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# Overlay Prediction Functions and Algorithms in Wireless Network Planning Software

Qi Li *, Chunyan Fen

Beijing University of Posts and Telecommunications, China

[a]liqi1996@aol.com

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*Abstract: In order to make better use of wireless network planning software, the functions and algorithms of coverage prediction in software were described. A very detailed analysis of the data structure was performed. Then, the implementation ideas, data structures, and processes of the three methods implemented by the coverage prediction computer were described in detail. The research results showed that different methods had their best application. Applying different algorithms on different occasions was the most reasonable and efficient implementation. Therefore, wireless network planning soft-ware has been gradually taken seriously. It will become a trend to simulate software before planning through wireless network planning software.*
*Keywords: planning, coverage prediction, indicators, efficient implementation.*

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## 1. INTRODUCTION

Wireless network planning software is a tool provided to users, especially wireless network planning engineers. Its planning content is mainly the wireless network part, including access network equipment such as base station location, antenna configuration, and carrier frequency configuration (Maloney, 2017). At the same time, it has business forecasting capabilities. Based on the electronic map and propagation model, the wireless resource environment is simulated. According to the radio resource management algorithm, the actual device operation algorithm is simulated. It has achieved the most realistic simulation of the results of the implementation of the planning scheme (Wang, 2017). Coverage prediction plays an important role in wireless network planning software. Although the principle of the algorithm is simple, the use of this module is very efficient. With this module, the entire area is understood in a macro way. Depending on graphic results and statistical results, it is easy to find problems in the program so as to adjust them in time (Partlett, 2017).

An efficient implementation of a computer for coverage prediction in wireless network planning was studied. First of all, the function and algorithm of the coverage prediction module are described, and the functional significance of the coverage prediction implemented in the wireless network planning software is described. Then, the basic data structure of software implementation coverage prediction algorithm is described in detail. By analyzing and finding suitable solutions, the basic data structure of coverage prediction and its role in calculation and the way of use are finally determined. Three implementations of coverage prediction are described, including single-point traversal calculations, pre-n strong signal calculations, and multiple-cycle ergodic calculations.

## 2. LITERATURE REVIEW

With the increasing demand for wireless data services and the continuous development of third-generation communications systems (3G) technologies, China's third-generation communications systems have entered the commercial phase (Peón, 2017). China's 3G system has three commercial standards: China Mobile's TD-SCDMA, China Unicom's WCDMA, China Telecom's CDMA2000. The three systems are under construction. In order to maximize the network capacity and performance, network planning before network construction is essential. Compared with second-generation mobile communication systems, 3G can provide diverse, high-speed, flexible, and high-capacity wireless data services (Wang, 2018). Because of the various bit rates and diversified services provided by 3G, it is particularly difficult to predict and model different services in 3G network planning.

At present, the 3G standards accepted by ITU are mainly the following three: WCDMA, CDMA2000 and TD-SCDMA. CDMA is the technical foundation of the third-generation mobile communication system. The first-generation mobile communication system uses frequency division multiple access analog modulation. The main disadvantage of this system is its low spectrum utilization. Signaling interferes with voice services. The second-generation mobile communication system mainly adopts a time division multiple access digital modulation method. The system capacity was increased, and independent channels were used to transmit the signaling, which greatly improved the system performance. However, the system capacity of TDMA was still limited, and handover performance was still imperfect (Huang, 2018). The CDMA system shows great potential for development due to its simple frequency planning, large system capacity, high frequency reuse factor, strong anti-multipath capability, good communication quality, soft capacity, and soft handover.

## 3. METHODOLOGY

### 3.1 Link loss calculation formula

Uplink loss is the total loss of the top interface from the terminal to the cell site. The formula for the total uplink loss is as follows:

$$L_T^{UL}(dB) = L_{path} + L_{body} + L_{indoor} + L_{feeder}^{UL} + L_{hopping}^{UL} + SFM - G_{Tx} - G_{term} \tag{1}$$

The derivation process of shadow fade margin in coverage prediction is as follows:

Shadow fading is a Gauss process with W mean and standard deviation of shadow fading as σ. Its probability density function is:

$$p_L(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{x^2}{2\sigma^2}} . \tag{2}$$

The probability that the shadow fading value exceeds the zdB is:

$$\Pr_L(x > z) = \int_z^\infty p_L(x)dx = \frac{1}{\sigma\sqrt{2\pi}} \int_z^\infty e^{\frac{x^2}{2\sigma^2}} dx . \tag{3}$$

If the σ is divided by x, there are:

$$\Pr_L(x > z) = \frac{1}{\sqrt{2\pi}} \int_z^{\infty} e^{-\frac{x^2}{2}} dx = Q(\frac{z}{\sigma}) . \tag{4}$$

Among them, Q is a supplementary cumulative function. As a result, the shadow fading margin is:

$$SFM(dB) = Q^{-1}(1 - \Pr_L) \times \sigma . \tag{5}$$

$\Pr_L$ is the cell edge coverage probability, which is the interface input parameter (input according to the user's coverage requirement). It relates to the type of ground feature for the shadow fade standard deviation receiver.

Downstream path loss refers to all losses from cell x to mobile station u. The formula is as follows:

$$L_T^{UL}(dB) = L_{path} + L_{body} + L_{indoor} + L_{feeder}^{UL} + L_{hopping}^{UL} + SFM + L_{TMA}^{DL} - G_x^{ant} - G_u^{recieve} . \tag{6}$$

The noise power considers thermal noise and the noise figure of the equipment. The calculation method is:

$$N_{BW} = N_0^{Term} + NF . \tag{7}$$

Among them, $N_0^{Term}$ is thermal noise. NF is the noise figure.

The thermal noise is calculated as follows:

$$N_0^{Term}(dBm) = n_0 + 10\lg(Band) . \tag{8}$$

Thermal noise power spectral density is $n_0$=-174dBm/Hz. Band is 5 MHz in the UMTS system.

The noise figure is divided into the base station side and the terminal side. The specific calculation is as follows: The noise coefficient at the terminal side refers to the noise coefficient of the receiver within the terminal. It is generally an interface input parameter. The default value is 8dB. The base station side noise figure refers to the noise factor NFBTS at the top of the set, which is related to the performance parameters of the base station equipment. It is generally set by the user according to the equipment.

### 3.2 The definition and calculation formula of each index in WCDMA

CPICH RSCP defines the strength of the CPICH signal received by user u.

$$RSCP_{CPICH}(dBm) = 10 \times \lg(\frac{P_{pilot}(ic)}{L_T^{DL}}) . \tag{9}$$

Best Server definition: In all the cells in which the UE can receive the downlink signal, the cell with the strongest downlink RSCP and greater sensitivity than the receiver is called the best serving cell.

The receiver sensitivity is the minimum CPICH signal power required by the receiver that can be decoded by the receiver without interference signals. The serving cell must be a cell whose received power is greater than the receiver sensitivity, and the best receiving cell is the best serving cell.

The CPICH Ec/Io is defined as the reception quality of the CPICH signal received by the user u. The formula is as follows:

$$CPICH \quad Ec / I_0(dB) = RSCP_{CPICH} - I_0^{DL}(ic) . \tag{10}$$

The Number of Services defines the number of cells that can provide services to the terminal, that is, the number of activated centralized cells. To add the activation set, the following two conditions need to be met simultaneously.

$$CPICH \quad Ec/I_0 > (Ec/I_0)_{Thresh}. \tag{11}$$

$$CPICH \quad Ec/I_0 > CPICH \quad Ec/I_0 - G_{Soft}. \tag{12}$$

## 4. RESULTS AND DISCUSSION

### 4.1 Interface features of overlay prediction dependent modules

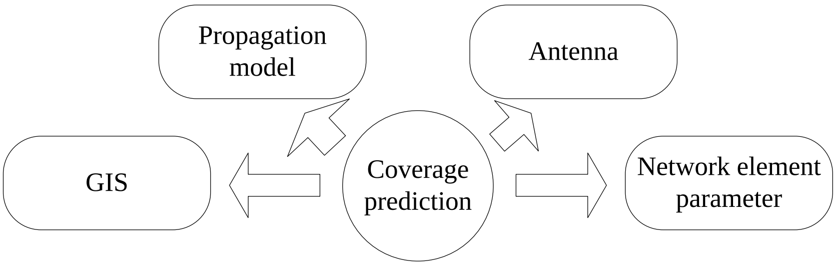


Figure 1. Coverage prediction dependence

The coverage forecasting dependency is shown in Figure 1. The interface functions provided by its GIS module include the following three:

First, the geographic information (land type, altitude, building height) of a given point is returned. This interface provides a single point of geographic information acquisition. At the same time, each feature has a standard deviation of shadow fading, which can be found by looking at the interface to the single point feature type. The feature of this interface is that when the interface is called frequently, the speed is not affected if the coordinates of the later incoming point are at the lower right of the previous point. However, if the coordinates of the point are relatively random and irregular, the speed of the call is slower. Therefore, when the coverage prediction is called, the interface is traversed and called in accordance with the matrix from the upper left to the lower right in order to achieve the best call speed.

Second, polygon objects and polygons are adjacent to rectangular objects. This interface is used to get a polygon object. Before the coverage prediction calculation is performed, the user needs to select the calculation area. This area is manually set by the user on the interface. The coverage is obtained as a polygon object. For details, see the description of the mark matrix below.

Third, it is the method of determining if a single point is in a large rectangle and whether it is in a polygon. This interface is used to determine if a point is within a polygon because the polygon is recorded as a vertex. The GIS module provides a method of judgment for coverage prediction calls. The specific use of the method is described in the following point mark matrix.

The interface function provided by the coverage prediction dependent propagation model module is given cell and the upper-left corner coordinates. The precision returns the path loss result of the same coordinate system.

The path loss of the propagation model can be calculated separately. The propagation path loss of multiple base stations can be calculated individually and stored. A lookup call is made when the coverage is used. For example, if the base station has a path loss accuracy of 5m, the accuracy of coverage prediction is greater than 5m after calculating the transmission loss of all base stations individually. The interval between the sampling points of the coverage prediction is larger than the sampling interval calculated by the propagation loss. At this time, the predicted values are derived from the previously transmitted loss files. The reason why the propagation loss calculation is stored in the file is because the propagation loss of a cell is not much. However, multiple cells, such as 500, will occupy a lot of memory space, thereby affecting the CPU's operating efficiency and program performance.

The propagation model module provides a readout interface for propagation loss. The working principle of this interface is essentially to read the file with a buffer of a certain size. If the system is always reading the path loss near a base station, then the path loss value of this base station will be fully loaded into memory, so the operating efficiency is quite high. If the value of the propagation path loss is found multiple times to traverse the base station, the best access speed can be achieved. If multiple times of finding the propagation path loss value is the way to traverse the coordinates of the mobile station, this interface will frequently switch between multiple files. It is very time-consuming to open, close, and read the file. The time required for accessing is generally 60 times that of traversing the base station. The best way for coverage prediction to call this interface is to traverse the base station.

Coverage prediction relies on the interface function provided by the antenna module: returning the antenna gain value to a given cell, mobile station coordinates and cell information.

The horizontal and vertical directions of the antenna are stored in memory. The calculation gain is always used to calculate, and this module does not involve any file reading operation. All operations are done in memory. Coverage prediction calls are used only when calculating link losses, and there are numerous combinations of relative positions between mobile stations and base stations. There is no need for these combinations to be buffered. The interface is called at that time, which does not need to consider efficiency.

Coverage prediction relies on the interface function provided by the antenna module, which is to get all base station information.

The coverage prediction only invokes the NE parameter interface at the initial time and obtains all network element information at one time, including the base station geographic coordinates, antenna configuration parameters, and carrier frequency configuration. The interface is no longer called in the calculation process after the coverage prediction to reduce the dependencies between the modules.

### 4.2 Coverage prediction software implementation method

The coverage forecast needs to store the calculation results of each index of each point in the calculation process, and these results need to be retained after running the coverage forecast. One reason is that these raw data can be used for various statistical work and presented on the geographic information system. Another important reason is that in order to facilitate viewing the current network coverage according to the coverage prediction results, the user needs to observe the specific values of the indicators of certain points. Then, after the coverage prediction calculation and the final calculation are completed, the index values of each point in the user-selected area need to be stored. At the same time, the users of wireless network planning software are mainly engineers for the optimization of wireless network planning, which is different from the general system-level simulation software. It needs a good presentation and user interaction experience. Software has high requirements for speed, so the storage of large amounts of data and file opening time are all factors that need to be considered.

Considering that coverage prediction essentially requires the calculation of sampling points on selected areas, the selected area may be irregular. The most straightforward idea is to use linked lists for storage. However, considering the display of the coverage indicator results, a matrix-like data structure is very suitable for geographic information systems. For the graphical result of the overlay prediction, the user also very much hopes to observe the numerical value on the interface again. If you use linked list storage, the search for points is inconvenient. This does not give the user a good feeling. Therefore, the matrix is used. This matrix is a circumscribed rectangle of the selected area, at the expense of storage space for time.

The matrix is a two-dimensional array. It is used to store the result value of each indicator. Each indicator is a matrix. They do not interfere with each other.

The result of the overlay is shown in Figure 2. The four corners are the coordinate values. Each cell is a point on the map that calculates the coverage index. The value in the grid is the index calculation result. Each cell size is 5m*5m.

(0,35) (25,35)

| | | | | |
|---|---|---|---|---|
| -117 | -117 | -110 | -117 | -117 |
| -117 | -102 | -105 | -102 | -117 |
| -102 | -100 | -100 | -100 | -102 |
| -105 | -100 | -90 | -100 | -105 |
| -102 | -100 | -100 | -100 | -102 |
| -117 | -102 | -105 | -102 | -117 |
| -117 | -117 | -110 | -117 | -117 |

(0,0) (25,0)

Figure 2. Overlay result storage schematic

A memory-mapped file is a mapping of a file to a piece of memory. Win32 provides functions that allow applications to map files to a process (Create File Mapping). In this way, the data in the file can be accessed using memory read/write instructions instead of using I/O system functions such as Read File and Write File, which improves file access speed.

This function is most suitable for applications that need to read a file and do syntax analysis of the information contained in the file, such as a color syntax editor for syntax analysis of the input file, the compiler, and so on. After mapping, the file is read and analyzed. It allows applications to manipulate files using memory operations without having to read, write, and move file pointers back and forth within the file.

Figure 3 compares the actual use of memory-mapped files and the logical relationships between various nouns.

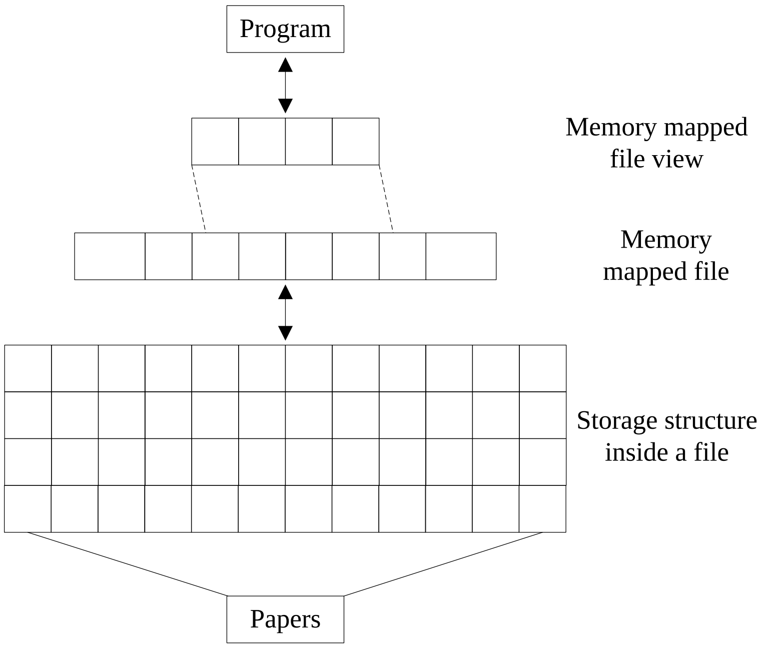


Figure 3. Memory mapping file

When it is necessary to access the data in the file, the memory-mapped file is created first, and then a new mapping file view is created. Just like a magnifying glass for a written enlargement, the program accesses data in a memory-mapped file through a memory-mapped file view. This is actually loading part of the file's data into memory. Memory-mapped files consider direct file reads and writes to be slower than using memory-mapped files. Win32API provides a very convenient method, so that the data in the memory-mapped file view can be easily written back to the file. The whole process does not require manual intervention, which is very convenient.

The use of a point marker matrix is divided into two phases, namely initialization and use.

Here, the initialization is the creation of a point marker matrix and the initialization of each point marker according to the selected area. The initialization of the members of the class itself needs to be completed. At the same time, the points that need to be calculated and the points that do not need to be calculated are marked according to the area selected by the user and points within the current area. Points that need to be calculated are marked as True (1) and points that do not need to be calculated are marked as False (0). The flow chart is as follows:

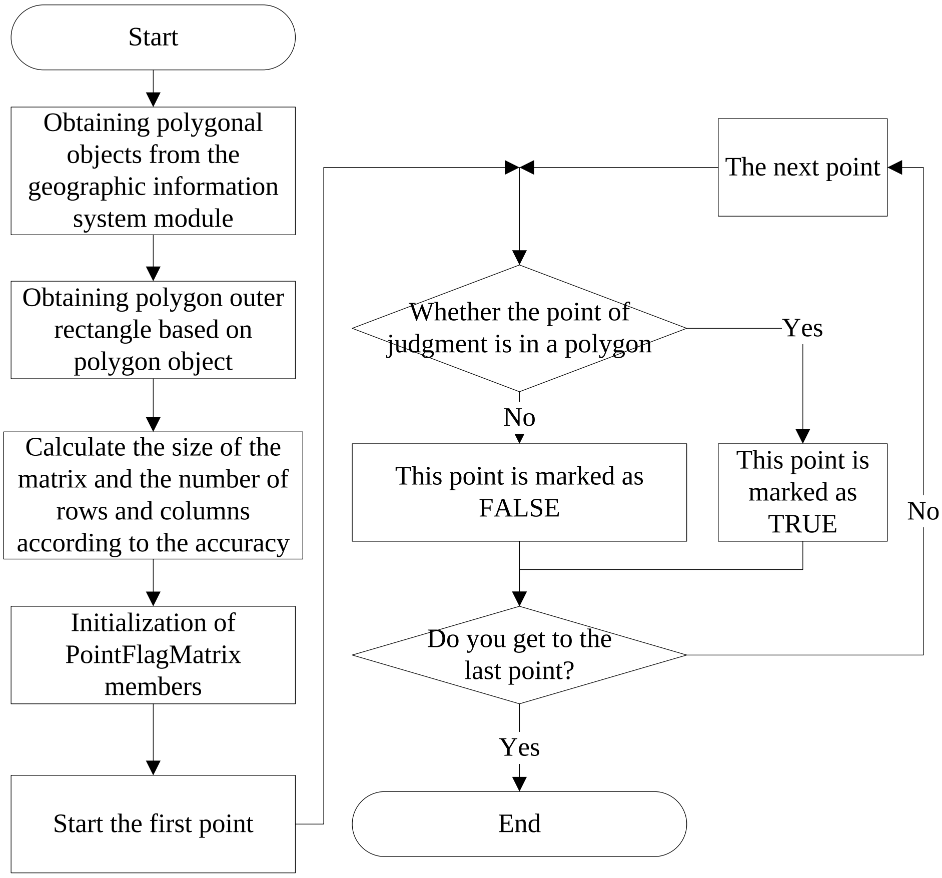


Figure 4. The initialization flow chart of the dot matrix

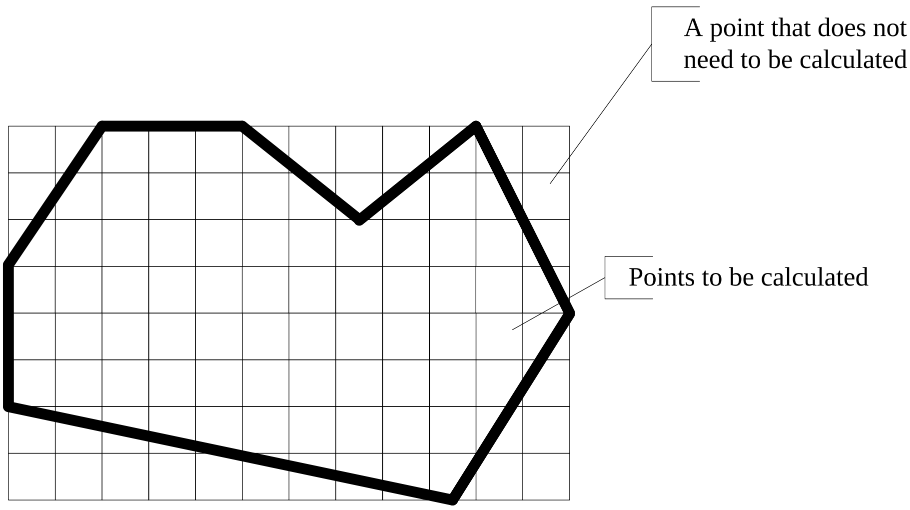


Figure 5. Polygon schematic diagram

First, according to polygonal objects, objects of polygons are obtained. This object includes the left and right boundary of the entire polygon. According to this boundary, the outer rectangle of this polygon can be created.

Then, according to the accuracy and boundary values, the outer rectangle can be sampled. The matrix lattice appears.

Finally, all points are traversed. GIS can determine whether a point is within a polygon. This method is used to mark all the points, as shown in Figure 5. The intersection point of a lattice is all the sampling points, that is, the points to be calculated eventually. The course black line represents the polygonal area chosen by the user, and the largest rectangle is the polygonal outer rectangle. Points between the bold black line and the circumscribed rectangle are all marked FALSE. All points within the thick black line are marked TRUE. This completes the markup for all points.

After initialization, it can be used directly. Data access is done through GetValue. When traversing points, the point's bool value (TRUE/FALSE) is directly obtained through GetValue. FALSE points skip all calculations directly, and TRUE points perform index calculations.

Single-point traversal is implemented in strict accordance with the principle of coverage prediction. The main flow is shown in Figure 6.

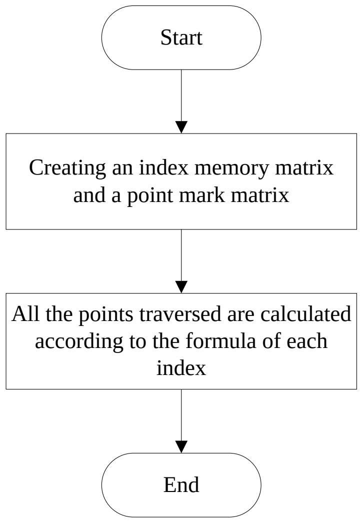


Figure 6. Single point traversal flow chart

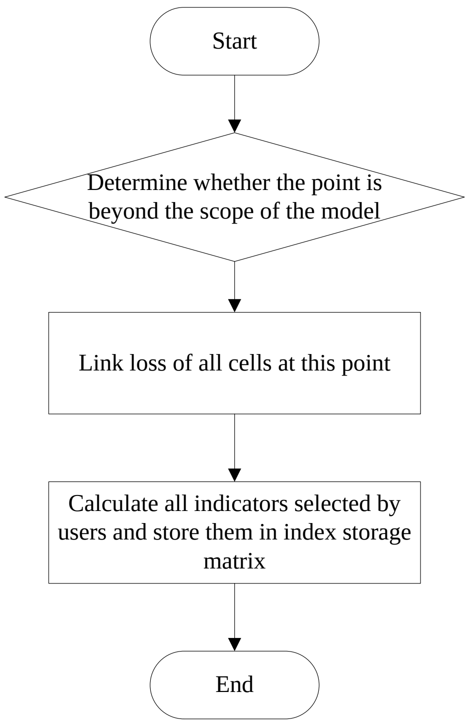


Figure 7. Single point calculation flow chart

The process is divided into 3 steps:

First, a memory matrix and a point marker matrix are generated according to the selected region and accuracy;

Second, each point calculation index on the matrix is traversed;

Third, after the traversal is completed, a number of index numerical matrices are generated, and the coverage of the forecast indicators is calculated.

Among them, for the single point calculation in step 2, there are the following processes:

The first n strong signal storage matrix and the single point traversal method have the same effect. The flow chart shown in Figure 8:

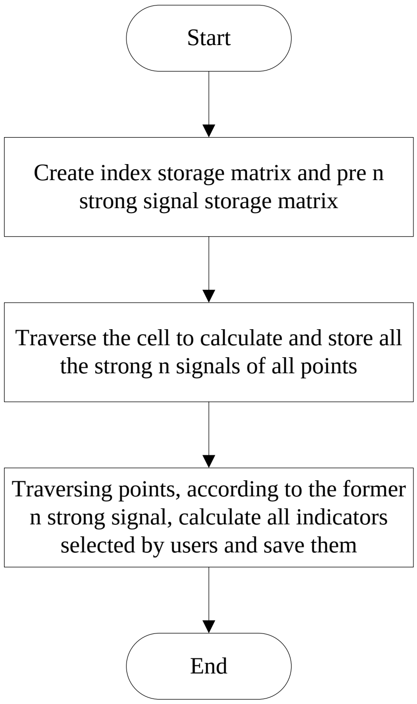


Figure 8. N strong signal flow chart before storage

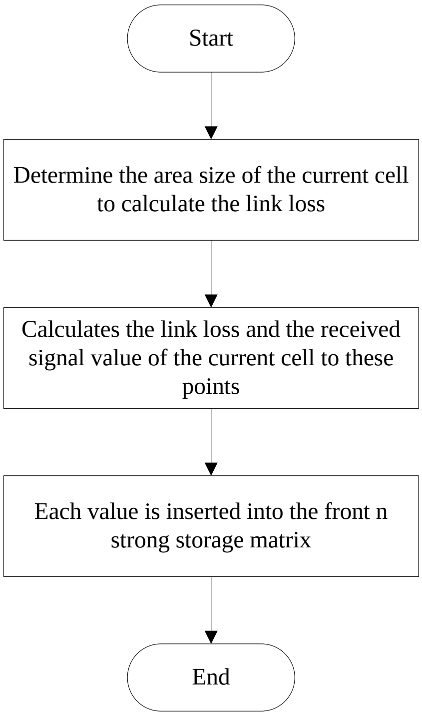


Figure 9. Flow chart of a cell calculation

The entire algorithm flow is divided into 3 steps:

First, according to the selected area, the first n strong signal storage matrix and the index storage matrix are initialized;
Second, the cell is traversed, and the pre-n strong signal is calculated and stored. The specific process will be described later;
Third, all calculation points are traversed, and indicators are calculated and stored according to the first n strong signals.
For a single cell calculation, there are the following processes:
The process of implementing multiple loop traversal is shown in Figure 10.

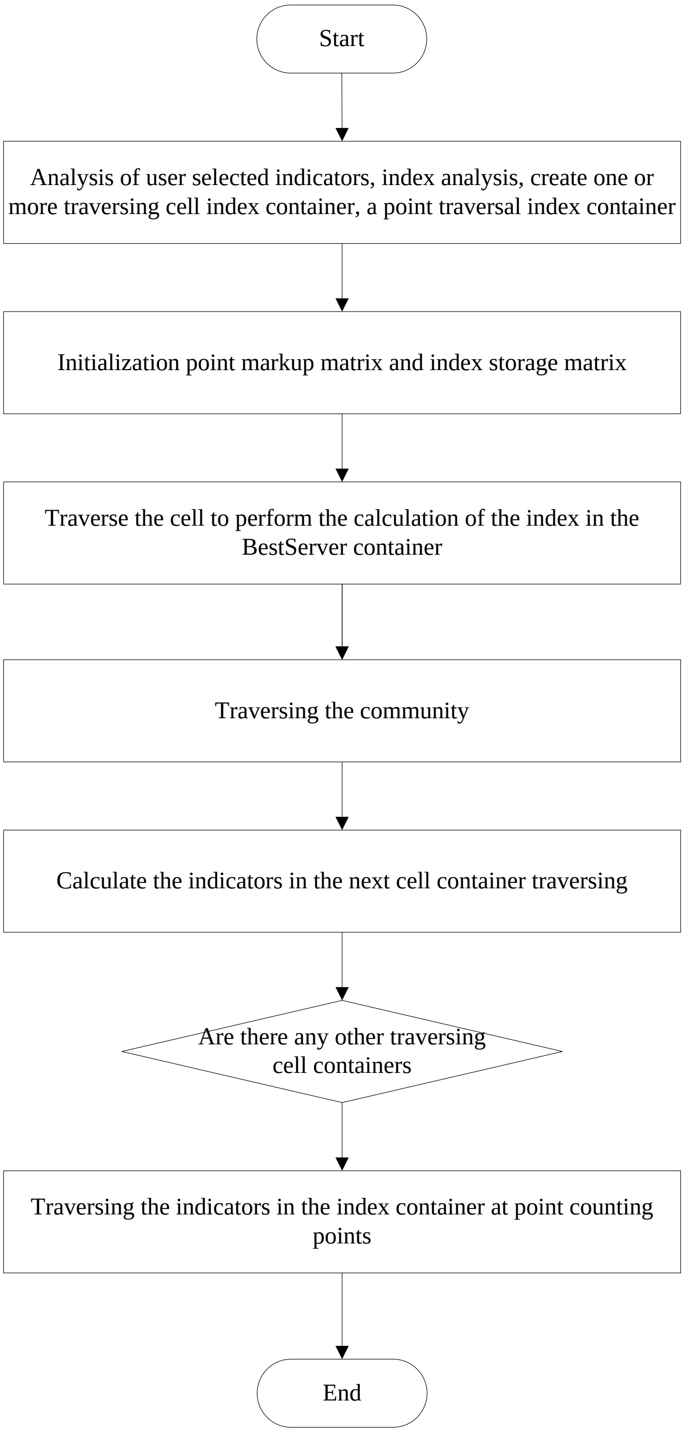


Figure 10. Multiloop traversal flow chart

## 5. CONCLUSION

An efficient implementation of a computer for coverage prediction in wireless network planning was studied. First of all, the function and algorithm of the module of coverage prediction are described, and the functional significance of the coverage prediction implemented in the wireless network planning software is described. Then, three kinds of realization methods of coverage prediction based on the characteristics of certain dependent modules are described in detail. The first is a basic calculation method based on the principle of coverage prediction, which is called single-point traversal calculation method. The principle of this method is simple, but the speed of operation is the slowest of the three algorithms. The second implementation is characterized by a relatively stable speed. The disadvantage is that only the strongest signal can be stored. The third is the implementation of multiple loop traversal. This method mainly considers the accuracy and time efficiency of the algorithm. The speed of this method is between the other two methods.

## REFERENCES

[1] Maloney, J. A., Kwon, D. H., Keller, S. D., & Janaswamy, R. (2017). Realistic gps coverage prediction for dualpolarized controlled reception pattern antennas. IEEE Antennas & Wireless Propagation Letters, PP(99), 1-1.

[2] Wang, Y., Wang, C., Shi, C., & Xiao, B. (2018). Short-term cloud coverage prediction using the arima time series model. Remote Sensing Letters, 9(3), 275-284.

[3] Partlett, C., & Riley, R. D. (2017). Random effects meta - analysis: coverage performance of 95% confidence and prediction intervals following reml estimation. Statistics in Medicine, 36(2), 301-317.

[4] Peón, A., Naulaerts, S., & Ballester, P. J. (2017). Predicting the reliability of drug-target interaction predictions with maximum coverage of target space. Scientific Reports, 7(1), 3820.

[5] Wang, Y., Wang, C., Shi, C., & Xiao, B. (2018). Short-term cloud coverage prediction using the arima time series model. Remote Sensing Letters, 9(3), 275-284.

[6] Huang, R., Xia, M., Sakamuru, S., Zhao, J., Lynch, C., & Zhao, T., et al. (2018). Expanding biological space coverage enhances the prediction of drug adverse effects in human using in vitro activity profiles. Sci Rep, 8(1), 3783.