Research and Simulation of Handover Algorithm in Mobile Communication System

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Abstract. In order to improve the handover rate and quickly handover the target cell, the handover control algorithm of the mobile communication system is explored, and the handover algorithm that combines signal strength and signal quality is researched. At the same time, it is experimentally demonstrated, and the handover user and the new user will be connected. The influence of the entry control threshold setting on the system was compared.

Keywords: Mobile Communication, System-level Dynamic Simulation, Link-level Simulation, Handover Control

1. Introduction
As the third-generation mobile communication international standard mobile communication wireless access technology, with its advanced technology and reasonable cost, it is widely recognized in the field of public mobile communication [1,2]. The expansion of the cluster system is fully in line with the development direction of cluster technology and the development strategy of national interests [3,4]. In order to ensure the continuity of mobile user communication, the handover process as an important part of radio resource management is particularly important [5,6]. In addition, from the consideration of improving system resource utilization and improving communication quality, the optimization of handover algorithms is also more important [7,8]. The communication of the trunking system is a half-duplex one-to-one call, that is, a call between two users. In addition to the half-duplex mode of the communication system, the other features are the same as the call mode of the ordinary mobile communication system, so it's switching. The way is also the same [9,10].

Handover technology is a research hotspot in cellular mobile communications, currently mainly focused on two aspects, network-based and wireless resource management. How to realize fast and seamless handover is one of the research hotspots of the third-generation mobile communication system and the future all-IP mobile communication system. At this stage, there is no special literature to introduce the computer simulation architecture and overall simulation ideas of mobile communication systems. The research on the handover control algorithm of mobile communication systems needs to be verified by the system-level dynamic simulation platform. The first part of this paper gives a brief introduction to the simulation architecture of the mobile communication system, including two simulation platforms at the physical layer link level and the high-level system level, as well as the simulation interfaces between them. The second part conducts theoretical research and
simulation analysis on the decision criteria of the handover control algorithm and the setting of the handover control threshold.

2. Mobile communication system simulation architecture
The simulation of mobile communication system includes link-level simulation and system-level simulation. Link-level simulation is mainly to test the performance of different RTT technical solutions. At present, it basically adopts a time-stream and data-stream-driven approach; the main purpose of system-level simulation is to verify the system-level characteristics based on the results of link-level simulation. Brings spectrum efficiency. Link-level and system-level simulations can be carried out on different system platforms. Interface interaction between the two simulation platforms is in the form of data files. The mathematical model of the interface usually uses methods such as instantaneous values. At present, link-level simulation tools include COSSAP, System View, and Matlab, and system-level simulation tools include OPNET, and Matlab's Simulink and NS (Network Simulator) can also be used.

2.1. Mobile communication link-level simulation
The purpose of link-level simulation is to establish a method and simulation platform that can verify the performance of the 3G radio transmission technology (RTT) link. The modules of the physical layer of the wireless air interface involved are shown in Figure 1.

![Figure 1. The functional modules of wireless transmission technology and their independent relationships](image)

The traditional model of link-level simulation consists of four parts: transmitter module, channel model, receiver module and power control/synchronization control module. The transmitter module generally includes: transmission channel processing and transmitter front-end two parts, and the transmission channel processing sub-module generally includes source generation, CRC plus check, tail bits, wireless frame equalization, channel coding, framing, inter-frame interleaving, Rate matching, transmission channel multiplexing, bit scrambling, physical channel framing, intra-frame interleaving, sub-frame division, physical channel mapping. The transmitter front end includes the following processing procedures: modulation, spreading, scrambling, inserting training sequences and protection chips to form a burst structure, generating channel gain, and so on. The receiver module is actually the reverse processing of the transmitter module, including the receiver front end and the transmission channel reverse processing. The receiver front end generally includes: channel estimation, denoising post-processing, joint detection and other processes; and the transmission channel. The anti-processing part is the inverse process of the transmission channel processing in the reflector module.

2.2. Mobile communication system level simulation
Dynamic system-level simulation is to allow the various behaviors of users and systems to fully fit the process of system-level simulation, so that the main behaviors adopted by users and systems in the real
environment can be embodied in system-level simulation. It mainly includes path loss model, user distribution model, service generation model, user movement model, etc.

(1) Simulation scene

According to the system coverage and geographic location, the simulation scenarios of the 3G system can generally be divided into macro cells (Macro), micro cells (Manhattan Grid) and pico cells (Pico), and their coverage areas decrease successively. For the Macro geographic topology, it is generally recommended to use Wrap Around technology when performing system-level simulation. That is, base stations and mobile stations at the edge of the simulation environment generate interference with at least two circles around the cell by folding. When using omnidirectional antennas In the cell topology structure, the network model considers 19 macro cells, and the cells at the edge of the study area simulate the actual interference levels they experience through the equivalent method of folding.

(2) Simulation fading model

Fading models include path loss models, fast fading models, and slow fading models. Macro simulation scenarios are generally used in urban or suburban environments. In these environments, buildings have similar heights without prominent heights. The path loss between the base station and the mobile station uses the following formula:

\[ L_{u,g_{_\text{BS}}} = 37.61 \log(d) + 15.3(dB) \]  \( (1) \)

Slow decay obeys a lognormal distribution, and its logarithmic value is a Gaussian distribution with zero mean. Since the slow decay is related to the moving distance \(x\), the adjacent slow decay values are correlated. Its normalized autocorrelation function \( R(\Delta x) \) can be expressed by an exponential function:

\[ R(\Delta x) = e^{-\frac{[\Delta x]}{d_{cor}}} \]  \( (2) \)

Among them, \( d_{cor} \) is the irrelevant distance, and its value is related to the environment. The irrelevant distance of the macro cell is 20 meters. In the micro cell and the pico cell indoor environment), the irrelevant distance can be set to 5 meters (not strictly measured yet). This means that in the simulation, the slow decay model of all users is the same. With the autocorrelation function \( R(\Delta x) \), the slow decay process of mobile users can be expressed as:

\[ f_t[dB] = R(\Delta x) f_{t-1}[dB] + X \sqrt{1-(R(\Delta x))^2} \]  \( (3) \)

Where \( ft \) is the slow decay value at time \( t \), \( R(\Delta x) \) is the above slow decay autocorrelation function, and \( X \) is a normally distributed random number with a mean value of \( \mu X \) and a mean square error of \( \sigma X \).

Fast fading is one of the basic characteristics of wireless communication channels. Spread spectrum communication technology enables the receiver to distinguish multipath components, and each component has its own fast fading process. In the simulation, the number of multipaths and the relative strength of each path are set by parameters, but the multipath environment is dependent on the cell base station, especially in the downlink. Therefore, for different base stations, the number of multipaths and the relative strength of each path are set by parameters. The strength of each diameter can be different. The only restriction is that the sum of the relative strength values of all diameters should be 1. In this dynamic system simulation platform, the generated fading process is generated according to the Jakes fast fading model.

(3) User mobile model

At the beginning of the simulation, users are randomly distributed in the cell coverage area; the user's geographic location is updated in each time slot, and the location update is determined by moving speed, moving direction, and whether it is within the boundary of the simulation scene.
order to evaluate the influence of different parameters on the performance of the handover control algorithm, the simulation can be performed based on two mobile models. The first is the mobile model recommended completely according to the UMTS30.03 protocol and the other is the recommended for the UMTS30.03 protocol. The mobile model is carried out in this article, that is, the mobile station will not move out of the serving cell when it is accessed, and the purpose is to study the smoothing effect of different handover parameters on fast and slow fading. In addition, when the mobile station moves out of the simulation scene set by the simulation, it automatically bounces back to the set simulation scene.

(4) Simulation business model
The voice service is a real-time service, and the call generation of the real-time service is a Poisson flow. For voice services, its average call length (Call Length) is set to 120 seconds. The voice service model is an On-Off model, and its active period (Active Period) or inactive period obeys a negative exponential distribution. The average value of active and inactive periods is equal to 3 seconds and is independent of uplink and downlink. The average call length refers to the average duration of a call. The activation period refers to the average length of time the user is in a call during a call, that is, the average time that the call is activated. The static period refers to the average length of time that the call is static during a call, that is, the average time that the system resources will not be occupied at this stage.

2.3. Mobile communication system wireless resource management algorithm module
In mobile communication systems, wireless resource management algorithm modeling is the key to dynamic system-level simulation platform design, which mainly includes: access control, dynamic channel allocation, power control, handover control, load control, etc. These resource management mechanisms will be triggered in different physical entities at different stages of communication: mobile terminal (UE), base station (NodeB) and radio network controller (RNC). The entities implemented by various RRM algorithms are shown in Figure 2.

![Figure 2. RRM algorithm and communication entity](image)

3. Research on handover control algorithm
In the mobile communication system, only the hard handover mechanism is adopted. Due to the time offset between the pilot channel and the service channel, switching decisions based on the pilot channel cannot truly reflect the interference characteristics of the service channel. In addition, in the mobile communication system, the introduction of smart antenna technology increases the airspace, which will have a huge impact on the measurement criteria, handover decision, handover execution and other processes of the traditional hard handover technology, and will have a huge impact on the handover algorithm based on interference measurement. System parameters need to be re-optimized. Smart antennas will increase the complexity of the switching algorithm and the uncertainty and
instability of the switching performance. At this time, the traditional switching control decision mechanism based on single signal strength needs to be improved.

3.1. Handover control decision mechanism

The basic algorithm of hard handover triggers the handover request based on the signal power relative to the handover reserve: only when the average received power value of the neighboring cell n is greater than the sum of the average power value of the current serving cell and the handover redundancy value, and the current UE receives The signal strength of the active set cell is lower than the given threshold before the handover is initiated:

\[
\text{RXLEV}_{DL/UL}(n) > \text{RXLEV}_{DL/UL} + \text{hoMarginLev(n)}/\text{Time(n)}
\]

In the formula, \(\text{RXLEV}_{DL/UL}(n)\) is the measured value of the signal strength of the base station in the candidate set received by the UE, and \(\text{RXLEV}_{DL/UL}\) is the measured value of the signal strength of the current serving base station received by the UE. \(\text{hoMarginLev(n)}/\text{Time(n)}\) represents the switching redundancy value of level and time respectively. The above algorithm is called a traditional handover control decision algorithm based on signal strength. The following introduces a handover control mechanism that combines signal quality and signal strength in this article.

In the above algorithm, the P-CCPCH channel quality is used as the only standard to measure the distance between the UE and the base station and the quality of the received and sent signals. The common channel signal is measured in the TS0 time slot of each subframe, rather than in the business. Measure the traffic channel of the UE under the time slot. The slotted characteristics of TDMA make the measurement results of the above handover algorithm not sufficiently accurate to characterize the signal quality of the UE in the communication timeslot, and cannot characterize the characteristics of different loads and interferences in different timeslots. Therefore, it is necessary to introduce a signal to the traffic channel. Quality measurement (such as measuring BER, or FER, etc.) to improve the accuracy of the handover algorithm and reduce unnecessary handover caused by the deficiencies of the original algorithm.

Use the handover algorithm based on the signal quality of the traffic channel to trigger the handover when the following criteria are established:

\[
\text{RXLEV}_{DL/UL}(n) > \text{RXLEV}_{DL/UL} + \text{hoMarginLev(n)}/\text{Time(n)} \land \text{QualityTraffic}_{DL/UL} > \text{QualityTrafficThreshold}_{DL/UL}
\]

In the formula, \(\text{QualityTrafficThreshold}_{DL/UL}\) is the service channel quality threshold of the UE, which corresponds to the characteristic value of the quality of the service communication. The core principle of the above algorithm is to determine whether the signal quality of the mobile station to be handed over has the wrong frame transmission in the previous handover cycle, and if there is, then the handover is triggered; if not, the UE is judged whether the BLER is lower than the target service threshold of the business, if it is lower than that, no handover will be triggered, otherwise, handover will be triggered.

3.2. Handover control decision mechanism

For mobile communication systems, although smart antenna technology is adopted, the magnitude of its interference will still directly affect the performance of the handover control algorithm. The working principle of the handover control algorithm based on resource reservation is that for newly connected users, if the total number of service users is greater than \(C\), user access will be blocked; for handover users, if the total number of service users is greater than \(N\) at this time, \(\text{And } N>C\), the user is not allowed to access, and the handover user drops the call. The core idea of the above algorithm is to reserve \(N-C\) radio resources for handover users. The resource reservation algorithm can be described by the Markov state transition model as shown in FIG. 3.
It can be seen from the analysis of Figures 4 and 4 that the algorithm in this paper has a certain degree of decline compared with the traditional algorithm UERSCP, but the number of handovers of the algorithm in this paper is significantly reduced. It can be seen that RSCP and the number of handovers are contradictory. Therefore, when studying the handover algorithm, the common gain of the two should be considered, and one party should not be sacrificed to obtain the gain of the other party. Both should be considered and the gain between the two should be weighed.
Figure 5. Comparison of the switching times between the traditional algorithm and the algorithm in this paper

In the simulation, the value of the parameter has a very obvious influence on the simulation result. The simulation in this paper is to take the optimal situation on the basis of multiple simulations, and ignore the influence of fast fading and Doppler frequency shift. In practical applications, the value of the parameter needs to be determined according to the terrain, landform and other conditions, and various factors need to be considered, so more in-depth research is needed.

5. Conclusion

This paper expounds the simulation idea of the mobile communication system and the modeling of the simulation platform, and conducts simulation research on the key technology of handover control. This paper proposes a handover decision algorithm that combines signal quality and signal strength, and analyzes the influence of the access control threshold of the handover user and the new access user on the performance of the handover algorithm. The simulation research results show that for the smart antenna system, in order to make the handover user have a higher priority, in addition to configuring a higher interference access threshold, it is also necessary to reserve a certain amount of wireless resources for the handover user to improve the handover adaptively. And access control algorithm performance.

References

[1] Taira, S, Takeda, O, Otsu, Y, & Katagiri, H. (2015). Comparative study of switching methods for the on-board processor in a mobile satellite communications system. International Journal of Satellite Communications & Networking, 16(3), 131-136.

[2] Lim, H. S, Lee, S. C, Cho, B. H, Pack, J. S, Yang, J. S, & Jung, J. H. (2015). Apparatus and method for removing noise of power amplifier in mobile communication system, 06(8), 12-24.

[3] Yeoum, T. (2016). Method and apparatus for providing voice call in mobile communication system and system thereof, 5(2), 90-92.

[4] Backfrieder, C, & Ostermayer, G. (2015). Analysis of an adaptive switching point for lte tdd by dynamic system-level simulations. International Journal of Electronics & Telecommunications, 61(2), 171-178.

[5] Dat, P. T, Kanno, A, Inagaki, K, Rottenberg, F, Yamamoto, N, & Kawanishi, T. (2019). High-speed and uninterrupted communication for high-speed trains by ultrafast wdm fiber - wireless backhaul system. Journal of Lightwave Technology, 37(1), 205-217.

[6] Wen, Q, Liu, Z, & Chen, Z. (2015). A novel observer-based formation for nonlinear multi-agent systems with time delay and intermittent communication. Nonlinear Dynamics, 79(3), 1651-1664.

[7] Bole, D, Hribar, M. M, & Pipan, P. (2017). Participatory research in community development: a case study of creating cultural tourism products. Acta Universitatis Carolinae. Geographica.
Univerzita Karlova, 52(2), 1-12.

[8] Schenato, L, & Zampieri, S. (2017). On rendezvous control with randomly switching communication graphs. Networks & Heterogeneous Media, 2(4), 627-646.

[9] Y Zou, & Qi, J. (2020). Research on the application of water element in the innovative design of clothing tourism products. Advances in Higher Education, 4(10), 376-384.

[10] Babitch, D. (2016). Reversible radio architecture between transmission and reception functions in a mobile communication system.