Call Blocking Probabilities Reduction of Channel Assignment in Mobile Communication Systems

Mohamed Abdelghader Morsi[1], Dr. Amin Babkir A.Alnabi[2], Dr. Ashraf Gasim Alsid[3]

[1]P.G. Student, Department of Communication Engineering, Engineering College, El. Neelain University and spectrum Engineer at National Telecommunication Corporation (NTC), Planning& Studies& Research Department, Head of Future Trends, Sudan.
[2]Assocaite Professor, Alneelain University, Sudan.
[3]School of Electronic Engineering, College of Engineering, Sudan University of Science & Technology, Sudan.

Abstract— *In wireless mobile communication systems, the radio spectrum is limited resource. However, efficient use of such limited spectrum becomes more important when the two, three or more cells in the network become hot - spot. The use of available channels has been shown to improve the system capacity. The role of channel assignment scheme is to allocate channels to cells in such way as to minimize call-blocking probability or call dropping probability and also maximize the quality of service. Different channel allocation schemes are in use for mobile communication systems, of which the Hybrid channel allocation (HCA) a combination of Fixed and Dynamic channel allocation schemes (FCA and DCA respectively) was effective. In this paper, the performance of three different channel allocation schemes FCA, DCA and HCA will be analytically compared and the results are presented.*

Keywords— HCA, DCA, FCA, call blocking probability, channel allocation, hotspot.

I. INTRODUCTION

Technological advances and rapid development of handheld wireless terminals have facilitated the rapid growth of wireless communications and mobile computing. Taking ergonomic and economic factors into account, and considering the new trend in the telecommunications industry to provide ubiquitous information access, the population of mobile users will continue to grow at a tremendous rate. Another important developing phenomenon is the shift of many applications to multimedia platforms in order to present information more effectively.

The tremendous growth of the wireless/mobile user population, coupled

With the bandwidth Requirements of multimedia applications, requires efficient reuse of the scarce radio spectrum Allocated to wireless/mobile communications. Efficient use of radio spectrum is also important from a cost-of service point of view, where the number of base stations required to service a given geographical area is an important factor. A reduction in the number of base stations, and hence in the cost of service, can be achieved by more efficient reuse of the radio spectrum. The basic prohibiting factor in radio spectrum reuse is interference caused by the environment or other mobiles. Interference can be reduced by deploying efficient radio subsystems and by making use of channel assignment techniques.

In the radio and transmission subsystems, techniques such as deployment of time and space diversity systems, use of low noise filters and efficient equalizers, and deployment of efficient modulation schemes can be used to suppress interference and to extract the desired signal. However, co-channel interference caused by frequency reuse is the most restraining factor on the overall system capacity in the wireless networks, and the main idea behind channel assignment algorithms is to make use of radio propagation path loss characteristics in order to minimize the carrier-to-interference ratio (CIR) and hence increase the radio spectrum re-use efficiency. The focus of this article is to provide an overview of different channel assignment algorithms and compare them in terms of performance, flexibility, and complexity. We first start by giving an overview of the channel assignment problem in a cellular environment and discuss the general idea behind major channel allocation schemes. Then we proceed to discuss different channel allocation schemes within each category .Here we made an simulation comparison of FCA,DCA,HCA in terms of blocking probability versus traffic load.

II. CALL BLOCKING PROBABILITY

Several metrics can be used to evaluate and compare the performance of the proposed algorithm. The call blocking probability is defined as the ratio of the number of new calls initiated by a mobile host which cannot be supported by existing channel arrangement to the total number of new

calls initiated. Call blocking probability (Pb) is given by the ratio of "number of calls lost by the system" to "the total number of new calls initiated".

III. FIXED CHANNEL ASSIGNMENT

In the FCA strategy a set of nominal channels is permanently allocated to each cell for its exclusive use. Here a definite relationship is assumed between each channel and each cell, in accordance to co-channel reuse constraints.

The total number of available channels in the system C is divided into sets, and the minimum number of channel sets N required to serve the entire coverage area is related to the reuse distance 's'.

$N = (1/3)$ ^2, for hexagonal cells.

Here _ is defined as D/Ra, where Ra is the radius of the cell and D is the physical distance between the two cell centers [5]. N can assume only the integer values 3, 4, 7, 9 . . . as generally presented by the series, (i + j) 2 – i, j, with i and j being integers [5, 7].]. Figures 1(a) and 2(b) give the allocation of channel sets to cells for N = 3 (0 = 3) and N = 7 (0 = 4.45), respectively.

In the simple FCA strategy, the same number of nominal channels is allocated to each cell. This uniform channel distribution is efficient if the traffic distribution of the system is also uniform. In that case, the overall average blocking probability of the mobile system is the same as the call blocking probability in a cell. Because traffic in cellular systems can be non uniform with temporal and spatial Fluctuations, a uniform allocation of channels to cells may result in high blocking in some cells, while others might have a sizeable number of spare channels. This could result in poor channel utilization. It is therefore appropriate to tailor the number of channels in a cell to match the load in it by non uniform channel allocation or static borrowing. In non uniform channel allocation the number of nominal channels allocated to each cell depends on the expected traffic profile in that cell.
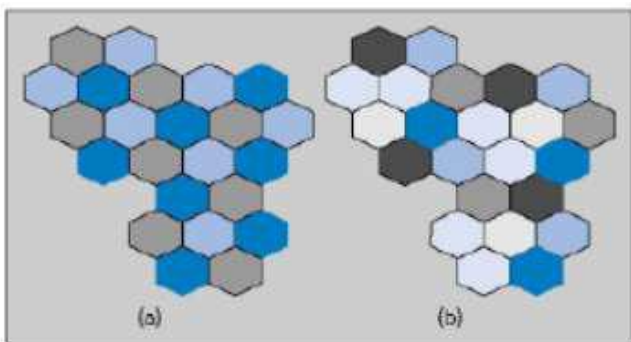

Fig.1: Allocation of channel sets to cells for N =3 and N = 7 respectively

IV. DYNAMIC CHANNEL ASSIGNMENT

Due to short-term temporal and spatial variations of traffic in cellular systems, FCA schemes are not able to attain high channel efficiency. To overcome this, DCA schemes have been studied during the past 20 years. In contrast to FCA, there is no fixed relationship between channels and cells in DCA. All channels are kept in a central pool and are assigned dynamically to radio cells as new calls arrive in the system. After a call is completed, its channel is returned to the central pool.

In DCA, a channel is eligible for use in any cell provided that signal interference constraints are

Satisfied. Because, in general, more than one channel might be available in the central pool to be assigned to a cell that requires a channel, some strategy must be applied to select the assigned channel. Based on information used for channel assignment, DCA strategies could be classified either as call by- call DCA or adaptive DCA schemes. In the call-by-call DCA, the channel assignment is based only on current channel usage conditions in the service area, while in adaptive DCA the channel assignment is adaptively carried out using information on the previous as well as present channel usage conditions.

V. COMPARISON BETWEEN FCA AND DCA

In general, there is a trade-off between quality of service, the implementation complexity of the channel allocation algorithms, and spectrum utilization efficiency. Under low traffic intensity, DCA strategies perform better. However, FCA schemes become superior at high offered traffic, especially in the case of uniform traffic. In the case of non uniform traffic and light to moderate loads, it is believed that the DCA scheme will perform better due to the fact that under low traffic intensity, DCA Uses channels more efficiently than FCA. In the FCA case channels are pre assigned to cells, so there are occasions when, due to fluctuation in traffic, calls are blocked, even though there are channels available in adjacent cells. In addition, a basic fact of telephone traffic engineering is that a server

With capacity C is more efficient than a number of small ones with the same total aggregate capacity. That is, for the same average blocking probability a system with high capacity has higher utilization. FCA schemes behave like a number of small groups of servers, while DCA provides a way of making these small groups of servers behave like a larger server. Then it is observed that in Fig. 2, with low traffic intensity DCA uses channels more efficiently than FCA because of flexible channel assignment and shows good performance. But with high traffic intensity, DCA

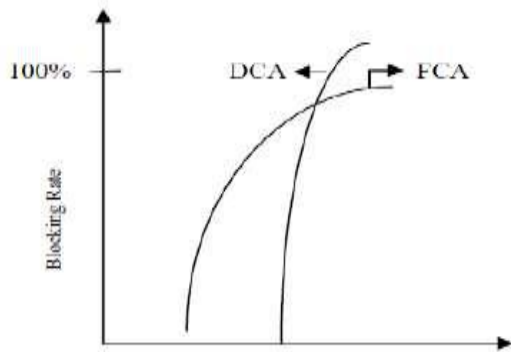does not show better performance Than FCA as stated above.

Fig.2: Traffic intensity and blocking rate.

A summary of the comparison between the fixed channel allocation schemes and dynamic channel allocation schemes is given in table (1):

Table.1: Comparison between the fixed channel allocation schemes and dynamic channel allocation schemes

FCA	DCA
Performs better under heavy traffic.	Performs better under light/moderate traffic.
Low flexibility in channel assignment.	Flexible allocation of channels.
Maximum channel reusability.	Not always Maximum channel reusability.
Sensitive to time and spatial changes.	Insensitive to time and spatial changes.
Not stable grade of service per cell in an interference cell group.	Stable grade of service per cell in an interference cell group.
High forced call termination probability.	Low to moderate forced call termination probability.
Suitable for large cell environment.	Suitable in micro-cellular environment.
Low flexibility.	High Flexibility.
Radio equipment covers all channels assigned to the cell.	Radio equipment covers the temporary channels assigned the cell
Low computational effort	Moderate to high call set up delay
Low call set up delay	No frequency planning
Complex. Labor intensive frequency planning	Moderate to high implementation complexity
Low implementation complexity	Centralized, decentralized. Distributed control depending on the scheme

VI. NON UNIFORM PROBABILITY DISTRIBUTION

6.1. Poisson distribution

Historically, the term process has been used to suggest the observation of a system over time. In our example with the copper wire, we showed that the Poisson distribution could also apply to intervals such as lengths. Figure (2.6) provides graphs of selected Poisson distributions. It is important to use consistent units in the calculation of probabilities, means, and variances involving Poisson random variables. The following example illustrates unit conversions.

For example, if the average number of flaws per millimeter of wire is 3.4, then the average number of flaws in 10 millimeters of wire is 34, and the average number of flaws in 100 millimeters of wire is 340.

If a Poisson random variable represents the number of counts in some interval, the mean of the random variable must equal the expected number of counts in the same length of interval.
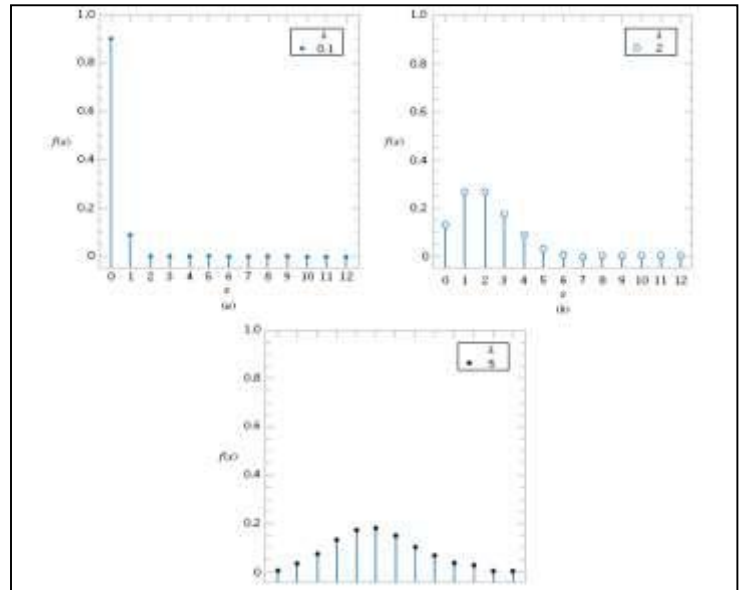

Fig.3: Poisson distribution for selected values of parameters.

VII. HYBRID CHANNEL ASSIGNMENT

Hybrid channel assignment schemes are a mixture of the FCA and DCA techniques. In HCA, the total number of channels available for service is divided into fixed and dynamic sets. The fixed set contains a number of nominal channels that are assigned to cells as in the FCA schemes and, in all cases, are to be preferred for use in their respective cells. The second set of channels is shared by all users in the system to increase flexibility. When a call requires service from a cell and all of its nominal channels are busy, a channel from the dynamic set is assigned to the call. The channel assignment procedure from the dynamic

set follows any of the DCA strategies described in the previous section. Variations of the main HCA schemes include HCA with channel reordering and HCA schemes where calls that cannot find an available channel are queued instead of blocked. The call blocking probability for an HCA scheme is defined as the probability that a call arriving to a cell finds both the fixed and dynamic channels busy.

Performance evaluation results of different HCA schemes have been compared. Theoretical study has done for an HCA scheme with Erlang-b service discipline for uniform size and shape cells where traffic is uniformly distributed over the whole system. The measure of interest is the probability of Blocking as the load increases for different ratios of fixed to dynamic cells. For a system with fixed to dynamic channel ratio 3: 1, the HCA gives a better grade of service than FCA for load increases up to 50 percent. Beyond this load HCA has been found to perform better by case study... A similar pattern of behavior is obtained from the analysis where the HCA scheme employed uses the FA DCA scheme and Erlang-c service discipline (calls that cannot find an available channel are queued instead of blocked). In addition, the HCA scheme with Erlang-c service discipline has lower probability of blocking than the HCA scheme with Erlang-b service discipline. In order to simplify the analysis of HCA we approximate the call blocking probability as a product of random pool as fixed channel allocation blocking probability and non random pool as dynamic channel allocation blocking probability. In comparison with all those channel allocation schemes in terms of call blocking probability HCA performs better results by using hotspot notification and central pool .The main advantage of central pool is that when new call arrives in hotspot cell automatically a channel is assigned to that call from central pool as long as traffic in the cell goes to normal level. Channels in central pools are accessible to hotspot cells. HCA plays a major role to minimize call blocking probability and effects positively on performance of system due to increased tracking capacity. HCA designs to take advantages of both FCA and DCA. An attempt is made to reduce call blocking probability by using hotspot notification.

VIII.   HCA ALGORITHM

It consists of two phases
• Channel acquisition phase
• Channel release phase

8.1 Channel Acquisition Phase

Set level (L = 0) at the beginning to indicate that the channel request can be accommodated from the first group (A) and there is no hot-spot cell in the network.

1. When a mobile host wants to initiate a call, it has to send a channel request on the control channel to its related base station.

2. If the base station has an available channel from first group (A), it will assign a channel to mobile host.

3. If no channel from the first group (A) is available, then base station updates the value of (L) as shown in Fig (4).
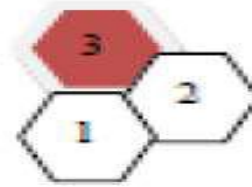

Fig.4: Cell no.3 is hot-spot cell, L=1

$L = L + 1$
$L = 0 + 1 = 1$
$L = max (L, M)$

4. The base station then sends a request to borrow a channel from the central pool located at MSC. It also includes the current value and maximum value of (L).

8.2 Channel Release Phase

1. The MSC, on receiving channel request from the base stations assign up to the (L) channels if available from dynamic pool.

2. When the base station successfully acquires channel from the dynamic pool at MSC, it also adds a channel to its temporary pool (T).

3. When a call terminates on a channel at a mobile host, the base station needs to find out which type of channel the call belonged to.

4. If channel is belonged to dynamic pool at MSC the base station estimates current level of hot-spot (h) in the cell as shown in Fig (5):
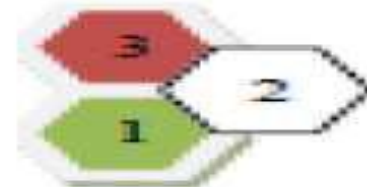

Fig.5: Estimation of current hot-spot level (h), cell no.1 and 3 hot-spot cells, h=2

5. If (h <= L) meaning that the congestion in the cell is same or easing, the base station checks its temporary pool (T) and retains up to (h) channels in random order and all the remaining channels in (T) are returned back to MSC.

6. If (h > L) meaning that the congestion in the cell is getting worse, the channel is retained in the cell. The channel is not returned back to MSC.

7. If MSC is unable to assign even one channel, the call will be blocked.

IX. SIMULATION

9.1 Simulated result of FCA:

$$B = A^2/2 / (1+A+A^2/2) ………… (1)$$

The resultant performance curve in this case plotting the blocking probability' B' versus load
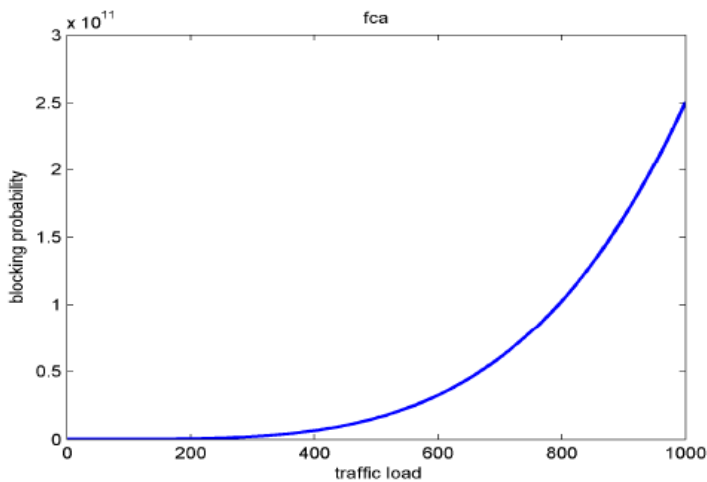
Intensity of traffic by using above formula.

Fig.6: blocking probability Traffic Load of FCA

9.2 Theoretical result of HCA:

The blocking probability (Pb) in HCA is given by as Eq 2:

$$p_b = \frac{\frac{A^N}{N!}}{\sum_{k=0}^{N} \frac{A^k}{k!}}$$

……… (2)

Where A is given by A = l/μ, which is successive call time arrivals. In which, _ is the call arrival rate per second, μ is average call departure rate of users per second, and N is number of channels in the system
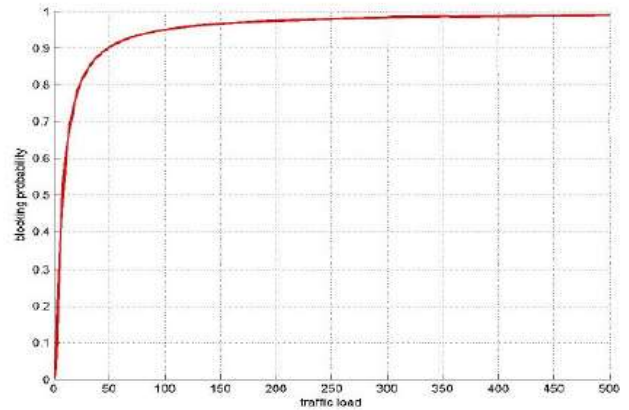

Fig.7: blocking probability traffic load of HCA

9.3 Simulated result of HCA:

The simulation result is shown in **Fig. 7**, HCA simulates with dynamic pool, and MSC does not have fixed number of channels. There is no fixed relationship between channels and cells. It keeps changing randomly within the range (here it is 50). This simulation scenario, for channel allocated from pool due to the lack of channels in the hot-spot has. Therefore, MSC has less channels to lend to other base stations. This indirectly simulates the effect of hot-spot in the Network.
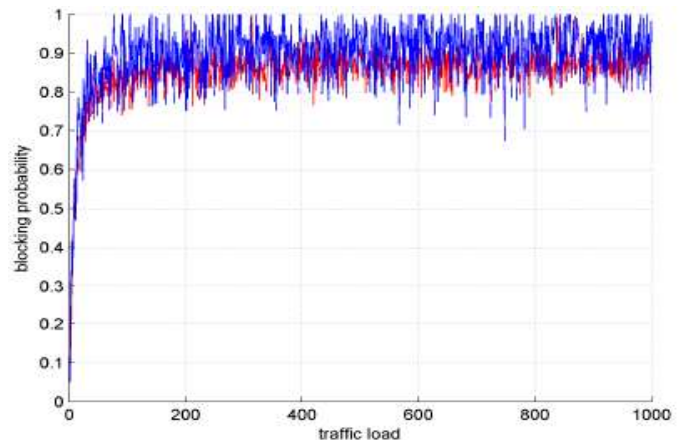

Fig.8: Simulated blocking probability traffic load of HCA.

X. SIMULATION TOOL

In order to evaluate the performance of channel assignment schemes we simulate the FCA, DCA, and HCA in terms of blocking probability versus traffic load by using MATLAB.

XI. CONCLUSION

The Channel Assignment is very important process and the channel Assignment Algorithm mechanism should be related to the traffic types and customer distribution. The HCA has Avery good performance for traffic load less than 200 erlang.

REFERENCES

[1] P.M.PAPAZOGLOU1, 3, D.A.KARRAS2, R.C.PAPADEMETRIOU3, Improved Integral Channel Allocation Algorithms in Cellular Communication Systems Enabling Multimedia Qos Services, **October 2008.**

[2] Kanagasabapathy A A, Franklin A A, Murthy C S R. An adaptive channel recon_guration al-Gorithm for multi-channel multi-radio wireless mesh networks [J]. IEEE transactions on wireless Communications**, 2010,** 9(10): 3064-3071.

[3] Rincy George and Jude Hemanth, Application of an Optimization Algorithm for Channel Assignment in Mobile Communication, **2011.**

[4] P.Ravi and P.Jesu Jayarin, Optimal Channel Allocation Mechanism to Improve the QoS in Wireless Networks, **2012.**

[5] Swati Sonavane1 and Dr. R, and R. Sedamkar2, Improved Channel Assignment Scheme in Cellular Mobile Communication, October **2012.**

[6] Y. Ryu, "A Buffer Management Scheme for Mobile Computers with Hybrid Main Memory and Flash Memory Storages", IJMUE, vol.7, no.2, **(2012)**, pp. 235-240.

[7] Seong-Hoon Lee1and Byung-Tae, an Intelligent Channel Allocation Mechanism, **2013.**

[8] Arafat Abu Mallouh1and Christian Bach2, Dynamic Channel Allocation in Cellular Networks, **2013** Innovative Space of Scientific Research Journals.

[9] G. Arul Dalton, Dr. T. Jeba Rajan, and Dr. K. Siva Sankar, an Optimized Channel Assignment Strategy for Wireless Cellular Networks, **2013.**

[10] Mohamed Abdelghader Morsi1, Ashraf Gasim Elsid Abdalla2, and Mohammed Abaker3, Adaptive Hybrid Channel Assignment (AHCA) Algorithm, **Feb 2015**.

[11] Mohamed Abdelghader Morsi1, Amin Babkir A.Alnabi2 and Asharf Gasim Alsid3, New Adaptive Channel Assignment Scheme for Cellular Network**, April 2015.**

AUTHOR[S] BRIEF INTRODUCTION

Mohamed Abdelghader Morsi is Research in the level of PhD, Faculty Engineering, Alneelain University, Khartoum, Sudan. He received Master of Science (Msc) in Telecommunication Engineering degree in 2010, from Sudan University, Sudan. He Received Bachelor Degree in Electronic Engineering (Computer), from University of Technological Science, Khartoum, Sudan.

Research interests are Mobile & Satellite Networks .He Spectrum Engineer in NTC (National Telecommunication Corporation), Planning & Studies & Research Department, **Head of Future Trends**, Khartoum, Sudan.

Dr.Amin Babkir Associate professor in telecommunication Engineering Also he is Associate Professor, Alneelain University, He got his PhD from Alneelain University and Msc from Khartoum University. He got his B.Sc. in electronic engineering Khartoum University. He is published more than 200 technical papers and supervised more than 150 Ph.D. and Master Students.

Dr.Ashraf Gasim Elsid Abdalla, Associate professor in telecommunication Engineering and researcher in space technology center in future university. Khartoum, Sudan. Also he is academic members of electronic department in college of engineering, Sudan University of science and technology. He was a former lecturer and researcher in many Malaysia Universities; UKM, UPM, UIA and MMU. He got his Ph.D. and M.Sc. from National university of Malaysia 2001 and 1996 in electrical and electronic system. He got his B.Sc. in electronic engineering from technical university of Budapest 1993. His research focus on Mobile and satellite communication. He published more than 100technical papers
And supervised more than 100 Ph.D. and Master Students.

Khalid Qasem Mohamed Alborahy, received the B.Sc degree in Electronic Engineering (major of telecommunications) from Sudan University of Science and Technology (SUST), Khartoum, Sudan, in 2007 and M.Sc. degree in Telecommunication Engineering from Sudan University of Science and Technology, Khartoum, Sudan, In 2010. Currently he is doing his PhD research in telecommunication engineering at the faculty of Engineering, Department of Electrical and Electronic Engineering, University of Khartoum (U of K), Khartoum, Sudan. His research interests are in wireless communications, including mobile broadband, 4G, 5G, heterogeneous networks, channel assignment, handover, integrated wireless networks, and next generation.