Cell Partitioning, Splitting and Sectorization

Partitioning

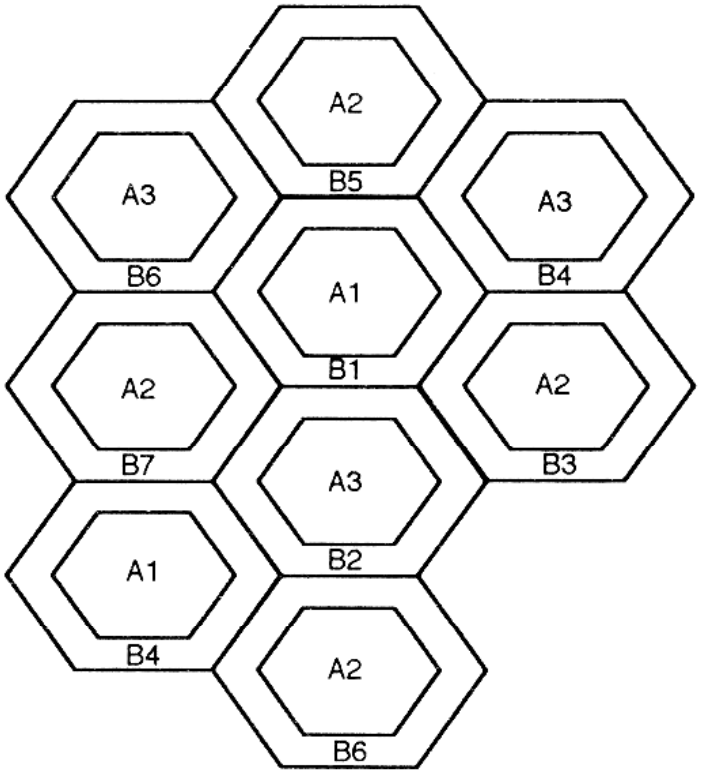
Partitioning uses two different D/R ratios

System capacity is increased over single reuse cluster size

It degrades C/I for users closer to a cell site

Without partitioning

$(C/I)_i \geq (C/I)_o$



Partitioning

A mobile with high C/I (inner cell user) is assigned a channel frequency from the lower reuse cluster size

A mobile with low C/I (outer cell user) is assigned a channel frequency from the higher reuse cluster size

Partitioning Example

Ex. Total 90 channels with N=3

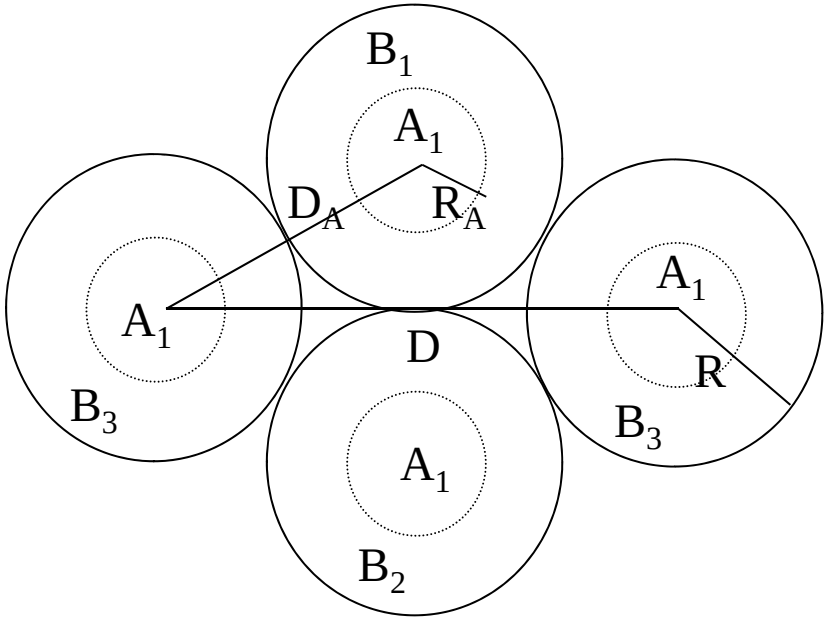
w/o partitioning: 30 ch/cell

with partitioning :

9 + (81/3) = 36 ch/cell

9 ch for inner cell with N_A=1

81ch for outer cell with N_B=3



Inner cell/Outer cell

$$\left(\frac{C}{I}\right)_A = \frac{1}{6}\left(\frac{D_A}{R_A}-1\right)^4 = \frac{1}{6}\left(\frac{R\sqrt{3N_A}}{R_A}-1\right)^4 \qquad \frac{D_A}{R} = \sqrt{3N_A}$$

To have $(C/I)_A \cong (C/I)_B$,

compute N_A with given R_A or compute R_A with given N_A

From R_A/R, obtain fraction of channels assigned to inner cell

$p = (R_A/R)^2$: under uniformly distributed users

$C_{cell} = C_A + C_B$, $p = C_A/(C_A + C_B)$

$C_{Tot} = C_A N_A + C_B N_B$

Partitioning

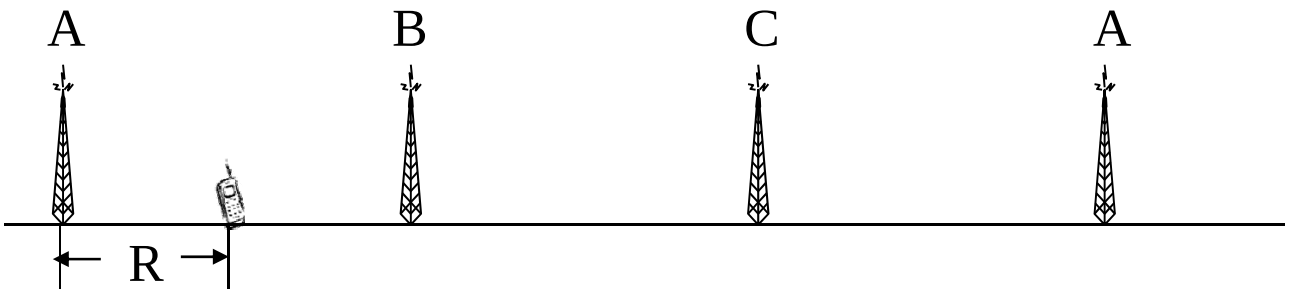
Partitioning requires no hardware cost, software operated

- If one approaches outer cell from inner cell,
  - C/I ↓ change to outer channel
- If one approaches inner cell from outer cell,
  - C/I ↑ use the same channel or change to inner channel

One-shot implementation (limited capacity increase), not a long-term solution

Cell Splitting

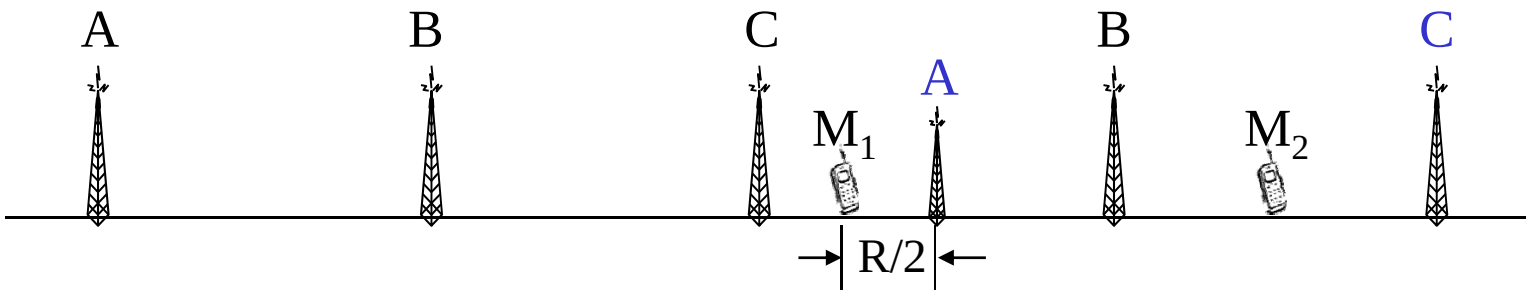
Cell splitting is adapted over time/space for increased traffic density



$$\frac{C}{I} = \left(\frac{D_I}{D_S}\right)^4 = \left(\frac{5R}{R}\right)^4 = 5^4$$ without splitting

Mixed cell system

large cell + small cell due to traffic density



M_1 in the smaller cell A, in general, has better C/I

$C/I = \{(9R/2)/(R/2)\}^4 = 9^4 > 5^4$

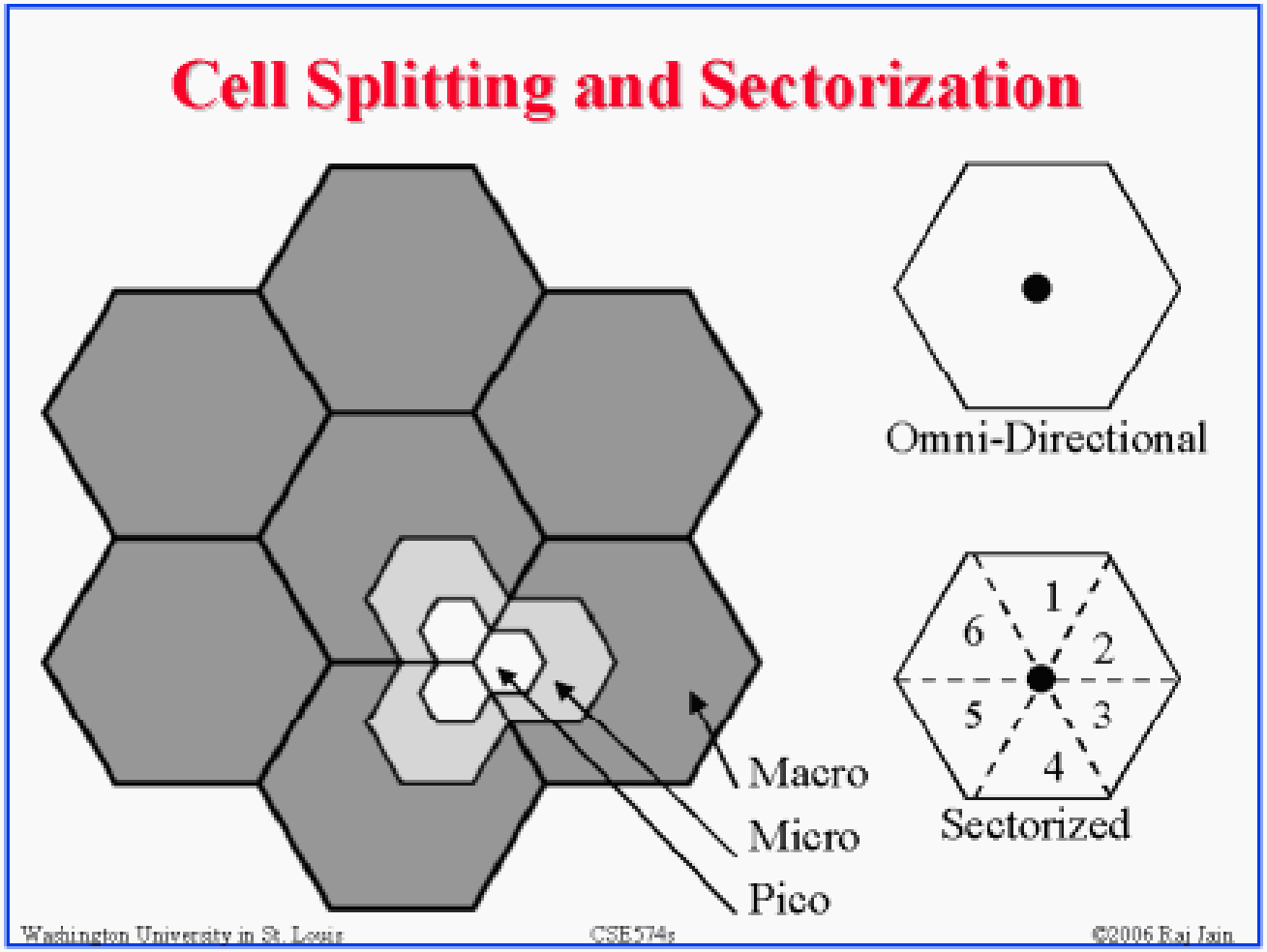
M_1 tx in low power

M_2 in the larger cell C has worse C/I

$C/I = (3R/R)^4 = 3^4 < 5^4$

M_2 tx in high power

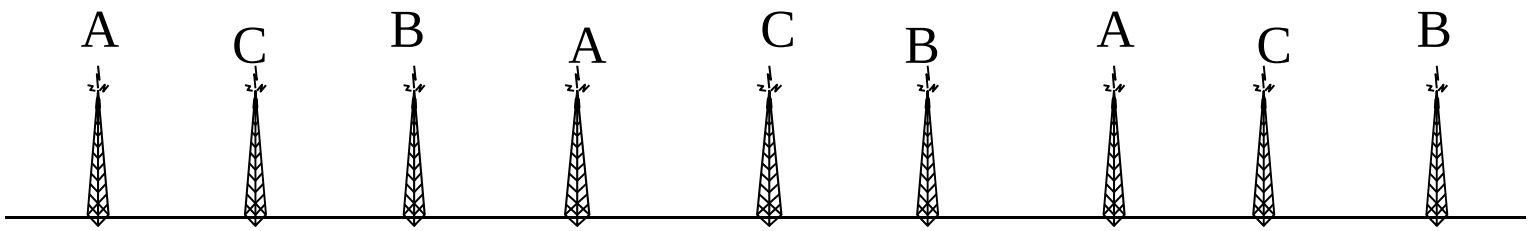
Mixed cell system



Cell Splitting

If every cell is split in the same way, the C/I is the same as in the initial system

i.e., R reduced and D/R unchanged



Splitting again and again increases capacity more and more

Splitting is not one-shot, it requires BS cost

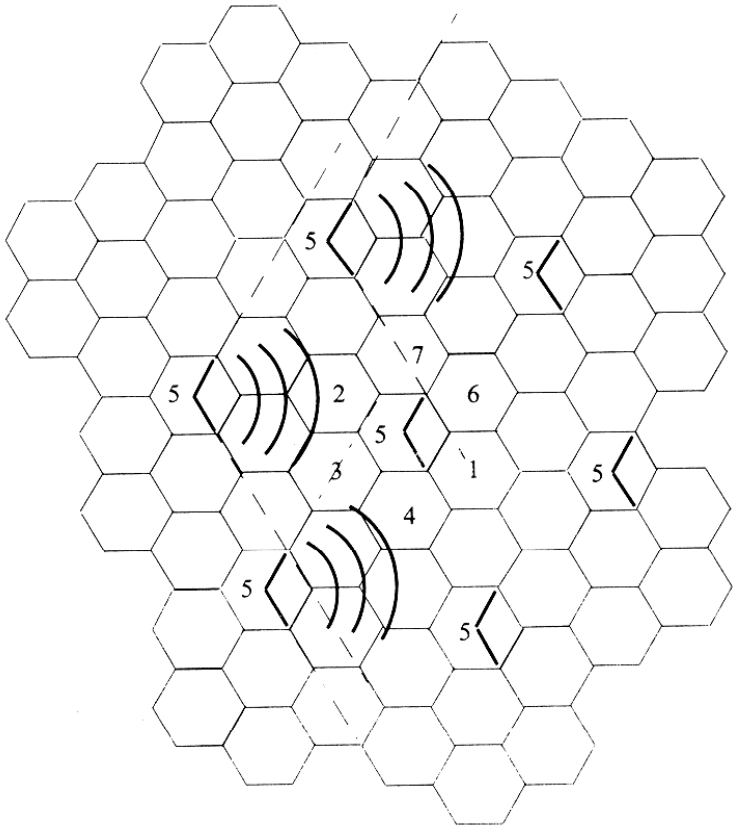
Sectorization

Splitting

- Decreases cell radius R while keeping D/R unchanged
- Increases the capacity

Sectorization

- Keeps the cell radius R unchanged
- Increases the capacity by reducing the relative interference
- Increased SIR
- -> Reduced cluster size N
- -> Increased capacity



Sectorization

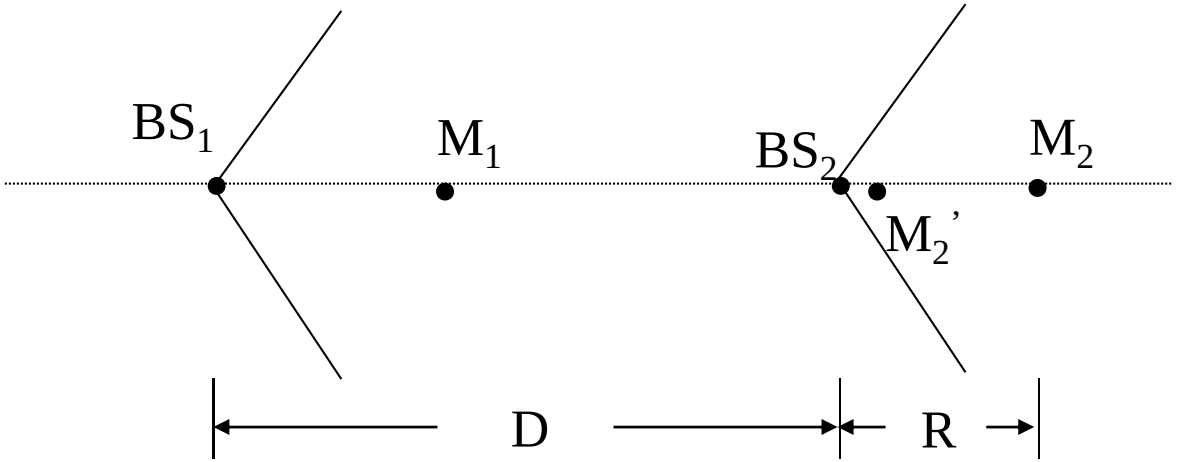
Co-channel interference is decreased by replacing a single omni-directional antenna by directional antennas

$$\left(\frac{C}{I}\right)_{omni} = \frac{1}{6}\left(\sqrt{3N} - 1\right)^4$$

$$\left(\frac{C}{I}\right)_{120^\circ} = \frac{1}{2}\left(\sqrt{3N} - 1\right)^4$$

The worst case interference is further away with proper power control

Sectorization



	Rx	Tx	Interference	C/I
Forward ch	M_2	BS_2	BS_1	$\{(D+R)/R\}^4=\{(D/R)+1\}^4=\{\sqrt{3N}+1\}^4$
Reverse ch w/o power control	BS_1	M_1	M_2'	$(D/R)^4=(\sqrt{3N})^4$
Reverse ch w. power control	BS_1	M_1	M_2	$\{(D+R)/R\}^4=\{\sqrt{3N}+1\}^4$

Sectorization

In AMPS

- N=12 without sectorizing
- N=7 with 120^o sectorizing
- N=4 with 60^o sectorizing

Why not < 60^o sectorizing?

- Decreases trunking efficiency
- Energy spills over adjacent sectors
- Ping-pong effect of handoff

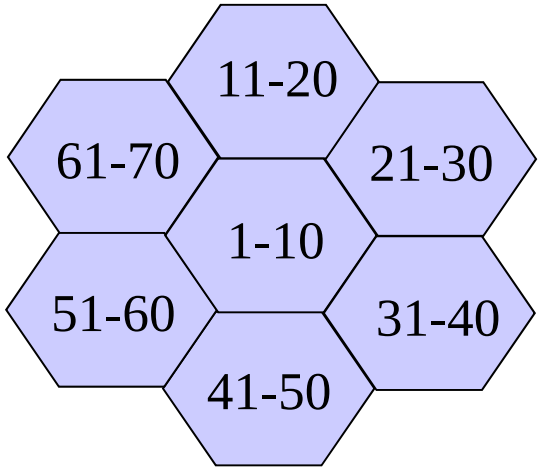
Channel Assignment

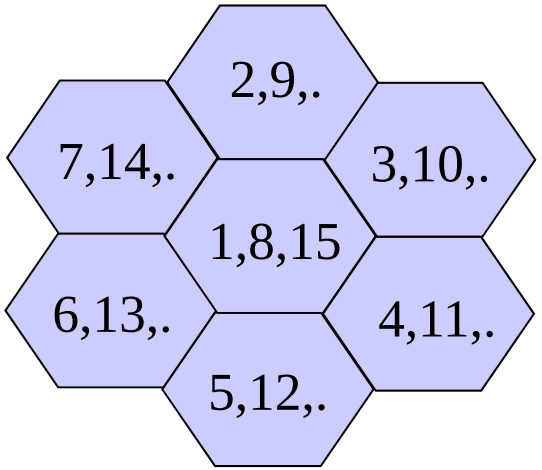
Objectives: increase the capacity

minimize the interference

Fixed Assignment

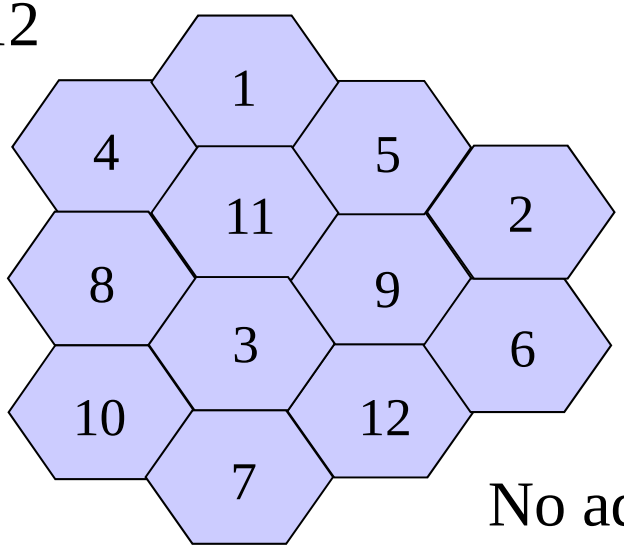
- Utilize reuse pattern *N* (i.e. *i* and *j*) to minimize the co-channel interference
- Keep the adjacent channel as far as possible
  - Ex. 70 channels with *N*=7





Channel Assignment

with N=12

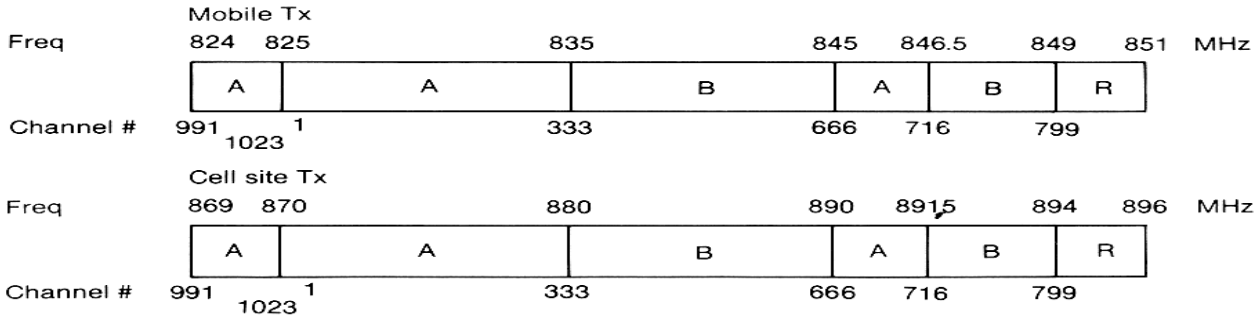


No adjacent channel interference

Need to consider competitors

A/B Carriers

Possible adjacent channel interference, if used in the same location



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
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
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
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	569	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	—	—	—

Block A system

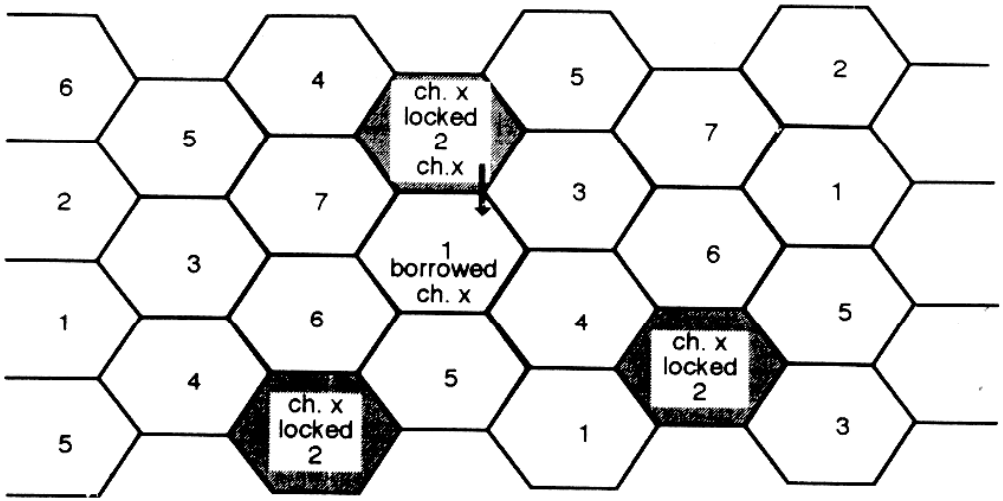
Block B system

Control channel sets

Borrowing channel/Dynamic Assignment

A channel is borrowed from one cell having the max available channel

For the duration that the borrowed channel is used, the channel is locked in the three co-channel cells



Borrowing channel/Dynamic Assignment

Three different time scales to consider

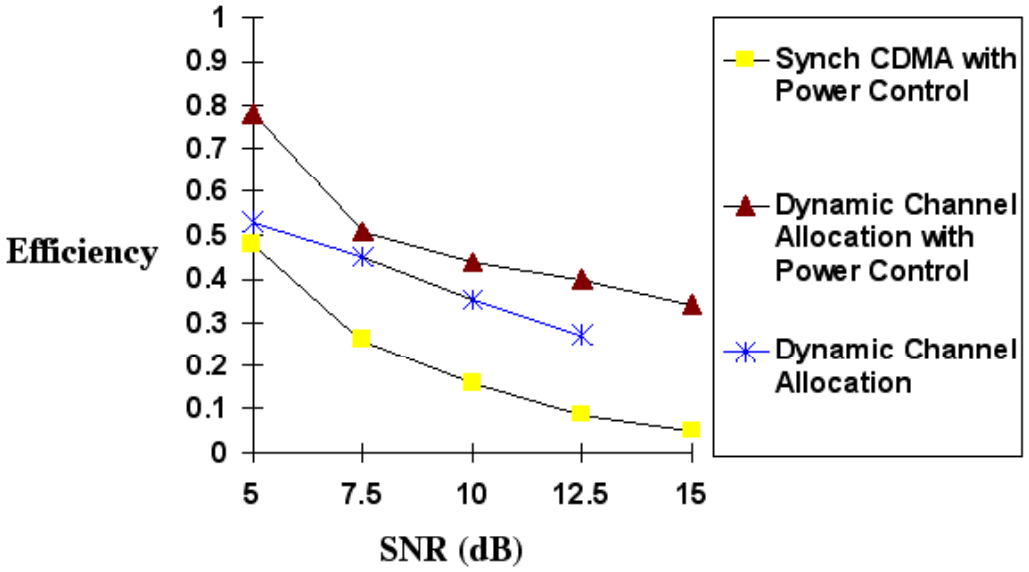
- Weeks
- Hours
- Seconds

Allocation Algorithms

1. Divide channels into two groups
   - Group I: reserved for basic capacity by fixed Assignment
   - Group II: strategic reservation for dynamic Assignment
2. Allocate all channels uniformly, then borrow
   - Not efficient when traffic is not locally centered to one cell

Channel Assignment

Spectrum Efficiency



Source: G. J. Pottie, *IEEE Personal Communications*, pp. 50-67, October 1995

Efficiency: IS-136 0.04; IS-95 0.07; GSM 0.04