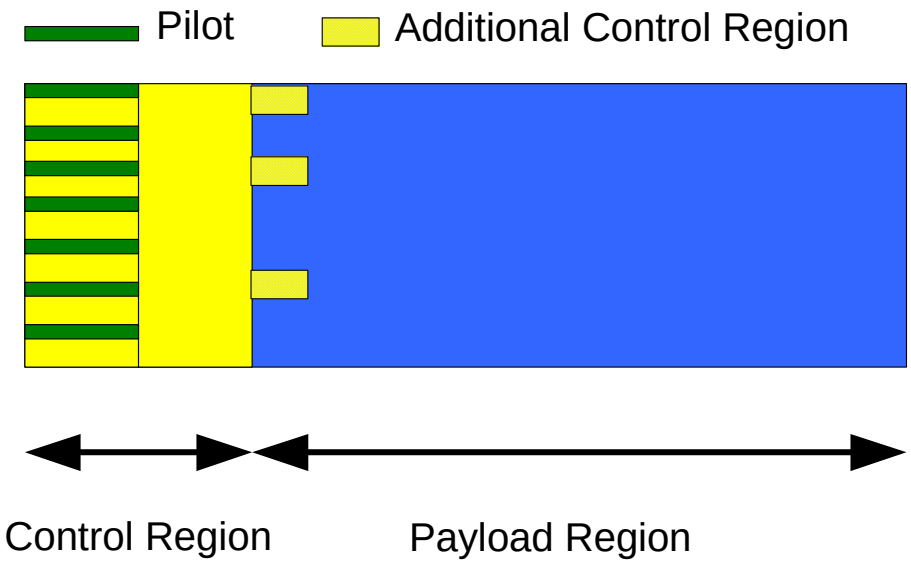
R2-060945 Control Signaling

Motorola

Agenda Item 3.5

Basics

- **First two symbols of downlink sub-frame define control region; remaining 5 symbols define payload region**
- **Minimally control information needs to identify**
  - **UE being scheduled (DL and UL)**
  - **Details of resource allocation**
  - **HARQ information**



Additional control information

- **Additional information to be transmitted in downlink**
  - **Downlink and Uplink Assignments**
    - Resource Assignment (resource blocks to be decoded by UE in downlink; resource blocks to be used in uplink)
      - Potentially also resource assignments for ACK/NACK and CQI
        - » Could be implicitly mapped
    - Temporal aspects (persistence, TTI length, etc.)
    - Details regarding localized and distributed allocation (for e.g. number of distributed allocations, etc.)
    - Modulation scheme
    - Payload size (payload size + modulation => coding rate known)
  - **Additional control for Downlink assignments**
    - Multi-antenna mode information (MIMO scheme, Tx diversity, beamforming, etc.)
    - HARQ process number (assuming Asynchronous HARQ)
    - Redundancy version +new data indicator (assuming Asynchronous HARQ)
    - Retransmission sequence number for synchronous HARQ
  - **Additional control for Uplink assignments**
    - ACK/NACK sent in DL for uplink transmission

Control signaling in uplink

- **Control Information sent in Uplink**
  - **HARQ related Information**
    - HARQ process number (assuming Asynchronous HARQ)
    - Redundancy version +new data indicator (assuming Asynchronous HARQ)
    - Retransmission sequence number for synchronous HARQ
  - **ACK/NACK**
  - **CQI**
  - **Buffer Occupancy**
    - can be L2 signaling; for e.g. piggy back with payload

UE Identity

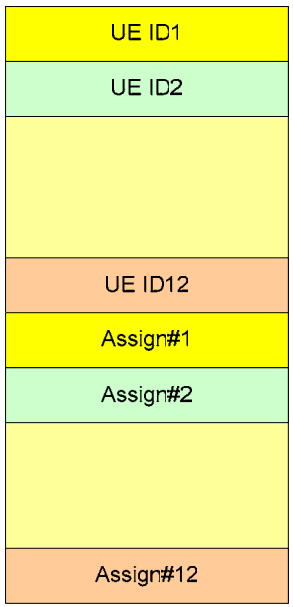
- **Multiple Considerations**
  - **Bandwidth**
    - Need to accommodate larger number of users for 20 MHz;
    - 5MHz BW may require ~ 10 bits to support 5.9 kbps AMR
    - Hierarchical identification is one possibility
      - Signal most significant 10/12 bits in control region and remaining 8 (or 16) bits in payload region
  - **Group Identities**
    - For voice applications (services with small packet sizes) useful to group users to limit control signaling and increase packing efficiency
      - Group is mapped to a 0.5 ms sub-frame with assigned periodicity based on group size and projected need for retransmissions
      - Bitmap in control region then helps identify individual UE within group (no need to identify user using 12 -24 bit identity) and resource assignments
        - » For downlink acts as indication that UE has voice packet in payload region and implicitly indicates how common group resource will be partitioned between UEs and MCS used.
        - » For uplink, same one bit can act as transmit in UL indicator for first transmission as well as ACK/NACK for subsequent transmission. Also indicates resource partitioning and MCSs.
    - Multicast and broadcast applications
      - Group identified through a group identity

Control signaling – the How?

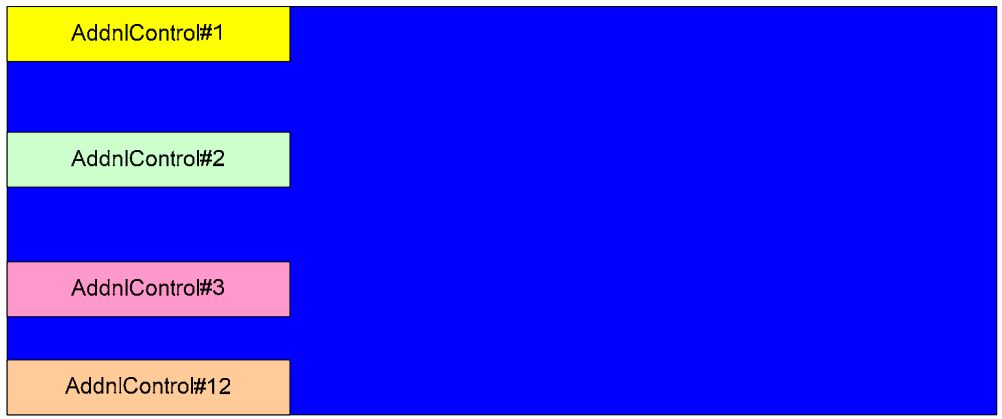
- **Considering 5 MHz BW:**
  - **Number of sub-carriers in control region for 1, 2 and 4 antennas is:**
    - 550, 500 and 400 respectively
    - For 98% cell edge reliability, one antenna: Number of information bits ~ 120 bits;
    - For 2 antenna case: number of information bits ~ 160 bits
- **At the minimum, useful to be able to identify 12 users (overall DL and UL) for 5 MHz**
- **Possible to consider adaptive modulation and coding in control region**
  - **Modulation & coding adapted to channel condition of UE being scheduled**
  - **Limited number of modulation and coding options allows for blind detection by UEs**
    - UEs could utilize CQI to further narrow down possibilities for processing
  - ***A priori* definition of AMC regions in control region**
- **Joint coding of control information is another possibility**
  - **Provides turbo coding gain and potentially avoids duplication of some information**
  - **Can be combined with AMC regions in control region**

Control signaling – the How? (2)

- **Additional Considerations:**
  - **Use of control region simply to communicate UE identities is very inefficient; necessary to provide some additional information in control region.**
    - Resource assignment information can be provided within control region
  - **UE needs to know *a priori* structure of control region and length/location of additional information**
    - Indicate e.g. number of UEs scheduled potentially needed to decode control region
    - In case of multiple jointly coded regions, first region could include this information



Control Region



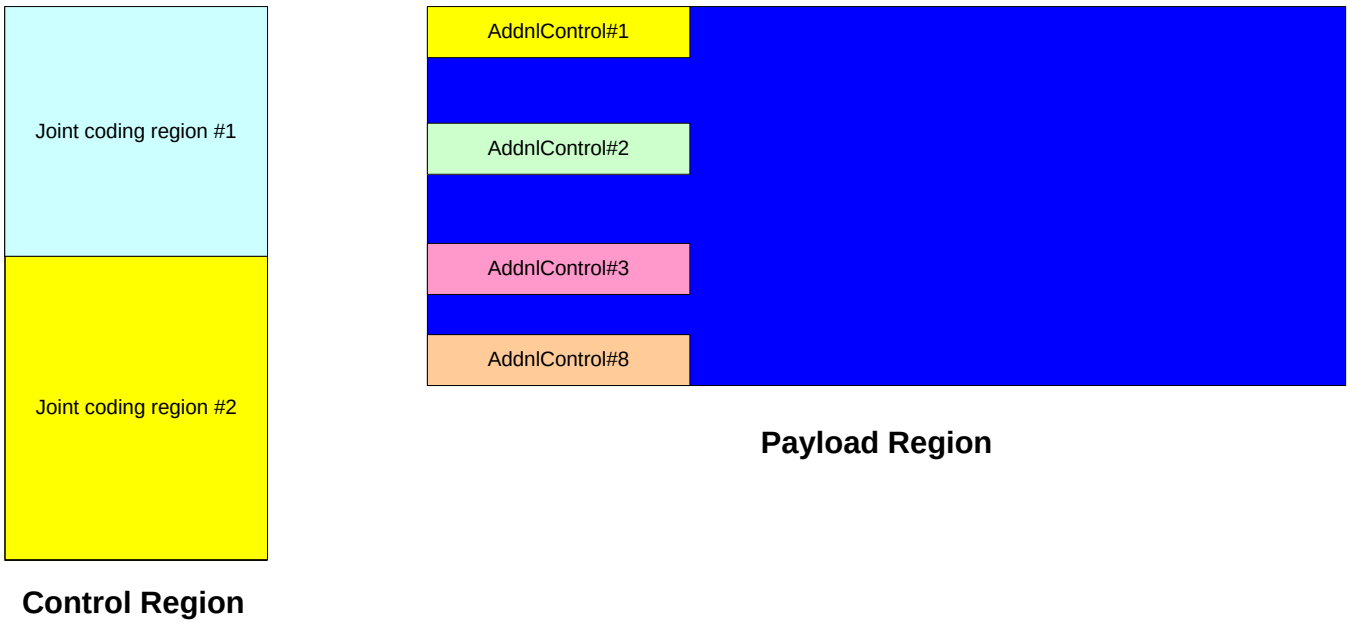
Payload Region

Options for transmission

- **Option 1: Separately code UE id and remaining information**
  - **UE checks presence of identity and confirms with CRC**
  - **Success implies UE reads remaining control information and confirms using separate CRC**
  - **Reduces UE processing but inefficient due to use of multiple CRC; still requires a priori knowledge of control signal areas embedded in payload region**
- **Option 2: 2-part scheme: Scrambled UE identity, single CRC**
  - **The control information is split into two parts, the first part contains a scrambled UE identity; second part consists of all remaining control information with one CRC across the UE identity and remaining control information.**
- **Option 3: Joint coding of UE identities and resource assignment, single CRC**
  - **This could utilize a bitmap approach to map UEs to their respective resource block assignments (including DL and UL and localized/distributed allocations)**
  - **Indicator to additional information or additional information located with resource assignment; additional information could be tailored to the specific assignment such as MCR**
    - Additional information is out-of-band => separately coded from data

Options for transmission (2)

- **Use of multiple (e.g. 2) joint coding regions is useful for targeting UEs in good and poor channel conditions**
  - *In the case where paging is mapped to unicast frames, the paging indication channel would need to be multiplexed into the joint coding region for the poor channel condition users.*



Summary

- Control information to be transmitted can be roughly divided up into
  - UE identity and resource assignments
  - All other control information
- Given the high reliability required for control signaling (98% at cell edge with 1% FER) and need to transmit information very efficiently
  - Useful to consider joint coding of control information using multiple joint coding regions targeting users in good and poor channel conditions
  - All control information other than UE identity and resource assignments is mapped to payload region with the control information transmitted in the time-frequency region allocated to the user but coded separately from data payload.