. Considering that in practical situations, the number of deployed cells is at least several thousand, and sometimes even reaches tens of thousands, in practical applications, deployment according to the algorithm in this paper has a more significant improvement on the Low-Speed Ratio K1 of cells. At the same time, the curve trends of the two algorithms can be combined to select the optimal cell combination.

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In conclusion, by comparing the Low-Speed Ratio K_1 and the absolute gain of the Low-Speed Ratio K_1 of the cells selected by the two algorithms after deploying feature X, it can be verified that this algorithm has more advantages in improving the network's Low-Speed indicator.

2.2.3. Comparison of time complexity between this algorithm and conventional algorithm 2

The time complexity of the traditional algorithm 2 (combination algorithm) is $O(2^N)$. When the number of cells N is large, the calculation time will increase sharply, and it cannot respond quickly to the needs of mobile operators.

For the optimal algorithm based on cell value scoring proposed in this paper, the time complexity of calculating the indicator K1 and its gain G_o after deploying feature X for all N cells is $O(N)$. The time complexity of calculating the cell value score is $O(N)$, the time complexity of sorting is $O(N\log N)$, and the time complexity of generating the gain result list is $O\left(\frac{N(N+1)}{2}\right) = O\left(N^2\right)$. The total time complexity is $O\left(N^2\right)$. Compared with algorithm 2, the time complexity is significantly reduced.

In the mobile operator network, usually N is at least several thousand, and in some big cities, the number of cells reaches tens of thousands. Compared with conventional algorithm 2, the algorithm in this paper can better meet the needs of mobile operators to quickly obtain the list and number of deployed cells.

3. Conclusion

This paper proposes an optimal algorithm for feature activation based on cell value scoring, aiming to solve the problem of low efficiency in cell selection when mobile operators deploy specific features in the field of wireless communication. This algorithm comprehensively considers the Low-Speed gain of cells after feature deployment and their contribution to the entire network, calculates the value score of cells, and then quickly determines the optimal list and number of deployed cells.

The experimental results show that by comparing the Low-Speed Ratios before and after feature deployment, the improvement effect of feature X on cell performance is verified. By comparing the post-deployment Low-Speed indicators with those of conventional algorithm 1, the advantages of this algorithm in improving network performance are demonstrated. By comparing the time complexity with that of conventional algorithm 2, the high efficiency of this algorithm is proven, which can quickly respond to the needs of mobile operators.

This research provides a scientific and efficient decision-making basis for mobile operators to deploy features under a limited budget, and has a certain promoting effect on the development of the wireless communication industry. However, the value scoring model in this paper depends on temporary deployment and collection of network-wide KPI data, which is relatively difficult to operate. Future research can attempt to build a neural network model using historical KPI data. For example, wireless indicators such as the number of cell users, load, modulation mode distribution, and the ratio of each speed interval are used as feature inputs, and the cell value score is used as the output of the model, so as to quickly predict and select the optimal cells in a new network. In addition, this framework can also be extended to the scenario of joint deployment of multiple features, and multiple key indicators such as the Low-Speed Ratio and uplink traffic can be improved simultaneously through multi-objective optimization methods.

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