5G Residency Enhancement Method based on 5G Beam Intelligent Optimization

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***Abstract*—With the rapid development of 5G technology, users can undertake high-quality services, including large bandwidth, high network speed, and ubiquitous services. However, in the early stage of 5G deployment, 5G network coverage has become the main factor affecting 5G network residency due to the imbalance between 5G investment and user development. This paper proposes a novel 5G residency enhancement method based on 5G beam smart optimization. Based on 5G terminal coverage and 5G-user-residenting 4G cells, the proposed method can precisely evaluate/find the 5G high-value areas, where 5G network coverage need to be optimized. The 5G antenna beam weight is intelligently optimized and evaluated based on hybrid Immune Genetic Algorithm with Particle Swarm Optimization (IGAPSO). This method has high practicability and popularization value in 5G network investment, planning, construction and optimization. Experiment results verify that the proposed method can lead to 5G residency enhancement.**

Keywords—5G Residency, 5G Beam Optimization, IGAPSO

I. INTRODUCTION

In the early stage of 5G network construction, the seamless 5G network coverage has not been completed, and the inter-network interoperability strategy and mobility parameter configuration have not been fully optimized, so the interoperability between 5G network and 4G network is relatively frequent[1]. In addition, terminal-to-network adaptation issues such as terminal power consumption and power configuration also make 5G users passively or actively disengage from 5G network, leading to "Fake, Dumb and Blind" problems of 5G network and low network utilization[2].

Recently, 5G resident ratio becomes a key indicator for 5G network operators' network quality evaluation[3]. 5G resident ratio indicates a series of performances (i.e., the actual utilization efficiency of 5G network, the traffic diversion of 5G users, the coordination between 4G and 5G networks) [4]. Telecom operators can improve the efficiency and quality of 5G network through the traction of 5G resident ratio, as well as gradually guiding users with 5G capability to use 5G network. This can assist users to enjoy 5G network service services with large bandwidth, low latency and multiple services.

At present, the main factor affecting 5G residency is 5G network coverage, especially at the period when 5G is expected to expand to the rural and suburban scenarios. 5G insufficient coverage problem, which is caused by irrational network planning or 5G frequency difference, results in numbers of 5G users cannot connect to 5G network, which will lead into flowing back of 5G network traffic. Moreover, for related 4G Base Stations(the abbreviation term "BS" is used In the later part of the paper), it is difficult to guarantee users awareness due to resource congestion. In addition, a large number of mobile users uses data/voice services in the indoor scenarios [6]. Under the condition that 5G indoor distribution system has not been fully deployed, indoor 5G coverage is completed by outdoor macro stations. It is urgent to optimize and improve indoor coverage level and indoor service experience through various measures [7].

Based on the network awareness issues and 5G technology characteristics mentioned above, this paper proposes a novel method to realize accurate matching of 5G network coverage based on 5G beam adjustment. Firstly, through key indexes and characteristics of 5G network, the dynamic threshold configuration scheme accurately locates weak coverage areas and grids of 5G network, which is based on 4G and 5G network mapping table grid clustering [8]. Secondly, by collecting and analyzing 5G Measurement Report(the abbreviation term "MR" is used In the later part of the paper) data and 5G terminal location information, 5G beam weights are optimized based on intelligent optimization algorithm, which lead to 5G three-dimensional network coverage enhancing [9]. Under the circumstances that the road coverage is well-optimized, real-time intelligent adjustment according to users' distribution is achieved.

The rest of this paper is organized as follows: Section II introduces the 5G resident ratio prediction and enhancement method. Section III introduces the realization of 5G resident ratio enhancement based on 5G beam intelligent optimization. Section IV gives the conclusions.

II. RESEARCH ON 5G RESIDENT RATIO PREDICTION AND ENHANCEMENT METHOD

A. 5G Network and Service Development Prediction

5G resident ratio can be subdivided into 5G traffic resident ratio and 5G duration resident ratio [10]. More specifically, 5G traffic resident ratio refers to the proportion of the data traffic generated by 5G users in the total traffic generated by 5G users during the statistical period. 5G duration resident ratio refers to the proportion of the resident duration of 5G users in the statistical period.

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5G resident ratio can be evaluated, analyzed or estimated based on different data sources, such as drive test data, network management system data, 5G core data, etc. With various data sources, the 5G resident ratio is widely used to identify and reveal network problems and areas under weak or no 5G network coverage [11].

5G resident ratio is strongly correlated with 5G terminal penetration, 5G Dataflow of Usage(the abbreviation term "DOU" is used In the later part of the paper) and 5G network coverage rate[12]. Based on the statistical data of mobile network users, 5G terminal penetration rate, number of 5G terminals, number of 4G terminals, 4G and 5G DOU, 5G terminal flow and 4G terminal flow of a super-large city from January 2020 to September 2021, the development prediction of 5G network is carried out according to the trend extrapolation method.

TABLE I. PREDICTION OF 4G AND 5G SERVICE DEVELOPMENT

Key Indexes	*Actual Network Statistics（Jan.2020~Sep.2021）*							
	Unit	*Q1. 2020*	*Q2. 2020*	*Q3. 2020*	*Q4. 2020*	*Q1. 2021*	*Q2. 2021*	*Q3. 2021*
Mobile Network Users	*Million*	311.0	309.3	309.2	309.2	309.8	310.4	311.0
4G&5G User Penetrat ion	*%*	82	85	86	91	93	94	95
5G User Penetrat ion	*%*	1	3	7	12	17	23	29
5G Device Users	*Million*	3.7	10.1	20.4	35.6	54.1	72.6	91.3
4G Device Users	*Million*	251.8	251.6	247.1	247.0	232.8	218.5	204.2
5G DOU	*GB*	14.9	16.4	17.6	19.6	21.4	23.2	25.0
4G DOU	*GB*	11.0	10.9	12.0	12.4	12.5	12.7	12.8
5G Device Traffic	*PB*	52	157	341	665	1103	1607	2176
4G Device Traffic	*PB*	2636	2604	2825	2919	2784	2645	2501
5G Resident Ratio	*%*	13	16	17	19	22	29	33
5G Network Traffic	*PB*	7	25	60	126	245	460	727
4G Network Traffic	*PB*	2681	2737	3106	3457	3642	3792	3951
4G PRB Usage Ratio	*%*	22.0	22.1	22.9	23.5	23.9	24.1	24.4

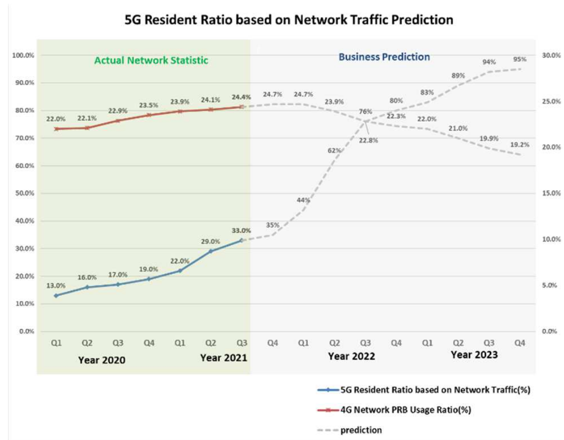


Fig. 1. Diagram of 5G Resident Ratio based on Network Traffic Prediction

It can be seen that the 5G traffic residing ratio in the city will reach over 60% in the second quarter of 2022 and over 80% at the end of 2022, while the PRB utilization rate of 4G network reaches its peak in the beginning of 2022. Since then, with the continuous development of 5G terminals and users, the service traffic will be gradually shifted to 5G network, and the 4G network load will gradually reduce to a low level.

In 5G weak coverage area, 5G users will only camp on 4G cells nearby and occupy numbers of network resource from 4G users[13]. Except for industrial chain and market factors, 5G coverage is the basis for improving 5G residency, which provides service support capability and market development capability.

B. Accurate Recognition of Insufficient 5G-Coverage Area based on 5G Terminal Coverage

Network coverage determines the quality of service awareness. As the operation and maintenance professionals cannot accurately and effectively evaluate the users' need in real time, the accuracy of 5G network coverage is not high, resulting in imbalance and mismatch between 5G base station (BS) coverage and user needs and service awareness[14]. For example, in an area with insufficient 5G network coverage, 5G users are gathered in 4G cells, so that the terminals with 5G capability in the area cannot connect to the 5G network, resulting in the loss of users in the area and the low 5G resident ratio[15]-[16]. Therefore, how to improve the accuracy of 5G BS deployment and optimization is an urgent problem to be solved.

By identifying the user's terminal type and associating 4G cell information within the region, the 5G terminal coverage can be filter out which indicates both the quality of 5G network coverage and the 5G user aggregation at the same time[17]. On the other hand, 5G users are dynamically moving and gathering[18]. For example, users will be gathering in certain scenes in different time periods such as office buildings during working days, high-rise roads in the morning and evening rush hours, high-rise residential buildings during weekends and holidays, which may become hot spots with high 5G service occurring frequency[19]. A network mapping table is constructed by collecting node information from each BS in the target area, cluster analysis is conducted for key indexes of 4G and 5G service awareness, and the network mapping table is scanned to filter out high-value 5G coverage areas[20]. Finally, the construction parameters information of neighboring 5G base stations (BSs) is correlated to further determine whether this area needs to be optimized by BS investment and construction[21]-[22].

① Statistical Method of 5G Terminal Coverage

5G terminal coverage ratio is used to indicate the probability and ability of 5G terminal occupying 5G network, which can assist in identifying the 5G terminals' resident 4G cells[23]. It is defined as the ratio of 5G terminal users covered by 5G BS to all 5G terminal users in specific area. The algorithm focuses on 4G cells and outputs the number of users with 5G capability camped on the cell[24]. Following three steps, the 5G terminal coverage ratio is calculated as Formula(1) :

$$\text{5G Terminal Coverage Rate} = \frac{N_{\text{5G terminal covered by 5G BS}}}{N_{5G\ terminals\ in\ total}} \times 100\% \quad (1)$$

Step 1: Find the resident cells of 5G terminal users in each statistical period. This algorithm marks the resident 4G cell of each 5G terminal user in each statistical period and records the service times and service types for each cell.

Step 2: Count the number of 5G terminal resident users, service type and service times of each cell in for specific period. Based on the detailed list generated in the first step, take the cell as the statistical object and count the number of users who have resided in the cell (need to be duplicated by Cell ID) and the cumulative number of services of all users who have resided in the cell during their residency in the 4G cell. Finally, a summary table is generated and converted in grid, as shown in Fig 2.

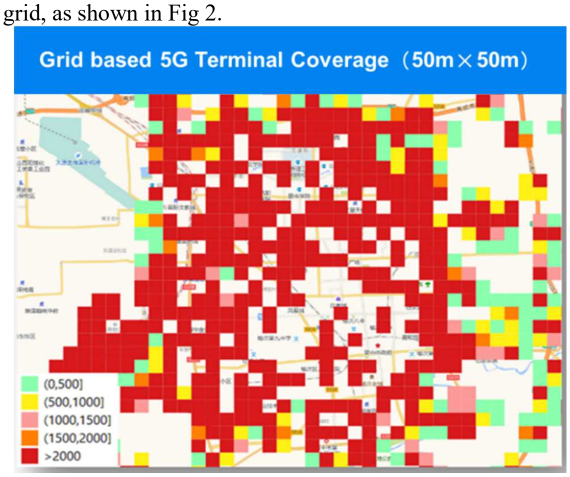


Fig. 2. Diagram of 5G terminal coverage in grid of 50m×50m

Step 3: Cluster and merge 5G BSs according to different scenarios. In the meantime, calculate the sum of 5G terminal users in 4G cells covered by 5G BSs according to different coverage radius of 5G BSs.

② Key Indexes Clustering and Gridding

The network mapping table is constructed by collecting node information from each BS in the target area[25]. According to the grid cluster analysis of key indexes of 4G and 5G service awareness, the network mapping table is scanned and correlated to screen out high-value 5G coverage areas. By interconnecting related 5G cells information such as azimuth, antenna height and down-tilt, the specific grid is labelled as 5G-covered and non-5G-covered, which need optimization method and construction method respectively to solve the coverage issue[26].

C. 5G Beam Coverage Optimization Based on Hybrid IGAPSO

1) 5G Massive MIMO BeamForming Optimization

Currently, 5G is entering stage of large-scale deployment. Compared with traditional Multi-Input-Multi-Output technology(the abbreviation term "MIMO" is used In the later part of the paper), 5G networks introduce Massive MIMO technology, which adopts spatial utilization of vertical dimension and realizes electromagnetic wave coverage in horizontal and vertical dimensions. Massive MIMO is also called as 3D-MIMO [27]-[28].

Massive MIMO brings three antenna gains: power gain, array gain and diversity gain. Massive MIMO antenna arrays have a large array of antennas that generate a high-gain, adjustable narrow beam, which not only improves cell throughput, but also reduces interference from neighboring BSs, known as Beam Forming(BF)[29]. With the acceleration of 5G construction and increasing BS density, 5G network optimization has gradually become the primary goal of network optimization, and beam optimization becomes a new network optimization method [30].

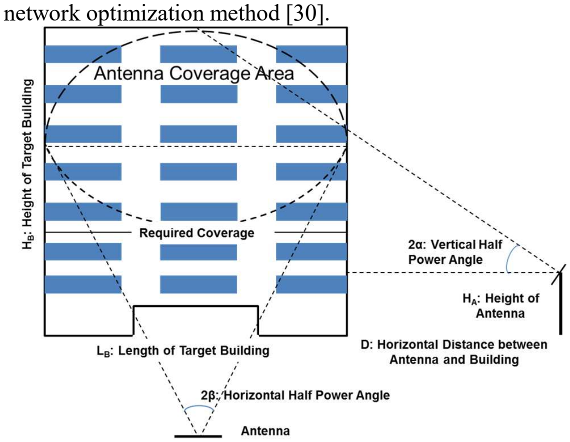


Fig. 3. Diagram of 5G antenna Beamforming 3-Dimention Coverage

Beamforming is a downlink multi-antenna technology. Beamforming technology refers to the 5G BS weighting the multi-antenna to send a signal, forming a narrow transmission beam and directing the energy to target users[31]. The 5G antenna uses a large-scale antenna, such as 64T64R, 32T32R, to shape the 5G BS transmission signals into multiple narrow beams covering the entire space, changing the horizontal and vertical coverage of the cell[32]. The beam forming process mainly consists of the following four steps:

Step 1. Channel correction: Ensure reciprocity and consistency between channels.

Step 2. Weight calculation: gNodeB calculates a weight vector based on the downlink channel characteristics to change the shape and direction of the beam.

Step 3. Weighting: In the baseband, the weights are vector added to the data to be transmitted to change the signal amplitude and phase.

Step 4. Shaping: apply the principle of interference to adjust the width and direction of the beam.

By selecting the weights, the 5G antenna can be configured and adjusted in four dimensions: azimuth offset, down-tilt angle, horizontal half power angle and vertical half power angle[33]. Currently, the main 5G BS equipment manufacturers have unique algorithms and combinations for the setup of beam pattern, which varies in beam shape and beam number[34]. Different antenna weights combinations are used according to different coverage scenarios to reduce and solve cell coverage problems and inter-cell interference problems for target areas. Therefore, an intelligent optimization algorithm based on real-time 5G user MR data and location information is proposed to find one beam weight combination with the current scene and user distribution to achieve the best match between network and service.

2) 5G Beam Coverage Optimization Based on IGAPSO

The 5G Massive MIMO Beam Weight Intelligent Optimization algorithm first counts and estimates the distribution of UE in a cell and the interference from neighboring cells, and then intelligently estimates the optimal broadcast beam weight value considering the coverage performance of the network, and realizes the adaptive adjustment of MM weights[35]. Weight adaptive can improve overlap coverage between cells, reduce and control inter-cell interference, which helps improving overall cell performance and user awareness[33].

Currently, the main steps for intelligent optimization of 5G Massive MIMO beam weights are shown as below:

Step 1: Send measurement requests to the 5G user camped on the 5G BS, and collect 5G users reports including signal strength, location information and path-loss information (such as serving cell RSRP, neighbor cells RSRP, DOA information of the serving cell and its neighbor cells) [29].

Step 2: The BS performs SINR fitting based on the RSRP information of the serving cell and neighbor cells received during the statistical period. The fitting formula is as (2):

$$SINR_{Serving\ Cell} = \frac{RSRP}{\sum_1^5 RSRP_{NeighborCell} * 50\% + AWGN} \quad (2)$$

Note that in the formula above, only TOP5 Strongest neighbor cells' RSRP are taken into account, with a Weighting of 50%.

Step 3: Find the best-matched beam weights by using intelligent optimization algorithm based on the RSRP values of each sample, DOA information and the fitted SINR data. Finally, find the locally optimal combination of the beam weights for RSRP and SINR.

Step 4: Evaluate the effect for the optimal combination of beam weights according to KPIs of service awareness.

It should be noted that the intelligent optimization algorithm proposed in this paper is IGAPSO. As global search optimization technology has been widely used in the field of network optimization, including Particle Swarm Optimization (PSO), Genetic Algorithm (GA), Immune Algorithm (IA), Ant Colony Algorithm (AC), and so on[29]. Particle swarm optimization is easy to implement and has good convergence. The genetic algorithm has strong global search ability and good robustness. Immune algorithm has the advantages of population diversity, relatively fast speed and easy to obtain global optimal solution.

In this paper, Immune Genetic Algorithm with Particle Swarm Optimization(IGAPSO) is formed by introducing genetic algorithm and immune algorithm into particle swarm optimization. This hybrid strategy not only improves the local optimum ability, but also guarantees the diversity of the population and improves the optimization efficiency[30]. The algorithm is as follows:

① Particle swarms are initialized to contain N particles (test data collected over a statistical period);

② Fitness of each particle is calculated (RSRP and SINR of each sample point are interval judged to determine weak coverage and high interference threshold);

③ To judge the current fitness value of each sample, if it is better than the individual extreme value, replace the individual extreme value with the current fitness value, and then compare the current individual extreme value with the global extreme value of each example [34]. If it is better than the global extreme value, replace the global extreme value with the reform hoof the extreme value, and save the current sample to the memory database;

④ Update particles based on individual and global optimum values;

⑤ Determine whether the termination conditions are met, if they are met, the termination will be completed, if not, the next judgment will be made;

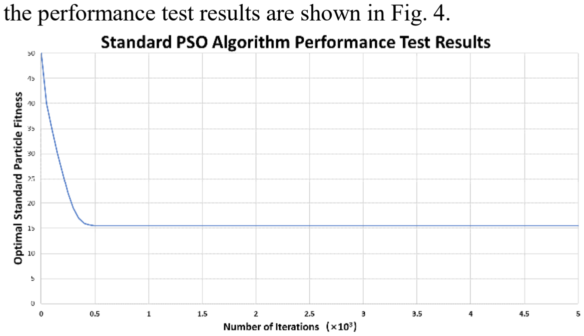
⑥ Decide whether "precocious" phenomenon appears or not, if not, change to step 2, otherwise make the next judgment;

⑦ Randomly generate n/2 particles, then randomly select n/2 particles in the memory library, which are composed of two parts of particles. For each of the new particles, based on their fitness size and concentration, each particle is given a choice probability to participate in the differential and mutation operation[35]. The particle varies by probability to get the next generation particle swarm, and then returns to step2.

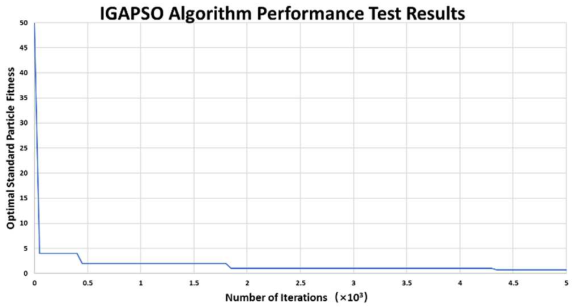
IGAPSO and standard PSO are used to optimize a standard multi-peak test function to compare their ability to "ESCAPE" from local extremum [36]. The test function formula is as (3):

$$\text{Rastrigin: } \mathrm{Ras}(x) = 20 + x_1^2 + x_2^2 - 10(cos2\pi x_1 + cos2\pi x_2) \quad (3)$$

The number of particles of the two algorithms is 40, and the performance test results are shown in Fig. 4.



(a) Standard PSO Algorithm Performance Test Results



(b) IGAPSO Algorithm Performance Test Results

Fig. 4. Comparison of Performance of Standard PSO and IGAPSO

The results show that the standard PSO falls into the local optimal value in 607 iterations, while the IGAPSO reaches the local optimal value in 4451 iterations. It can be seen that after improvement, the ability of the new algorithm in "ESCAPING" from local extremum has been significantly enhanced.

Considering the limitations of the static prediction model, the IGAPSO algorithm is used to optimize the network parameters of the prediction model, and the experimental comparison shows that the optimized prediction model has higher prediction accuracy, faster convergence, and better stability. The dynamic prediction model is established by taking the relative error and error rate of the network index corresponding to the beam configuration at the prediction time as the input of the fuzzy controller and the correction factor as the output and adjusting the prediction results.

Based on the above steps, the local optimum can be jumped out on the basis of the traditional intelligent optimization algorithm, which ensures the diversity of the particle cluster and achieves accurate matching of antenna weights [33]-[35].

III. Realization of 5G Residency Enhancement based on 5G Beam Intelligent Optimization

A. Solutions and Implementation

For the target area, based on 5G users real-time distribution, a network mapping table is constructed by collecting node information from each BS in the target area. Then, the cluster analysis for 4G and 5G service awareness key indexes is conducted, and the network mapping table is scanned to filter out high-value areas with insufficient 5G network coverage [36]. Furthermore, this paper associates the construction parameter configuration of the neighbor 5G BS, and then, whether the area needs further construction or optimization can be accurately determined.

Scenery beam weight optimization is performed for 5G BSs around areas with insufficient 5G coverage filtered out by the above steps. Based on the MR data and location information in the raster surrounding the BS during the statistical cycle, the optimal matching of beam weights is carried out based on IGAPSO. The optimal scheme of beam coverage is determined according to the actual situation of the coverage area under different scenarios and different building characteristics. Finally, based on real-time service and user distribution, the 5G coverage in three-dimensional space can be precisely improved, which enhance 5G service and user awareness, and achieve intelligent optimization and promotion of 5G residential ratio in target area.

B. Implementation of Accurate Recognition for 5G Weak Coverage Area

Take area A(Urban Scene) as an example, select and label the 5G terminal users resident 4G cell within a week which achieve the threshold according to the time granularity of 1 hour. Moreover, count the number and type of services in the cell during the week. According to the detailed list with labelled 4G cells, count the number of users staying in the cell in a week (duplication is required) and the cumulative service times of users staying in the cell at all layers. As shown in Fig.5, 4G cells in the whole network are divided into 5G user resident 4G cells and 5G user non-resident 4G cells, according to a set-up threshold.

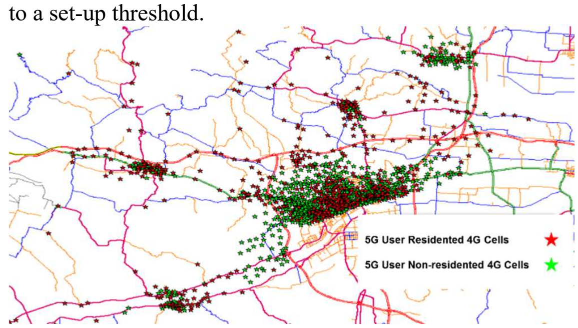


Fig. 5. Grographic distribution of selected 5G user resident 4G Cells in Area A

Taking these screened BSs as the center, we select the adjacent 5G BSs in the range of 400m. We count the number of 5G RRC connections, 5G total traffic, 5G backflow ratio of each relevant 5G cell, as well as the 5G terminal service total traffic and 4G PRB utilization of 5G users residing in 4G cell. This paper conducts the grid analysis to generate the network mapping table. Furthermore, this paper merges these grids and screen out high-value 5G weak coverage grids by scanning the network mapping table. Meanwhile, 4G cells, which need 5G coverage in the target area, can also be prioritized through indexes such as 4G PRB utilization rate of 5G terminal resident 4G cells and 5G terminal service traffic. This can achieve accurate 5G coverage grid level identification and positioning, as exemplified in Fig.6.

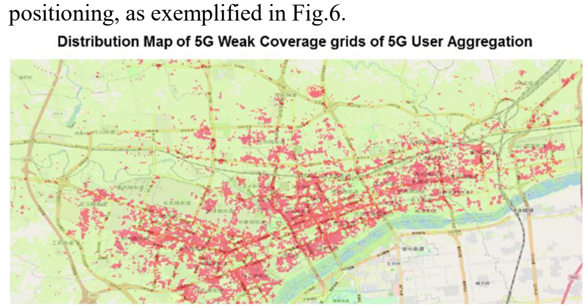


Fig. 6. Grographic distribution of 5G weak coverage grids in Area A

C. Implementation of 5G Beam Coverage Optimization Based on IGAPSO

1) Optimization of Road Surface and Wide Coverage

These continuous grids with 5G services and users gathered but insufficient 5G coverage and poor quality are aggregated. The area with more than 100 aggregation grids (aggregation degree) and 5G stations within 400m around the grid is further optimized for 5G beam weight. Most of these continuous grids reflect the coverage of 5G network in urban roads. Collect the MR data of relevant 5G cells for one week, and optimize the beam weight based on the IGAPSO optimization algorithm according to the above steps. Through the comparison of RSRP and SINR before and after the road, it can be seen that the optimization of beam weight has significantly improved the coverage of the road, and the downlink rate awareness of users and services has also been optimized and improved.

Key Indexes statistics of road coverage before and after optimization are shown in Table II.

TABLE II. KEY INDEXES STATISTICS OF ROAD COVERAGE

Key Indexes	*AVG RSRP*	*RSRP>=-85dBm*	*AVG SINR*	*SINR>=10dB*	*AVG DL THP*	*DL THP>=10 0Mbps*
	dBm	*%*	*dB*	*%*	*Mbps*	*%*
Before	-84.2	60.2	5.8	33.4	324.8	90.9
After	-82.3	62.4	8.6	36.6	335.8	93.9
Improvement	1.9	2.2	2.8	3.2	11.0	2.0

2) Optimization of High-rise Residential Scene Coverage

Merge the building grids with 5G services and users but insufficient 5G coverage and poor quality, delete the area where no room construction is carried out and there are 5G macro stations within 200m around the grid, and optimize the 5G beam weight. These grids reflect the indoor coverage of 5G network. These grids generally have certain laws. For residential buildings, the probability of user aggregation in the morning, evening or weekend is large. For the office building scenario, the probability of users and service aggregation during working hours on weekdays is high. To sum up, it is necessary to adjust and optimize the beam weight in real time.

Take an example of Building A and Building B, which are covered by the same 5G cell. Collect the MR data of relevant 5G cells for one week, and optimize the beam weight based on the IGAPSO optimization algorithm according to the above steps. The optimization results are shown in Table III.

Table III shows the weight before/after optimization.

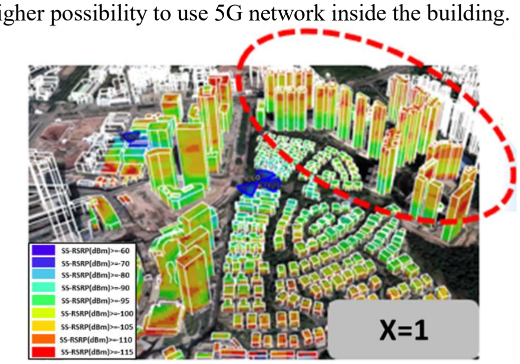
TABLE III. WEIGHT TABLE OF BEAM-OPTIMIZED ANTENNA

Key Indexes	*Weight Index*	*Azimuth*	*Number of Beam*	*Down-tilt*	*Beam-Width Horizontal*	*Beam-Width Vertical*
Before	53	5	1	12	65	15
After	291	-20	5	12	30	15

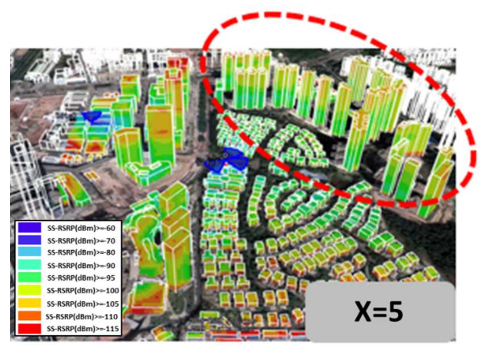
TABLE IV. COMPARISON OF BEFORE AND AFTER BEAM OPTIMIZATION

Scenario	*Floor*	*SS-RSRP/dBm*			*SS-SINR/dB*		
		Before	*After*	*Gain*	*Before*	*After*	*Gain*
Building A	2rd	-73.6	-72.6	0.9	27..3	27.6	0.3
	7th	-74.7	-70.0	4.7	15.6	23.8	8.2
	AVG	-86.0	-82.7	3.2	23.5	25.8	2.3
Building B	2rd	-77.6	-75.2	2.4	22.4	21.8	-0.6
	5th	-87.3	-80.8	6.5	12.3	18.1	5.8
	AVG	-84.5	-82.3	2.2	24.0	24.4	0.4
Outdoor	AVG	-73.6	-75.3	-1.7	19.7	18.8	-0.9

As shown in Table IV, for Building A and Building B, as the antenna coverage is adjusted to higher space after beam optimization, the indoor coverage is enhanced, whilst the road coverage becomes worse, which will slightly affect user awareness. For the weekend period, the adjustment can assist to improve the overall cell traffic, as the 5G users have a higher possibility to use 5G network inside the building.



(a) RSRP Distribution for Target Building before Optimization



(b) RSRP Distribution for Target Building after Optimization

Fig. 7. 3D-Grographic RSRP distribution of Target Building

3) Optimization of 5G Residential Ratio for Target Area

Based on accurate 5G high-value weak coverage area identification and 5G beam weight optimization of associated BSs, the monthly average residence ratio of the target area is increased from 23.5% to 28.6%, an increase of 5.1pp, with remarkable effect, as exemplified in Fig. 7.

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IV. Conclusions

This paper proposes a joint cluster analysis based on 5G terminal coverage and service awareness index to identify 5G high-value area with weak coverage, and realizes real-time and accurate optimization and adjustment of 5G beam weight based on novel IGAPSO algorithm. This scheme has been applied to the actual network operation and maintenance, which has a significant effect on improving the 5G residency in target area. Based on this hybrid intelligent optimization method, 5G coverage can be effectively improved, and users with 5G capability could camp on 5G network in time.

For further work, there are still some aspects of research worthy of attention. Firstly, the efficiency and accuracy of IGAPSO algorithm should be studied. By introducing new intelligent optimization algorithms, the balance between accuracy and computational efficiency may be realized. The second is the research on 4G and 5G network resource utilization and 5G capacity expansion standards, which will help to realize real-time network load monitoring and prediction based on 5G network KPI. The study also ensure that users get good service perception under the good coverage of 4G and 5G network.

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