UNIT-VII

INTRODUCTION TO FREQUENCY MANAGEMENT

The function of frequency management is to divide the total number of available channels into subsets which can be assigned to each cell either in a fixed fashion or dynamically (i.e., in response to any channel among the available channels). The terms –frequency management‖ and –channel assignment‖ often create some confusion. Frequency management refers to designating setup channels and voice channels (done by the FCC), numbering the channels (done by the FCC), and grouping the voice channels into subsets (done by each system according to its preference).

Channel assignment refers to the allocation of specific channels to cell sites and mobile units. A fixed channel set consisting of one more subsets is assigned to a cell site on a long-term basis. During a call, a particular channel is assigned to a mobile unit on a short- term basis. For a short-term assignment, one channel assignment per call is handled by the mobile telephone switching office (MTSO). Ideally channel assignment should be based on causing the least interference in the system. However, most cellular systems cannot perform this way.

7.1 NUMBERING THE RADIO CHANNELS

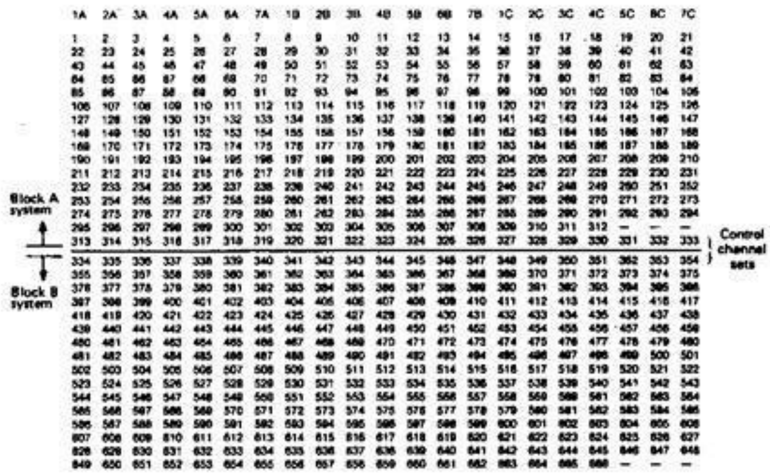
The total number of channels at present (January 1988) is 832. But most mobile units an systems are still operating on 666 channels. Therefore we describe the 666 channel numbering first. A channel consists of two frequency channel bandwidths, one in the low band and one in the high band. Two frequencies in channel 1 are 825.030 MHz (mobile transmit) 870.030 MHz (cell-site transmit). The two frequencies in channel 666 are 844.98 MHz (mobile transmit) and 898 MHz (cell-site transmit). The 666 channels are divided into two groups: block A system and block B system. Each market (i.e., each city) has two systems for a duopoly market policy. Each block has 333 channels, as shown in Fig.1.1.

The 42 set-up channels are assigned as follows.

Channels 313-333	block A
Channels 334-354	block B

The voice channels are assigned as follows.

Channels 1-312 (312 voice channels)	block A
Channels 355-666 (312 voice channels)	block B



	1A	2A	3A	4A	5A	6A	7A	1B	2B	3B	4B	5B	6B	7B	1C	2C	3C	4C	5C	6C	7C	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	
	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	
	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	
	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	
	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	
	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	
	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	
	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	
	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	
	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	
	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	
Block A system	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	
	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	
	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	—	—	—	
	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	Control channel sets
	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	
	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	
Block B system	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	
	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	
	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	
	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	
	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	
	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	
	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	
	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	
	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	
	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	
	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	
	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	
	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	
	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	—	—	—	

Fig.7.1. Frequency management chart

These 42 set-up channels are assigned in the middle of all the assigned channels to facilitate scanning of those channels by frequency synthesizers. In the new additional spectrum allocation of 10 MHz (sec Fig. 1.2.), an additional 166 channels are assigned. Since a 1 MHz is assigned below 825 MHz (or 870 MHz) in the future, additional channels will be numbered up to 849 MHz (or 894 MHz) and will then circle back. The last channel number is 1023. There are no Channels between channels 799 and 991.

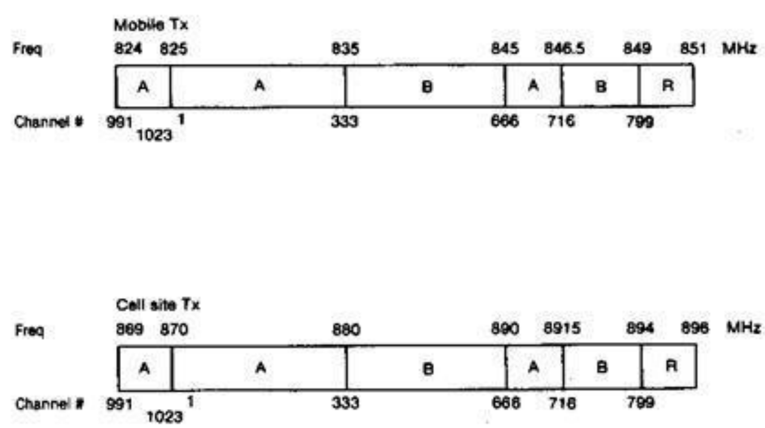


Fig.7.2. New additional spectrum allocation

7.2 GROUPING INTO SUBSETS

The number of voice channels for each system is 312. We can group these into any number of subsets. Since there are 21 set-up channels for each system, it is logical to group the 312 channels into 21 subsets. Each subset then consists of 16 channels. In each set, the closest adjacent channel is 21 channels away, as shown in Fig.1.1. The 16 channels in each subset can be mounted on a frame and connected to a channel combiner. Wide separation between adjacent channels is required for meeting the requirement of minimum isolation. Each 16- channel subset is idealized for each 16-channel combiner. In a seven- cell frequency-reuse cell system each cell contains three subsets, iA+iB+iC, where i is an integer from 1 to 7. The total number of voice channels in a cell is about 45. The minimum separation between three subsets is 7 channels. If six subsets are equipped in an omnicell site, the minimum separation between two adjacent channels can be only three (21/6> 3) physical channel bandwidths.

For example,
1A+1B+1C+4A+4B
+4 C

or 1A+1B+1C+5A+5B+5C

7.3 SET-UP CHANNELS

Set-up channels also called control channels are the channels designated to setup calls. We should not be confused by fact that a call always needs a set-up channel. A system can be operated without set-up channels. If we are choosing such a system all the 333 channels in each cellular system (block A or block B) can be voice channels; however each mobile unit must then scan 333 channels continuously and detect the signaling for its call. A customer who wants to initiate a call must scan all the channels and find an idle (unoccupied) one to use.

In a cellular system, we are implementing frequency-reuse concepts. In this case the set-up channels are acting as control channels. The 21 set-up channels are taken out from the total number of channels. The number 21 is derived from a seven-cell frequency-reuse pattern with three 120◦ sectors per cell, or a total of 21 sectors, which require 21 set-up channels. However, now only a few of the 21 setup channels are being used in each system. Theoretically, when cell size decreases the use of set-up channels should increase. Set-up channels can be classified by usage into two types: access channels and paging channels.

An access channel is used for the mobile-originating calls and paging channels for the land originating calls. For this reason, a set-up channel is sometimes called an ‗access channel' and sometimes called a ‗paging channel.' Every two- way channel contains two 30-kHz bandwidth.. Normally one set-up channel is also specified by two operations as a forward set-up channel (using the upper band) and a reverse set-up channel (using the lower band). In the most common types of cellular systems, one set-up channel is used for both access and paging. The forward set-up channel functions as the paging channel for responding to the mobile-originating calls. The reverse set-up channel functions as the access channel for the responder to the paging call. The forward set-up channel is transmitted at the cell site, and the reverse set-up channel is transmitted at the mobile unit. All set-up channels carry data information only.

7.3.1. Access channels:

In mobile-originating calls, the mobile unit scans its 21 set-up channels and chooses the strongest one. Because each set-up channel is associated with one cell, the strongest set-up channel indicates which cell is to serve the mobile-originating calls. Th. mobile unit detects the system information transmitted from the cell site. Also, the mobile unit monitors the Busy/Idle status bits over the desired forward setup channel. When the idle bits are received, the mobile unit can use the corresponding reverse set-up channel to initiate a call.

Frequently only one system operates in a given city; for instance, block B system might be operating and the mobile unit could be set to –preferable A system.‖ When the mobile unit first scans the 21 set-up channels in block A, two conditions can occur.

1. If no set-up channels of block A are operational, the mobile unit automatically switches to block B.

2. If a strong set-up signal strength is received but no message can be detected, then the scanner chooses the second strongest set-up channel. If the message still cannot be detected, the mobile unit switches to block B and scans to block B set-up channels.

The operational functions are described as follows:

1. Power of a forward set-up channel [or forward control channel (FOCC)]: The power of the set-up channel can be varied in order to control the number of incoming calls served by the cell. The number of mobile-originating calls is limited by the number of voice channels in each cell site, when the traffic is heavy, most voice channels are occupied and the power of the set-up channel should be reduced in order to reduce the coverage of the cell for the incoming calls originating from the mobile unit. This will force the mobile units to originate calls from other cell sites, assuming that all cells are adequately overlapped.

2. The set-up channel received level: The setup channel threshold level is determined in order to control the reception at the reverse control channel (RECC). If the received power level is greater than the given set-up threshold level, the call request will be taken.

3. Change power at the mobile unit: When the mobile unit monitors the strongest signal strength from all Set-up channels and selects that channel to receive the messages, there are three types of message.

a. Mobile station control message. This message is used for paging and consists of one, two, or four words -DCC, MIN, SCC and VMAX.

b. System parameter overhead message. This message contains two words, including DCC, SID, CMAX, or CPA.

c. Control-filler message. This message may be sent with a system parameter overhead message, CMAC—a control mobile attenuation code (seven levels).

4. Direct calls retry. When a cell site has no available voice channels, it can send a direct call-retry message through the set-up channel. The mobile unit will initiate, the call from a neighboring cell which is on the list of neighboring cells in the direct call-retry message.

7.3.2. Paging channels:

Each cell site has been allocated its own setup channel (control channel). The assigned forward set-up channel (FOCC) of each cell site is used to page the mobile unit with the same mobile station control message.

Because the same message is transmitted by the different set-up channels, no simulcast interference occurs in the system. The algorithm for paging & mobile unit can be performed in different ways. The simplest way is to page from all the cell sites. This can occupy a large amount of the traffic load. The other way is to page in an area corresponding to the mobile unit phone number. If there is no answer, the system tries to page in other areas. The drawback is that response time is sometimes too long.

When the mobile unit responds to the page on the reverse set-up channel, the cell site which receives the response checks the signal reception level and makes a decision regarding the voice channel assignment based on least interference in the selected sector or underlay-overlay region.

7.4 FIXED CHANNEL ASSIGNMENT

Adjacent-Channel Assignment:

Adjacent-channel assignment includes neighboring-channel assignment and next-channel assignment. The near-end–far-end (ratio) interference can occur among the neighboring channels (four channels on each side of the desired channel). Therefore, within a cell we have to be sure to assign neighboring channels in an Omni-directional-cell system and in a directional-antenna-cell system properly.

In an Omni-directional-cell system, if one channel is assigned to the middle cell of seven cells, next channels cannot be assigned in the same cell. Also, no next channel (preferably including neighboring channels) should be assigned in the six neighboring sites in the same cell system area (Fig. 7.3a). In a directional-antenna-cell system, if one channel is assigned to a face, next channels cannot be assigned to the same face or to the other two faces in the same cell. Also, next channels cannot be assigned to the other two faces at the same cell site (Fig. 7.3b). Sometimes the next channels are assigned in the next sector of the same cell in order to increase capacity. Then performance can still be in the tolerance range if the design is proper.

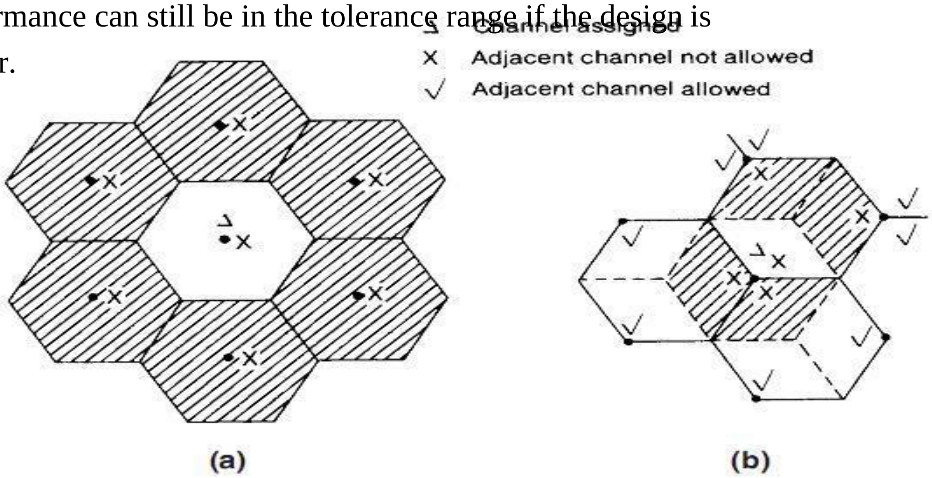


Fig.7.3 Adjacent channel assignment (a) Omni direction antenna cells; (b) Directional antenna cells

7.5 CHANNEL SHARING

Channel sharing is a short-term traffic-relief scheme. A scheme used for a seven-cell three-face system is shown in Fig. 7.2. There are 21 channel sets, with each set consisting of about 16 channels. Figure7.2 shows the channel set numbers. When a cell needs more channels, the channels of another face at the same cell site can be shared to handle the short-term overload. To obey the adjacent-channel assignment algorithm, the sharing is always cyclic. Sharing always increases the trunking efficiency of channels.

Since we cannot allow adjacent channels to share with the nominal channels in the same cell, channel sets 4 and 5 cannot both be shared with channel sets 12 and 18, a indicated by the grid mark. Many grid marks are indicated in Fig.7.2 for the same reason. However, the upper subset of set 4 can be shared with the lower subset of set 5 with no interference. In channel-sharing systems, the channel combiner should be flexible in order to combine up to 32 channels in one face in real time. An alternative method is to install a standby antenna.

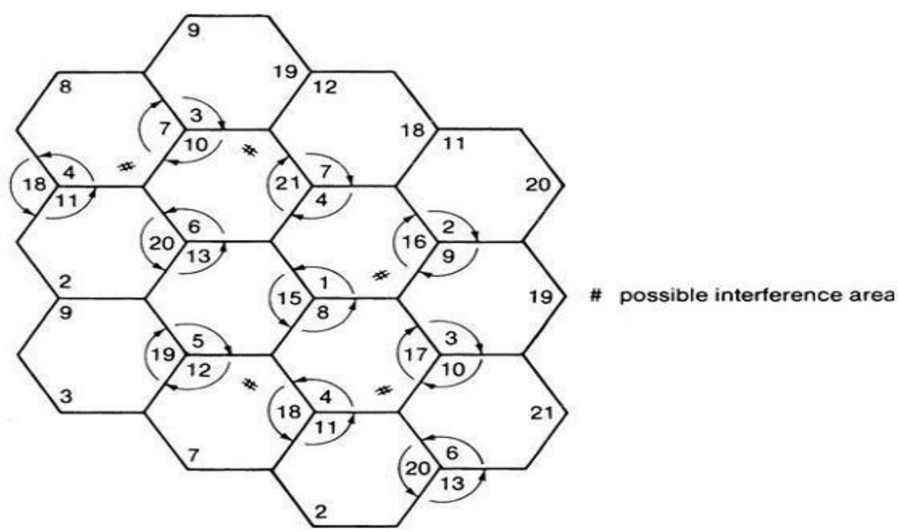


Fig.7.4. Channel sharing algorithm

7.6 CHANNEL BORROWING

Channel borrowing is usually handled on a long-term basis. The extent of borrowing more available channels from other cells depends on the traffic density in the area. Channel borrowing can be implemented from one cell-site face to another face at the same cell site. In addition, the central cell site can borrow channels from neighboring cells. The channel-borrowing scheme is used primarily for slowly-growing systems. It is often helpful in delaying cell splitting in peak traffic areas. Since cell splitting is costly, it should be implemented only as a last resort.

Advantage of Sectorization:

The total number of available channels can be divided into sets (subgroups) depending on the Sectorization of the cell configuration: the 120◦-sector system, the 60◦-sector system, and the 45◦-sector system. In certain locations and special situations, the sector angle can be reduced (narrowed) in order to assign more channels in one sector without increasing neighboring-channel interference. Sectorization serves the same purpose as the channel-borrowing scheme in delaying cell splitting. In addition, channel coordination to avoid co-channel interference is much easier in sectorization than in cell splitting. Given the same number of channels, trunking efficiency decreases in Sectorization.

Sectorized Cells: There are three basic types.

1. The 120◦-sector cell is used for both transmitting and receiving Sectorization. Each sector has an assigned a number of frequencies. Changing sectors during a call requires handoffs.

2. The 60◦-sector cell is used for both transmitting and receiving Sectorization. Changing sectors during a call requires handoffs. More handoffs are expected for a 60◦ sector than a 120◦ sector in areas close to cell sites (close-in areas).

3. The 120◦ or 60◦-sector cell is used for receiving Sectorization only. In this case, the transmitting antenna is Omni directional. The number of channels in this cell is not sub- divided for each sector. Therefore, no handoffs are required when changing sectors. This receiving-Sectorization-only configuration does not decrease interference or increase the D/R ratio; it only allows for a more accurate decision regarding handing off the calls to neighboring cells.

7.7 UNDERLAY-OVERLAY ARRANGEMENT

In actual cellular systems cell grids are seldom uniform because of varying traffic conditions in different areas and cell-site locations.

Overlaid Cells: To permit the two groups to reuse the channels in two different cell-reuse patterns of the same size, an ―under laid‖ small cell is sometimes established at the same cell site as the large cell (see Fig. 7.5a). The ―doughnut‖ (large) and ―hole‖ (small) cells are treated as two different cells. They are usually considered as ―neighboring cells.‖

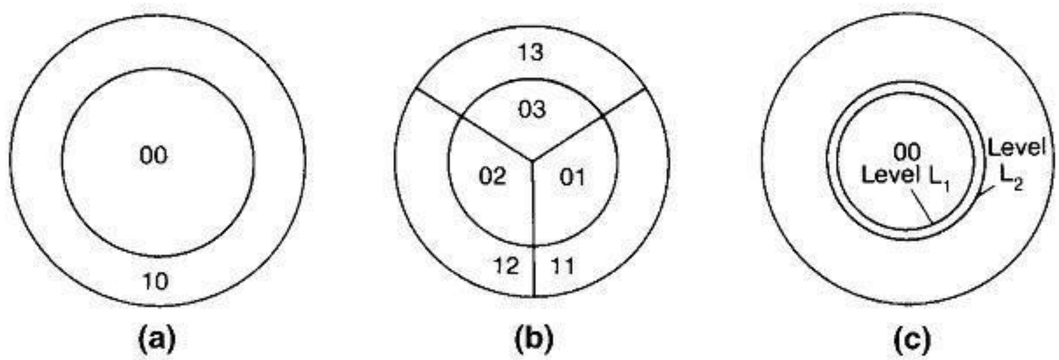


Fig.7.5. Under laid-overlaid cell arrangements. (a) Underlay-overlay in omnicell; (b) Underlay-overlay in Sectorized cell; (c) Two level handoff scheme

The use of either an Omni directional antenna at one site to create two sub ring areas or three directional antennas to create six subareas is illustrated in Fig. 7.5 b. As seen in Fig.7.5, a set of frequencies used in an overlay area will differ from a set of frequencies used in an underlay area in order to avoid adjacent-channel and co-channel interference.

The channels assigned to one combiner—say, 16 channels—can be used for overlay, and another combiner can be used for underlay.

Implementation:

The antenna of a set-up channel is usually Omni directional. When an incoming call is received by the set-up channel and its signal strength is higher than a level L, the under laid cell is assigned; otherwise, the overlaid cell is assigned. The handoffs are implemented between the under laid and overlaid cells. In order to avoid the unnecessary handoffs, we may choose two levels L1 and L2 and L1 > L2 as shown in Fig. 7.5 (c). When a mobile signal is higher than a level L1 the call is handed off to the under laid cell. When a signal is lower than a level L2 the call is handed off to the overlaid cell. The channels assigned in the under laid cell have more protection against co-channel interference.

7.8 NON FIXED CHANNEL ASSIGNMENT STRATEGY

1. Fixed Channel Assignment: The fixed channel assignment (FCA) algorithm is the most common algorithm adopted in many cellular systems. In this algorithm, each cell assigns its own radio channels to the vehicles within its cell.

2. Dynamic Channel Assignment: In dynamic channel assignment (DCA), no fixed channels are assigned to each cell. Therefore, any channel in a composite of N radio channels can be assigned to the mobile unit. This means that a channel is assigned directly to a mobile unit. On the basis of overall system performance, DCA can also be used during a call.

3. Hybrid Channel Assignment: Hybrid channel assignment (HCA) is a combination of FCA and DCA. A portion of the total frequency channels will use FCA and the rest will use DCA.

4. Borrowing Channel Assignment: Borrowing channel assignment (BCA) uses FCA as a normal assignment condition. When all the fixed channels are occupied, then the cell borrows channels from the neighboring cells.

5. Forcible-Borrowing Channel Assignment: In forcible-borrowing channel assignment (FBCA), if a channel is in operation and the situation warrants it, channels must be borrowed from the neighboring cells and at the same time, another voice channel will be assigned to continue the call in the neighboring cell. There are many different ways of implementing FBCA. In a general sense, FBCA can also be applied while accounting for the forcible borrowing of the channels within a fixed channel set to reduce the chance of co-channel assignment in a reuse cell pattern. The FBCA algorithms based on assigning a channel dynamically but obeying the rule of reuse distance.

The distance between the two cells is reuse distance, which is the minimum distance at which no co-channel interference would occur. Very infrequently, no channel can be borrowed in the neighboring cells. Even those channels currently in operation can be forcibly borrowed and will be replaced by a new channel in the neighboring cell or the neighboring cell of the neighboring cell. If all the channels in the neighboring cells cannot be borrowed because of interference problems, the FBCA stops.