

R1-060905



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Adaptive Fractional Frequency Reuse

3GPP TSG-RAN Working Group 1 Meeting #44bis

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NORTEL



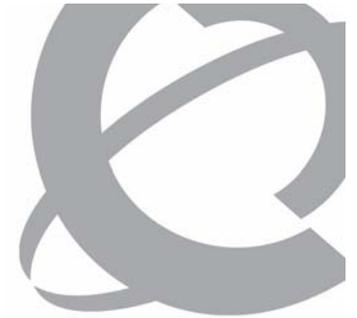
Introduction and Background

> Options for fractional frequency reuse (FFR) based inter-cell interference control:

- Option-1
 - Hard frequency reuse - define interference avoidance channel
 - when a sub-channel is assigned to a sector, the corresponding sub-channel belongs to the adjacent sectors should be muted to ensure such that sub-channel has not other cell interference
 - The number of interference avoidance channels can be configurable
 - Does not require additional feedback from UE. Same reuse pattern applies to all users
- Option-2
 - Soft frequency reuse
 - when a sub-channel is assigned to a sector, the corresponding sub-channel belongs to the adjacent sectors, reduce the transmit power level on this sub-channel
 - Reuse factor and pattern are fixed
 - Requires frequency planning
 - Allocated frequency set is based on the mobile's active set
 - may not require additional feedback

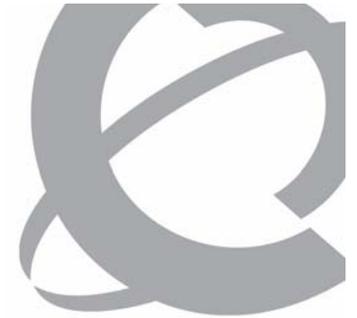
> Proposed Solution:

- Soft frequency reuse
- Reuse factor and pattern are adaptive
- Can be implemented with or without frequency planning
- Does not require any additional feedback from UE
- Can leverage existing active set information if frequency set used between sectors are overlapped.



Overview of Proposed Solution

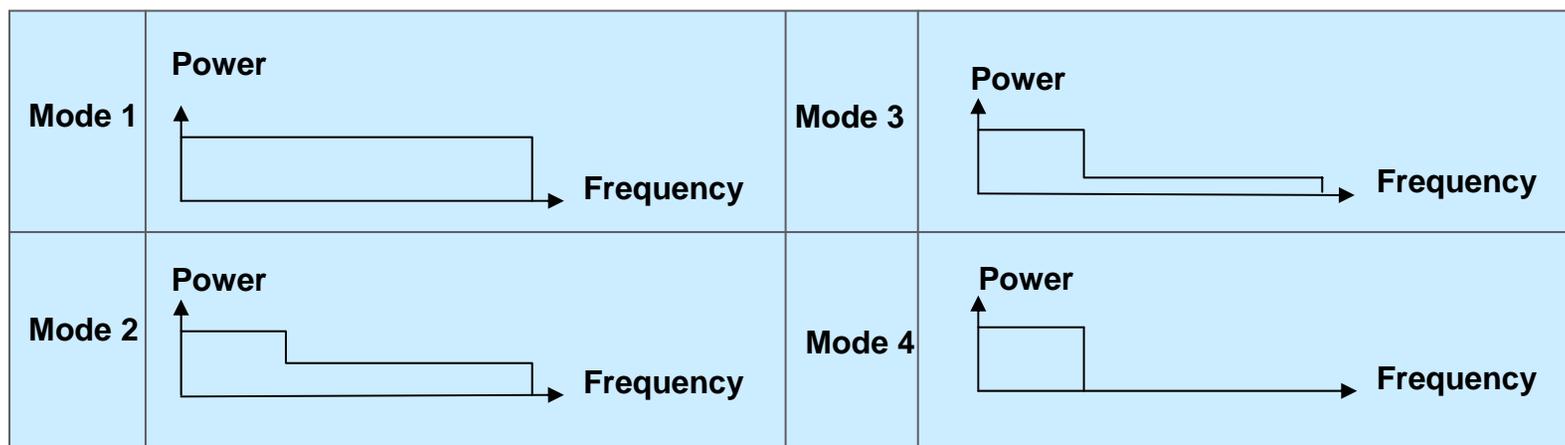
- > In the proposed fractional frequency reuse (FFR) scheme, the reuse factor is adaptive. Each Node-B begins with a reuse factor of one, where all of the sub-carriers are used with full power, and only increases the reuse factor if a coverage problem is detected by the Node-B or by its neighbors. In this scheme, throughput can be maximized.
- > In existing FFR solutions, the reuse factor is fixed. There will always be some impact on throughput even when there are no coverage problems.
- > The proposed scheme can be implemented with or without frequency planning. The frequency planning can be a simple scheme where the planning only depends on the FFR mode and the sector ID.



Adaptive Fractional Frequency Reuse

Definition

- > There are a fixed number of modes for AFFR:
 - Mode 1 is reuse 1
 - Mode 2 is soft reuse 2
 - Sub-carriers are divided into high power tones and low power, 1/3 of the sub-carriers are full power, the other sub-carriers have half the power
 - Mode 3 is soft reuse 3
 - Sub-carriers are divided into high power and low power, only 1/3 of the sub-carriers are full power, the other sub-carriers are 1/4 the power.
 - Mode 4 is reuse 3
 - full power on 1/3 of the sub-carriers, the other sub-carriers are not used
- > In modes 2 and 3, the DVRB (distributed sub-channel) and LVRB (localized sub-channel) channels are assigned either high power or low power.



Adaptive Fractional Frequency Reuse

Operation-1



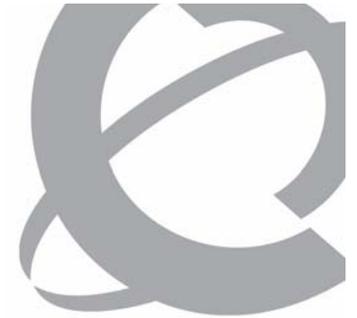
- > **Step-1:** Each Node-B begins in Mode 1 and keeps track of coverage request through the UE CQI feedback.
- > **Step-2:** If the Node-B detects a request (for example the number of users at the cell edge with data to transmit/receive exceeds a certain threshold) then the Node-B begins to use Mode 2 and sends a message to the members of its pre-configured neighbour list to use at least Mode 2.
- > **Step-3:** If a neighbour is already using Mode 2 or higher no further action is necessary. Each Node-B keeps track of which Node-B made the request and the requested mode of operation.
- > **Step-4:** When a Node-B changes to a different mode, it sends a broadcast message to inform the mobiles of the new mode. It also sends an acknowledgement to the requesting Node-B and propagates the new mode information to its list of neighbours.

Adaptive Fractional Frequency Reuse

Operation-2



- > **Step-2a:** If a Node-B in Mode 2 or higher detects that there is no longer a coverage problem (e.g. the UE's CQI is higher than necessary for operating in the higher mode), the Node-B sends a message to the neighbours in its neighbour list indicating its preferred mode of operation.
- > **Step-3a:** A Node-B can go down to a lower level only if all the mode requests from its neighbors are at that level or lower.
- > Each mode gradually increases coverage and therefore the impact on throughput is minimized.
- > For soft reuse modes, the low power sub-carriers can be scheduled for users at or close to the cell centre. The high power sub-carriers can be scheduled for either cell edge or cell centre users.



Adaptive FFR Example

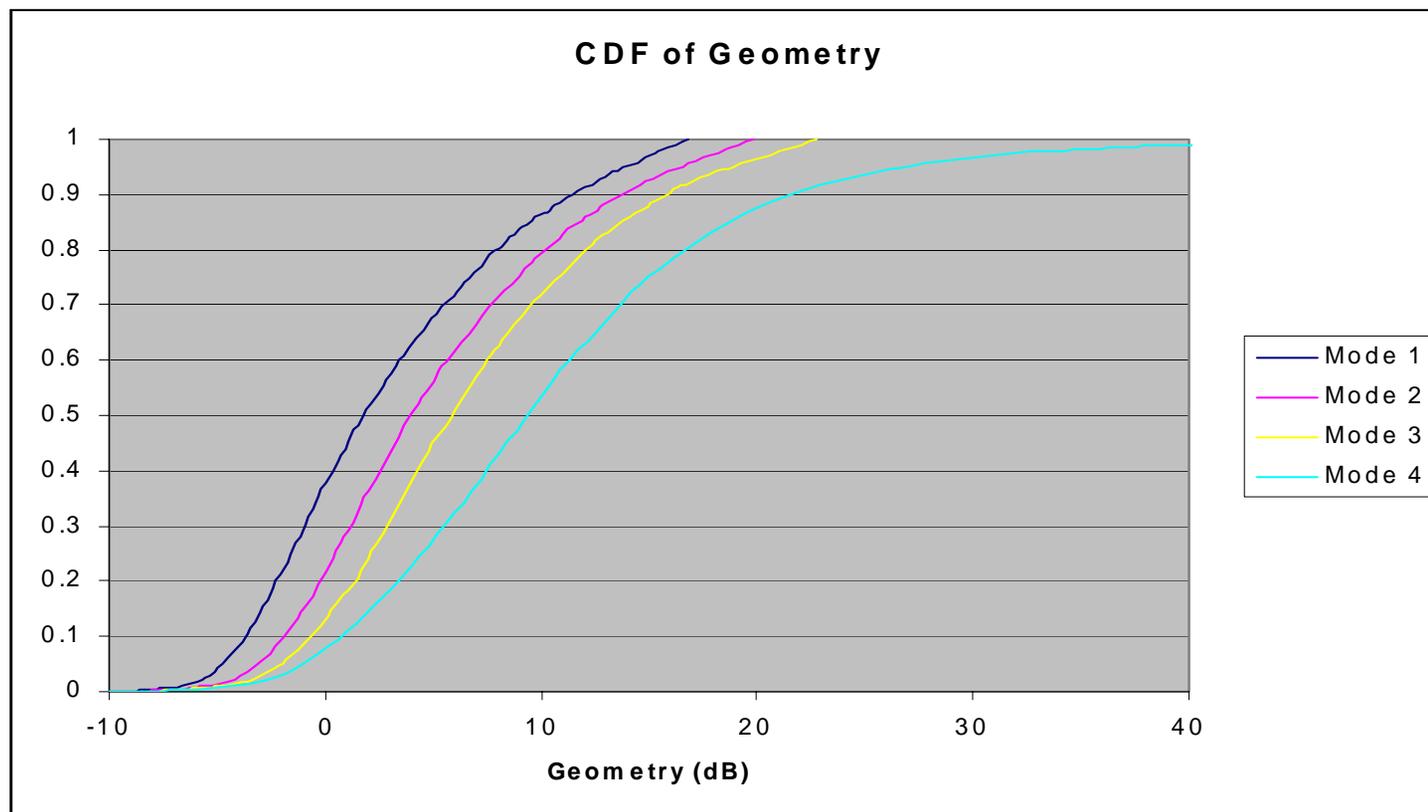
- > Each Node-B keeps track of the mode requests from the neighbours in its pre-configured neighbour list. For example, Node-B# A has 4 neighbours, the table below shows the operating mode after each mode request from a neighbouring Node-B.

Neighbor	Mode at time t_0	Mode at time t_1	Mode at time t_2	Mode at time t_3	Mode at time t_4
1	1	1	1	1	1
2	1	2	2	1	1
3	1	1	2	2	1
4	1	1	1	1	1
Node-B #A	1	2	2	2	1



AFFR Impacts on Geometry

> The coverage gain for the given frequency reuse modes is illustrated below

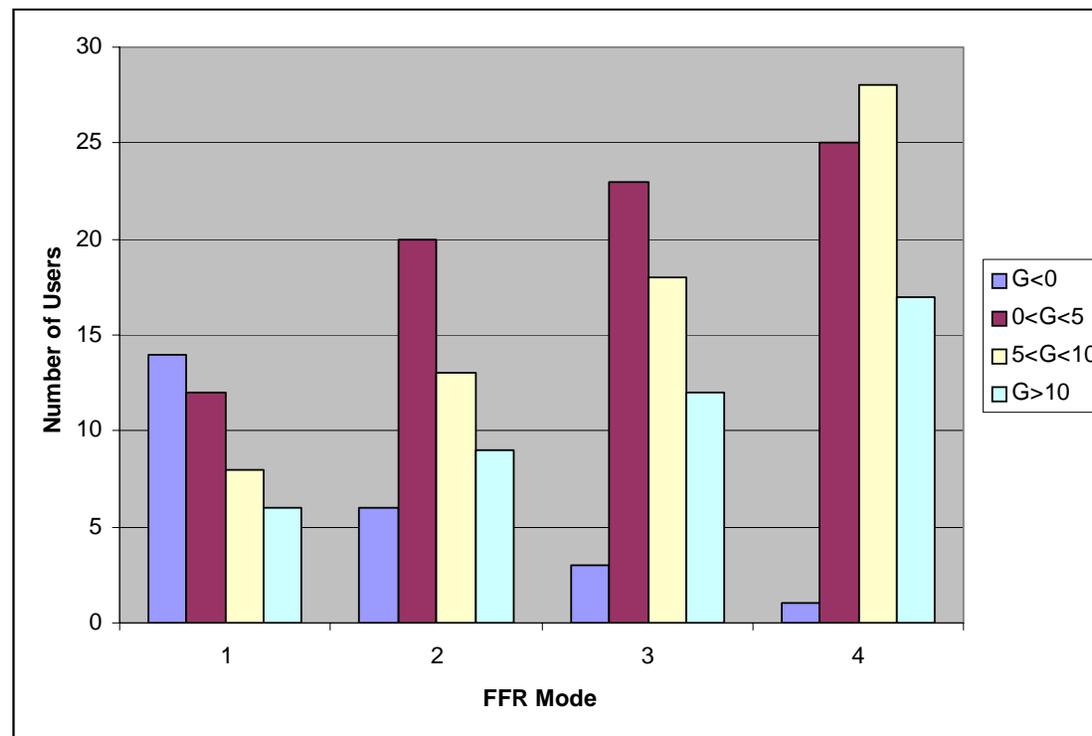


AFFR Impacts on User Geometry Improvement



- > The coverage gain for 40 users randomly dropped in a sector is illustrated below. The users are grouped into zones based on their geometry. When the FFR operating mode increases to a higher level, the number of users with geometry less than zero decreases.

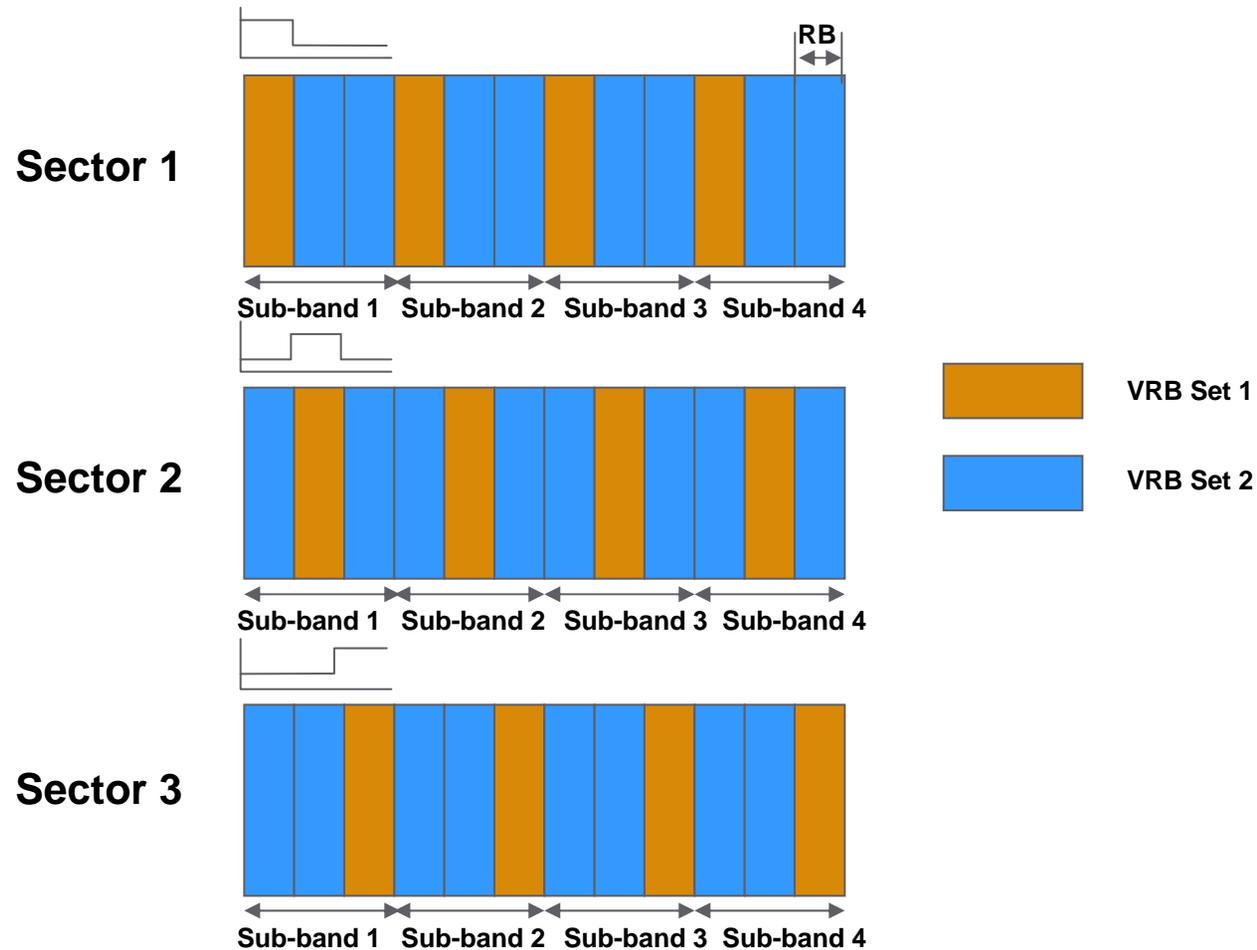
Distribution of User Geometry

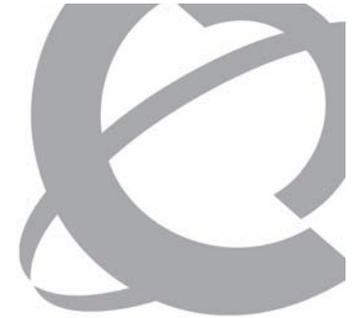


AFFR and Channelization Mapping –(1)



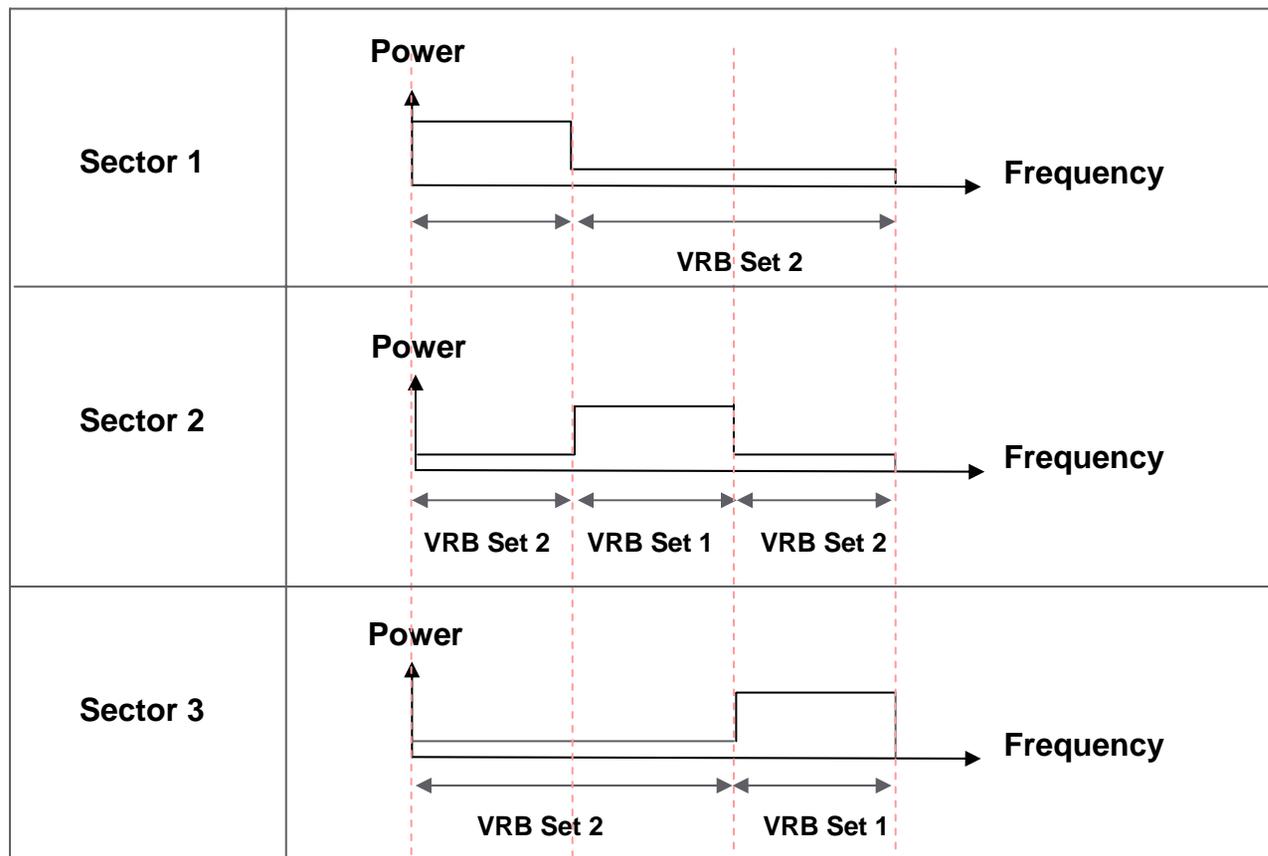
Example of LVRB Channelization for Mode 3



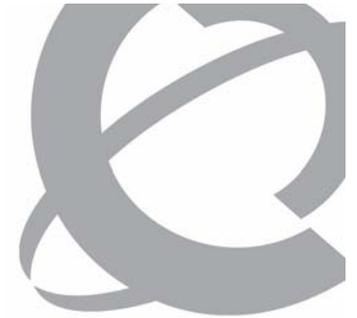


AFFR and Channelization Mapping –(2)

Example of DVRB Channelization for Mode 3



VRB Set 1 → High power
VRB Set 2 → Low power



Summary and Conclusion

- > The proposed adaptive FFR scheme can be used with per cell frequency planning.
- > Each sector has two groups of sub-carriers (high power and low power) for each mode of operation.
 - The high power sub-carriers are selected so that the overlap among the sectors within a cell is minimized.
- > The frequency pattern is obtained from the mode of operation and sector ID.
- > With per Node-B frequency planning, the channelization requires two separate resource allocation sets for both the DVRB and LVRB sub-channels.
 - One for full power assignment, the other for low power assignment.
- > The advantages of proposed adaptive FFR scheme are
 - There is no impact on throughput when there are no coverage problems
 - The impact on throughput is minimized by only obtaining the required coverage gain
 - This scheme does not require any network wide frequency planning
 - No additional feedback from the mobiles is necessary.