Proposal for IEEE 802.16m CQI Feedback Framework

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Purpose: Discussion and Approval

Outline:

- Requirements on CQI feedback
- CQI feedback components
- Reporting Framework (primary/secondary)
- CQI reporting control (BS/MS controls)
- Granularity of CQI FB vs RB size
- CQI FB compression in Frequency, Time and Space domains
- Event-driven CQI feedback
- Conclusions and recommendations
- SDD Text

UL Channel Feedback Design Requirements

- Overhead: Should reduce the overhead
  - less than 15% on average. Overhead for distributed is low, but for localized with MIMO would be high
  - CQI Feedback granularity: Tradeoff between accurate reporting vs. broader reporting; allow optimization for different scenarios;
- Coverage: CQICH design should be optimized for 1.5km/5km cell sizes with the assumed propagation models;
- Mobility: CQICH should be able to support optimal DL performance up to 10km/h.
- CQI feedback mechanism should support advanced PHY/MAC techniques:
  - frequency selective scheduling (FSS)
  - MIMO
  - Fractional frequency reuse (FFR)
- Error recovery: Error propagation possibility should be avoided or minimized;
- Complexity: The complexity involved in the CQI feedback scheme should be minimized

CQICH Channel Content

CQICH type	Bits	Notes
CINR	4-6	Physical CINR or effective CINR
MIMO mode	2-4	MIMO mode selection
FSS band selection	4-6	4-6 bits per-band, size depending on the total number of bands in the operating bandwidth. Total number of bits required per MS varies based on the indexing mechanism such as bitmap, indexing or hierarchical tree.
MIMO pre-coding codebook	4/11	Close-loop MIMO codebook size. 4 bits for 2x2 and 11 bits for 4x2 or 4x4, per band per user.
MU-MIMO feedback	TBD	MU-MIMO related feedback. Feedback includes CQI per stream per band and precoding vector per band.
SU-MIMO feedback	TBD	SU-MIMO related feedback. Feedback includes CQI per band and precoding vector per band.
UL bandwidth request	2	UL bandwidth request quantized to different levels
Handoff	1	UL initiated handoff

Primary/Secondary Feedback Reporting Framework

We need to have “primary” feedback channel to periodically receive channel and other required information from the MS. And “secondary” feedback channel is required to achieve an efficient scheduling gain and support all traffic demands.

- Primary CQI feedback channel:
  - To facilitate a reliable basic connection
  - Less frequent, Low rate, periodic
  - Used for average CQI especially for distributed RB
  - Non-traffic related info: bandwidth request, handoff,
- Secondary CQI feedback channel:
  - To optimize performance; it’s allocated/updated adaptively based on channel/traffic variation and required MIMO support
  - High frequent, High rate, periodic/event-driven
  - Used for localized RB
  - Traffic demand dependent
  - Link adaptation should be supported on the secondary CQI feedback channel:
    - Amount of CQI feedback information can be high based on FSS, FFR and MIMO feedback required
    - Since secondary channel is adaptively allocated/updated, link adaptation is possible

CQI Reporting Control

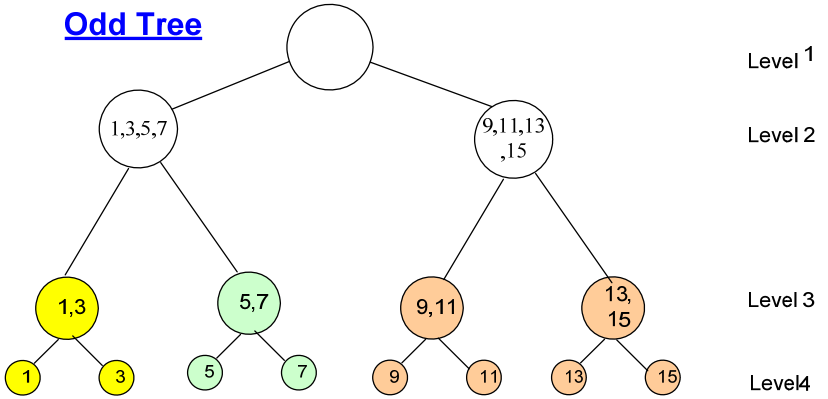
- Different reporting/compression is optimal in different channel conditions based on the channel variation
- UL resources for the CQI feedback need to be allocated by the BS, while only the MS knows what is the best way to report at any point in time.
- Neither BS nor MS can individually make the CQI feedback optimal; hence allow for:
  - BS allocates CQI feedback resources based on:
    - traffic requirement
    - number of users in the sector
    - Previous CQI reports, both primary and secondary
  - Given the CQI feedback resources allocated, MS has the best knowledge to decide on the feedback. This adaptive mechanism would help improving the scheduling gain and user/sector throughput.

CQI Feedback and RB size granularities

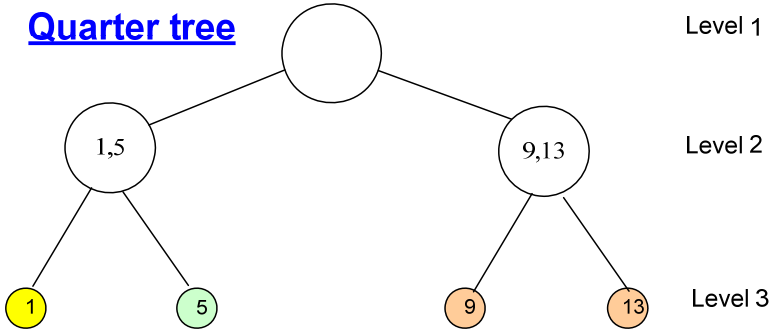
- It would be ideal to have CQI feedback on a schedulable RB size granularity.
  - E.g., if there are 64 RBs, then will need a 64 bit bitmap
  - The CQI feedback overhead will be high
  - For MU/SU-MIMO it is observed that the performance deteriorates when combine several RBs into a band and receive only the average value of the band
- To, reduce the overhead we can support:
  - Multiple tree types (e.g., blind odd and even trees as in 16e), we can support several meaningful sub-trees
  - Hierarchical tree – when the channel is flat, higher layer node of the tree can be chosen

Examples of Tree types and Hierarchical Tree

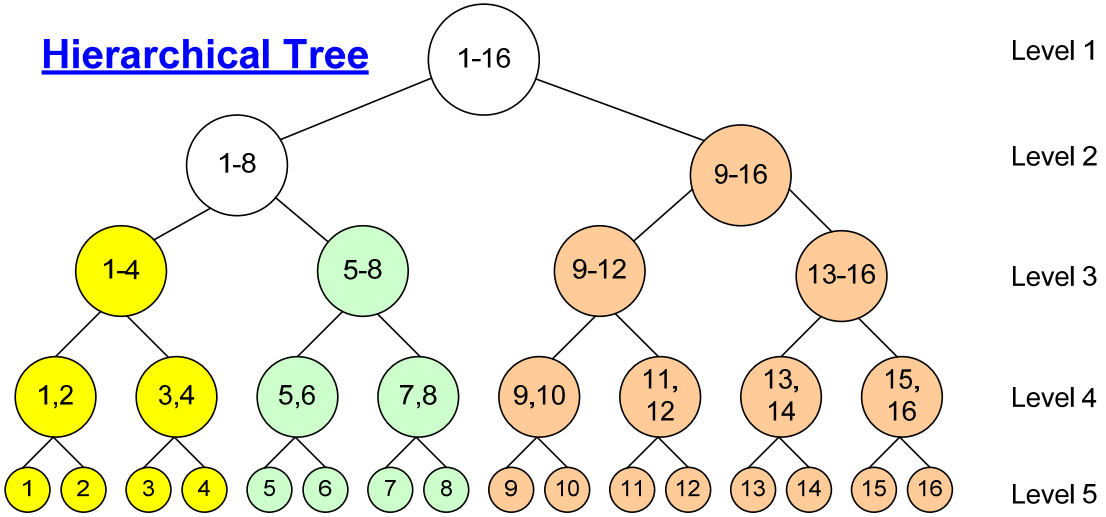
Odd Tree



Quarter tree



Hierarchical Tree



CQI Feedback Compression

- Reporting the full CQI for the entire band is not possible since there are two many bands and (possibly) users, and the OH needs to be limited.
- Several feasible compression techniques possible:
  - Frequency Domain Compression Techniques
  - Time Domain Compression Techniques
  - Space domain compression Techniques
- Techniques should support mechanisms to optimize reporting CQI:
  - Amount,
  - Granularity,
  - Indexing, and
  - value

Event Driven CQI Reporting

- The CQI feedback period and amount depend on:
  - channel variation
  - traffic demand
- Event driven CQI feedback should be supported so that:
  - The required CQI feedback is available when needed and
  - Reduce/remove the feedback when it is not required

Conclusions and Recommendations

We would like to recommend the following to be incorporated in for the CQI feedback support in 16m in order to have the required CQI feedback while reducing the CQI feedback overhead:

- Support Primary and secondary CQI feedback channel framework
- Support a generic tree structure based CQI reporting so that further frequency, time and space domain compressions can be incorporated in order to keep the CQI feedback overhead within a reasonable level.
- Support event driven CQI reporting
- Support link adaptation on the secondary CQICH channel

Proposed Text for SDD

Insert the following text into Medium Access Control sub-layer sub-clause (i.e. Chapter 10 in [3]):

---------- Text Start ----------

10.2 UL Control Channel Structure

10.2.x CQI Feedback Channel

10.2.x.1 Primary and Secondary CQI Feedback Channel

IEEE 802.16m supports a primary and a secondary CQI feedback scheme in the uplink . The primary CQI feedback channel is to facilitate a reliable basic connection, and the secondary channel is to optimize link adaptation and scheduling performance based on channel/traffic variation. The secondary feedback channel is also important for MIMO support where the CQI allocation can be adaptively updated. The primary CQI channel is transmitted at low rate, less frequently, periodic and used for average CQI especially for distributed resource blocks. The secondary CQI channel is transmitted at high rate, more frequently, and is traffic-demand dependent and used for localized resource blocks.

10.2.x.2 Event Driven CQI Feedback Reporting

IEEE 802.16m further supports an event-driven CQI reporting. The CQI feedback period and granularity depend on the channel variation and traffic demand. The event-driven CQI feedback support is needed in order to have the required CQI feedback when needed and the feedback can be reduced/removed when it is not required.

10.2.x.3 Link Adaptation Support for Secondary CQICH channel

IEEE 802.16m also supports link adaptation on the secondary CQI channel. The granularity of CQI feedback information can be high based on FSS, FFR and MIMO feedback required. Since the secondary CQI channel is adaptively allocated/updated link adaptation on secondary CQICH channel is implemented.

10.2.x.4 Tree Structure based CQI Feedback Reporting

IEEE 802.16m supports a generic tree structured CQI reporting scheme. Further frequency, time and space domain compressions can further be incorporated in the tree-structured CQI feedback framework in order to keep the CQI feedback overhead within a reasonable level.

---------- Text End ----------