Proposal for IEEE 802.16m VoIP Resource Allocation and Control Structure

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Re: IEEE 802.16m-08/005 – Call for Contributions on Project 802.16m System Description Document (SDD), on the topic of "Downlink Control Structures"

Purpose: Adopt the proposal into the IEEE 802.16m System Description Document

Scope

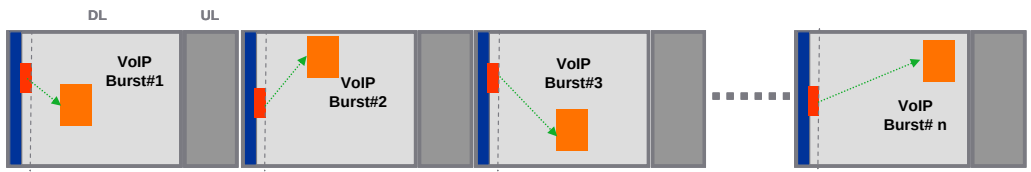
- This contribution presents resource allocation and control structure for the support of real-time services such as VoIP for IEEE 802.16m
- This contribution, in conjunction with the control structure proposed in IEEE C802.16m-08/173 and IEEE C802.16m-08/176 provide the overall 802.16m control structure to support various types of applications
- Details of the choice of resource block size to support VoIP are provided

Introduction

- Real-time service support is an essential feature of 16m systems. Such services may include:
  - VoIP
  - Gaming
  - Video telephony
- These services are characterized by delay sensitive data requirements, small throughputs, and relatively high number of users.
- The SRD requirements (IEEE 802.16m-08/002r4) necessitate efficient control channel signaling design with capability of accommodating a large numbers of users
  - Efficient multiplexing of users on the UL and DL is necessary to ensure high capacity for such services.
  - 16m VoIP SRD requirements:
    - 1.5x reference system capacity
    - 30 users/MHz/sector
- Control channel design for real-time service can be different than those used for delay tolerant data application, but different types of control channel design should co-exist simultaneously in order to support mixed traffic scenarios

Background (1/2)

- Due to the relatively larger number of simultaneous VoIP users, it is imperative that the 16m control channel structure for VoIP be designed such that the overhead per HARQ transmission assignment must remain on the order of a few bits. In addition, many transmission parameters such as packet and modulation schemes may be common to all VoIP users and therefore do not need to be signaled.
- Explicit signaling with conventional unicast control signaling used for data packet transmissions, while generally power efficient, can be prohibitive due to larger overhead associated with additional transmission parameters not necessary for VoIP.
- Broadcast methods can eliminate many of these common fields but suffer from inefficient transmission to both cell edge and high geometry user simultaneously.
- Current methods in 802.16e do not have specific signaling support for VoIP, and as a results the signaling overhead is large. This allows for maximum flexibility and specification of VoIP packet allocation, however it is capacity limiting. This is due to the large broadcast fixed overhead, as well as the considerable signaling overhead per HARQ transmissions.
  - The legacy 16e system can use sub-MAPS to target several geometry groups separately, however the overhead limitation exists even with the use of sub-MAPS.



Background (2/2)

- Multi-cast control methods, such as group signaling methods as specified for 3GPP2 UMB systems, are useful in that the number of bits per assignment is relatively small, while the use of multiple groups allow targeting of different geometries to improve power efficiency.
  - Efficient multiplexing of group resources is needed to maintain this power efficiency.
- In some cases, assignment modifiers may be desirable to enhance system features or reduce hypotheses in blind detection of a transmission.
  - Such modifiers can be useful for group allocations. However, in many cases, the number of assignments for a group is unknown prior to bitmap reception and ultimately require significant bit-padding in order to make use of these fields.

Proposal

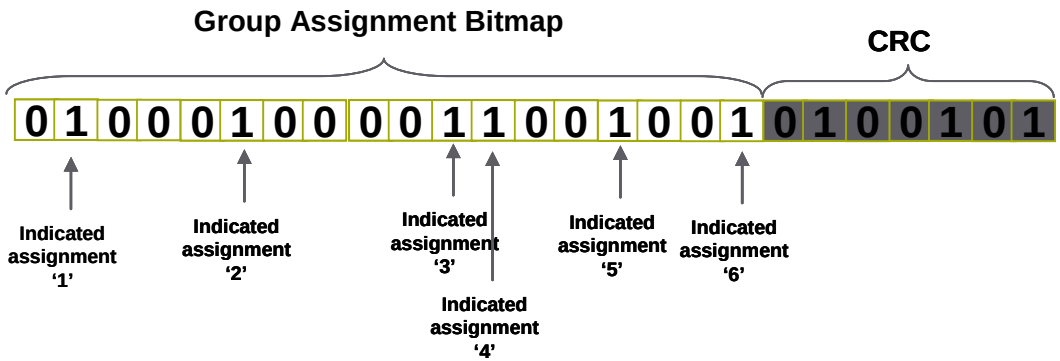
- This contribution proposes a group-based resource allocation and control structure for VoIP and real-time services. The proposal combines the efficiency and flexibility of unicast control by maintaining small groups and adding assignment modifiers, as well as reduces control overhead and messages by using group-based assignment.
- The group signaling methods can be integrated with a dynamic resource partition framework (see IEEE C802.16m-08/176) to provide efficient multiplexing of different multi-cast groups, and well as non-VoIP data traffic.
  - Assignment modifiers can also be added to group signaling with minimum field padding in this proposal.

Proposal for 16m Group Assignment

- Group-based assignment (bitmap)
  - Allow efficient signaling to many VoIP users simultaneously
  - Signaling only non-persistent assignments/transmissions
  - Assignment modifier to allow additional specification of transmission
- Persistent allocation
  - Predefined resource for certain VoIP transmissions or assignments to reduce signaling
  - Occupied resource indicated by resource availability bitmap (RAB)
- Multiplexing of group resources achieved by resource partitioning
  - Flexible group resource assignment size and multiplexing by signaling resource partition sizes
  - Hypothesis detection of group bitmaps allows flexibility in group resource location

Non-Persistent Group Assignment (1/2)

- Group assignment is used to benefit large number of users
  - A group is signaled by a group bitmap.
  - Each location in the bitmap is assigned to a user. The value of the bit for each user indicates whether the user is being assigned resources (‘1’), or not being assigned resources (‘0’).
  - The first indicated assignment is assigned to the first available resource(s), the second indicated assignment is assigned to the second available resource(s).



  - Each group bitmap has its own set of resources (i.e. different resource segment)

Non-Persistent Group Assignment (2/2)

- Improve flexibility by hypothesis detection of group bitmaps
  - A user will try to decode a possible group control channel location with its group ID attempting to find its group resource assignment (see later slides and IEEE C802.16m-08/176)
  - Allows bitmaps to be sent as needed on a 16m subframe and on different resource location
- Easy multiplexing of group resource facilitates the use of many groups
  - Groups based on service class
    - Some services require frequent transmission (VoIP), others less frequent
  - Groups based on geometry
    - Power efficiency
  - To reduce signalling, groups may also have the same attributes (useful for VoIP):
    - MIMO mode
    - Resource allocation size
    - MCS
  - A specific group assignment bitmap may be omitted if no users of that group require assignment
- Users are assigned to groups by group configuration message
  - Message indicates size of bitmap, bitfields to be included, and attributes
  - Assigns user a position on the bitmap

Supporting features for Group Assignments

Assignment Related Fields

- Each field is linked to number of indicated assignments of the bitmap, which can be derived from the partition size.
- Hence each user can determine the field/index sizes dynamically

- Supplemental Transmission Information Field (STIF)
  - Up to 2 bits to indicate new packet transmissions, multiple packets or packet start position
- Resource permutation index:
  - Index linked to table of possible resource allocations sizes to indicated assignment in bitmaps
  - Allows dynamic resource size for bitmaps allocations
- Users set index
  - Index that shuffles indicated assignments.
  - Examples of uses:
    - create “pairs” or sets of users
    - assigned specific resources to specific users
    - in MIMO applications

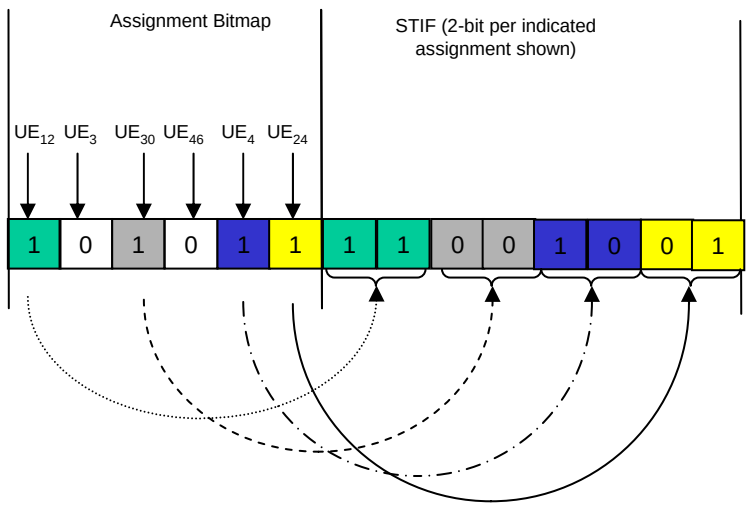
Group Related Field

- UL resource/partition index
  - Indicates the resource partition assigned to the group bitmap
  - Multiple groups can be assigned to the same partition

Supplemental Transmission Information Field (STIF)

- Indicates one (or more) of the following modes:
  - new packet toggle (NPT) (multi-state toggle)
    - Prevents ambiguity of transmission to user in case of ACK/NAK error as it changes values each time a new packet is started
  - multiple packets (MP)
    - Allows BS to specify that 2 packets are being transmitted to a user, also indicates to other users of the group that this assignment will uses twice the resources
  - packet start frame (PSF) within superframe
    - Indicates the frame within the superframe on which the first HARQ packet transmission occurred. This indication simplifies hypothesis detection in the presence of control signaling errors
  - Subpacket HARQ transmission index (SPID)
    - Indicates the subpacket ID for HARQ transmissions. Enables asynchronous IR HARQ packet transmissions.

- The STIF mode is configured for each bitmap at group assignment (i.e. property of group)
  - Can also be configured as one-bit field (2 state) for 1 mode, or 2-bit field (4 state) which can be configured to support one or more of the above modes



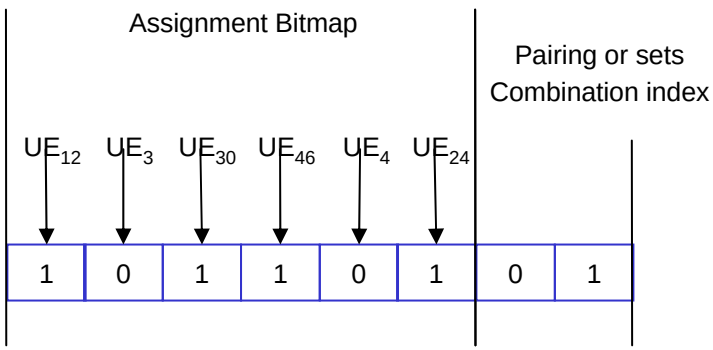
Resource Permutation Index

- This field may be present and may be used to assign different numbers of resources to users of a given group
  - For a particular number of resources within the group assignment segment, a table can be created to indicate possible resource partitions to different users within the group.
  - This field signals the index associated with resource partitions of the group assignment.
  - For example, for the case of a partition size of 4 resources, a table can be created linking possible partitions with an index.
    - If the group is configured to use this filed, by noting the partition size and the minimum resource division size , the user can determine the field size appended to the bitmap.
    - Hence the size of the index is dynamically flexible, and is associated with the partition size

Partition divisions (in resource elements)	Index number	bitfield
1,1,1,1	0	000
1,1,2	1	001
1,2,1	2	010
2,1,1	3	011
3,1	4	100
1,3	5	101
2,2	6	110
4	7	111

Users Sets Index
Reordering, or creating users sets within bitmap

- The field indicates an index that corresponds to combinations of pairs or sets of assigned users.
  - Users with indicated assignments are combined into pairs, triples, quadruples, etc…..,
  - This allows selected multiple users to be assigned to the same resource
  - Without this index the users are paired in the order of bitmap positions
- For a number of indicated assignments, a table can be created for the possible pairs or sets of users.
- Example:
  - The bitfield “01”, indicates that assignment 1 and 3 are paired on the first resource, and assignment 2 and 4 are paired ion the second resource
  - Hence, UE12 and UE46 are paired on the first resource, and UE30 and UE24 and paired on the second resource.
- Ordering index is a specific case of user set index, with user set size equal to 1
  - Allows ordering of assignments
- If the group is configured to use this filed, by noting the partition size and the minimum resource division size , the user can determine the number of assignments and field size appended to the bitmap.
  - Hence the size of the index is dynamically flexible, and is associated with the partition size



Users combinations (e.g. users numbered 1 through 4 in order of assignment in bitmap)	Index number	bitfield
1 and 2; 3 and 4	0	00
1 and 3; 2 and 4	1	01
1 and 4; 2 and 3	2	10
Reserved field	3	11

UL Resource/Partition Index

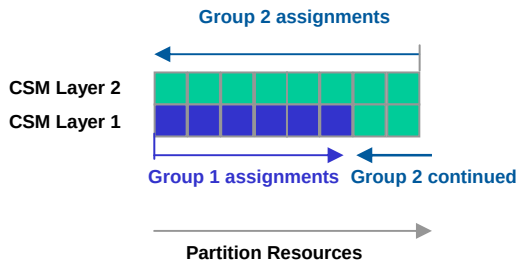
- Group assignment bitmap is appended by a bit field specifying the UL resource partition number for the assignment
- Multiple bitmaps can be assigned to the same partition
  - Multiple groups can be assigned to the same partition to support collaborative spatial multiplexing (CSM)
- Group assignments with indicated assigned resources greater than the partition size, start from the end of the partition and allocate resource across to the partition to the beginning, and then continue starting again from the end of the partition.
  - Mobiles can derive total number of assigned resources to group from bitmap, and compare with indicated resource partition size
  - Method allows efficient packing of different sized group assignments
- Users ordering index can also be used to allocate users in a specific order
  - For a number of indicated assignments, a table can be created of possible ordering of users.
  - user ordering index may also be used to “shuffle” the assignments of one or more group bitmaps to allow further control over which users are grouped together for optimization
  - Index to be appended to high geometry bitmap to minimize overhead
    - In order to allow derivation of field size, index applies to only one CSM layer
  - Ordering index is a specific case of user set index, with user set size equal to 1

Multiplexing of unequal assignments

Group 1: 6 assigned resources

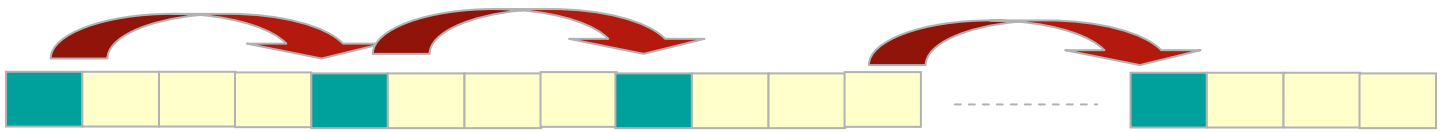
Group 2: 10 assigned resources

Partition: 8 resources



Persistent Resource Assignment

- Persistent resource assignment can be used for low geometry users
  - Persistent assignment does not require control signal after initial configuration
  - All HARQ transmissions are sent on periodically occurring persistent assignment

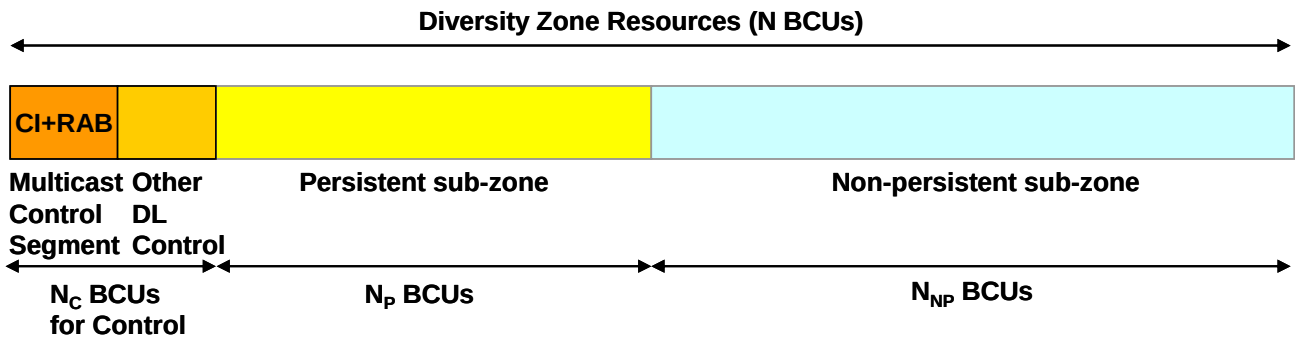


- Persistent sub-zone allows multiplexing of persistent resource and non-persistent assignments
  - A resource availability bitmap is employed to indicate which specific resources are available within the partition within the persistent sub-zone.
- Persistent assignment for first HARQ transmission, or re-transmissions is also supported
  - Persistent resources for first HARQ transmissions are configured at initial assignment, and re-transmissions are signaled non-persistently by group assignment
- Assigned/deassigned by unicast control message

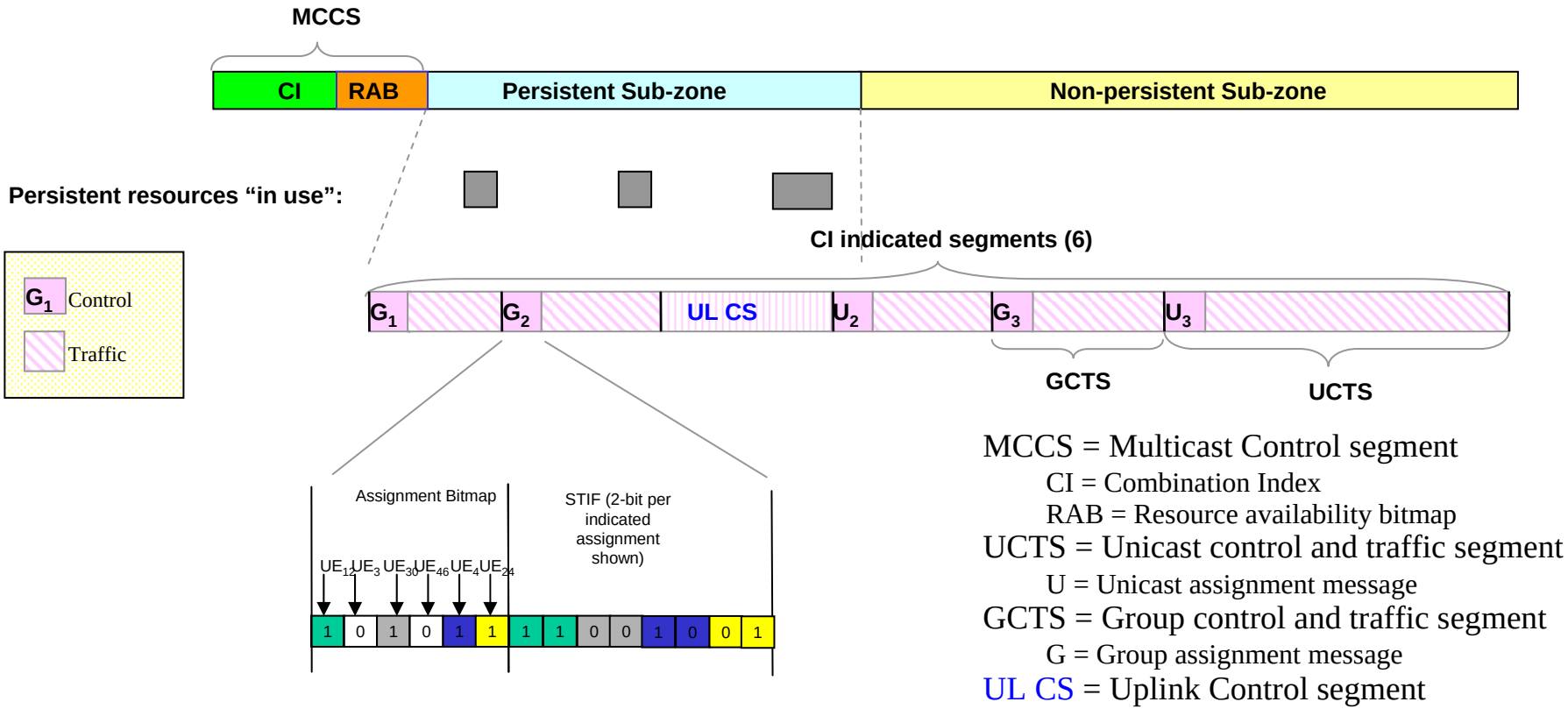
VoIP Support within the Resource Allocation/Control Structure

Overview of VoIP Support within the Resource Allocation/Control Structure

- The overall resource allocation and control structure is presented in IEEE C802.16m-08/176.
- VoIP transmissions can be persistent assignments, or non-persistent assignments signalled within specific resource partitions
  - Group assignment using a bitmap is used for non-persistent VoIP assignments
    - Each group is assigned a separate resource partition of basic channel units (BCU's) (see IEEE C802.16m-08/175)
    - Individual VoIP allocations can be allocated resources in units of RB's if needed
  - Low geometry users can be assigned persistent resources
    - Available persistent resources for non-persistent assignments are indicated the by resource availability bitmap (RAB)
- Division and identification of available resources is indicated by the multicast control segment (MCCS)
  - Partition of zones is signalled by combination index (CI) which signals the resource partitions within the persistent and non-persistent zones.
- The CI is concatenated and encoded with a resource availability bitmap (RAB) which indicates the available resources in the persistent sub-zone.
  - The RAB is a bitmap that indicates which resources are available, and which are occupied with a persistent HARQ transmission.
    - Persistent resources that are unused due to packet arrival Jitter, silence state, or early termination of HARQ transmissions are shown as available
- The resource partitions indicated by the CI divide the set of resources remaining after resources indicated as occupied by the RAB are removed from the resource list.
  - The size of the persistent zone is carried in the secondary broadcast channel



DL Control and Traffic Segments



MCCS = Multicast Control segment
- CI = Combination Index
- RAB = Resource availability bitmap

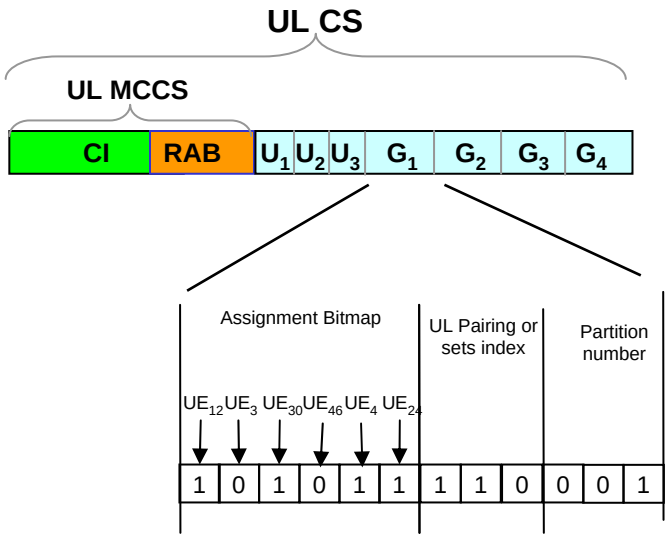
UCTS = Unicast control and traffic segment
- U = Unicast assignment message

GCTS = Group control and traffic segment
- G = Group assignment message

UL CS = Uplink Control segment

- The available resources for each group assignment are indicated by separate resource partitions per subframe (see IEEE C802.16m-08/176).
  - Resources for different groups are dynamically multiplexed.
  - A resource availability bitmap (RAB) may also be employed indicate which specific resources are available within the partition.
  - For DL assignments, a user will try to decode the start of each resource segment with its group ID attempting to find its group resource assignment

UL Control Segment (UL CS)



MCCS = Multicast Control segment

CI = Combination Index

RAB = Resource availability bitmap

U = Unicast control message

G = Group control message

- UL Assignment block is located in a DL resource partition
  - Partition contains CI, RAB, and unicast/group assignments
- Combination index indicates the resource partitions on the Uplink
  - RAB indicates resources “in use” by persistent assignments, and resources available.
  - Resource partitions specified in CI excluded resources indicated as “in use” by the RAB
- For group assignment messages
  - For UL assignments, a user will try to decode each possible position for a control message in the UL assignment control segment with its group ID attempting to find its group resource assignment
  - Similar to the UL unicast assignment messages, UL assignment messages are appended by a field specifying the UL partition number for the assignment
  - Multiple groups can be assigned to the same partition to support collaborative spatial multiplexing (CSM)
  - Group message length is set to be multiple of unicast length

Resource Block Size for VoIP

VoIP Packet Sizes (1/2)

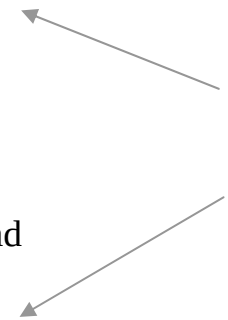
- For group assignments, such as VoIP, group resource segments are allocated in units of basic channel units (BCUs), whereas individual VoIP users can be allocated resources in units of Resource blocks (RBs)
- Small RB size allows for efficient support of:
  - Multiple MCS's per packet size
  - AMR and other codecs (i.e. EVRC)
  - Different pilots patterns and associated overheads
- Resource block size 72 (12x6) bits (as recommended in IEEE C802.16m-08/172) provides flexibility in code rate for VoIP assignments

VoIP Packet Sizes (2/2)

- Example code rates for resource block size 72 (12x6) bits:
  - BCU size of 3 RB's is adequate for certain QPSK VoIP AMR or EVRC allocations

- DL:
  - 2 transmit antennas -> 6 % common pilot overhead
  - 320 bit VoIP packet size (AMR full rate)
    - 2 Options for resource size for QPSK
      - 3 RB = 1st transmission code rate 0.79
      - 4 RB = 1st transmission code rate 0.59
  - 256 bit VoIP packet size (EVRC full rate)
    - 2 Options for resource size for QPSK
      - 2 RB = 1st transmission code rate 0.95
      - 3 RB = 1st transmission code rate 0.63

- UL:
  - 1 transmit antenna -> 8% dedicated pilot overhead
  - 320 bit VoIP packet size (AMR full rate)
    - 2 Options for resource size for QPSK
      - 3 RB = 1st transmission code rate 0.81
      - 4 RB = 1st transmission code rate 0.60
  - 256 bit VoIP packet size (EVRC full rate)
    - 2 Options for resource size for QPSK
      - 2 RB = 1st transmission code rate 0.97
      - 3 RB = 1st transmission code rate 0.64



Small RB size allows for multiple reliability options with QPSK, and allows for adaptation to pilot/codec requirements

Different MCS for different groups allows allocation of 1 or 2 RB's per VoIP packet

Summary

- This contribution presents a proposal for 16m resource allocation and control for real-time services such as VoIP
- The proposed group control method provides an efficient mechanism for resource allocation and control for services with a high number of users and some common parameters for allocations
- The proposed group control method allows for low overhead in VoIP assignments utilizing
  - non-persistent and persistent assignments
  - Multiple geometry based groups that enhance power efficiency that can be efficiently multiplexed within the resource partition framework
- Assignment related fields which can be dynamically sized and determined by the mobile for hypothesis detection according to partition and group parameters. These fields support several features including:
  - supplemental transmission information to provide additional specification or reduce number hypotheses required for packet detection by the mobile
  - Dynamic mobile assignment pairing to support applications such as collaborative spatial multiplexing (CSM)
- Efficient multiplexing of VoIP resources with other assignments (i.e. non-VoIP) through resource partition framework