IEEE 802.16m Identifying Femtocells Subscriber Groups

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Base Contributions:

Re: Contribution in support of a comment on LB30

Purpose: **Discussion and Approval**

Use cases to support

- Use cases will direct and shape our specific design
- The possibilities of use cases could be, for example,
  - 1. Home
    - E.g., a home owner can buy a femto and open it up only to family members and friends
  - 2. Enterprise
    - E.g., a company can buy tens/hundreds femtocells to enhance the connectivity, then such femtos can be open only to the company employees
  - 3. Membership
    - E.g., a use can buy a membership of Starbucks, which means all the femtocells owned by Starbucks should be open to the user
  - 4. Operator
    - E.g., the operator uses femtocells to fix coverage holes, then such femtocells should be open to subscribers of this operator
  - And so on.

Motivation (1/3)

- IEEE 802.16m System Requirements
  - Shall support CSG (Closed Subscriber Group)
  - Shall allow dense deployment of large number of Femtocells
  - Shall support preferred access and handover of MS's to their designated Femtocell BSs
- Some operations (such as Cell Selection, Network RE-/Entry) could be different for Femtocells and macro cells, and for CSG and OSG (Open Subscriber Group) Femtocells.
- Therefore, an MS may need to differentiate Femtocells from macro cells, CSG from OSG, or one CSG from the other CSG.

Motivation (2/3)

- Accessibility of a BS
  - Macro BS: accessible to all MSs
  - OSG Femtocell BS: accessible to all MSs
  - CSG Femtocell BS: only accessible to its authorized MSs, though open to all MSs for emergency access.
- An MS needs to determine whether it is allowed to access a CSG Femtocell
  - CSG BS may not be accessible to many MSs, the chance that an MS cannot access to a CSG BS is large, so the accessibility should be checked early.
  - The number of SCH symbols for cell IDs may not be large enough to differentiate a potential large number of CSG Femtocells.
  - PBCH can be a good place to offer information for MS to check accessibility.
  - Consider methods avoiding using expensive PBCH payload.

Motivation (3/3)

- CSG ID – to ease the management
  - Several Femtocell BSs could belong to a same CSG entity, which have the same group of authorized MSs.
  - Benefits of using a common CSG ID for this set of BSs
    - Shorten the list of allowable femtocells stored in MS
    - To ease the management at the paging controller, and avoid location update when the MS is moving inside the CSG.
    - To ease the management of subscriber groups. E.g., an MS subscribes a membership of Starbucks, which has stores throughout country. Consider Starbucks installs a new femto BS,
      - Without CSG ID, Starbucks has to ask the operator to update it by adding this new femtocell to the white list of all its membership subscribers
      - With CSG ID, such update is not needed.

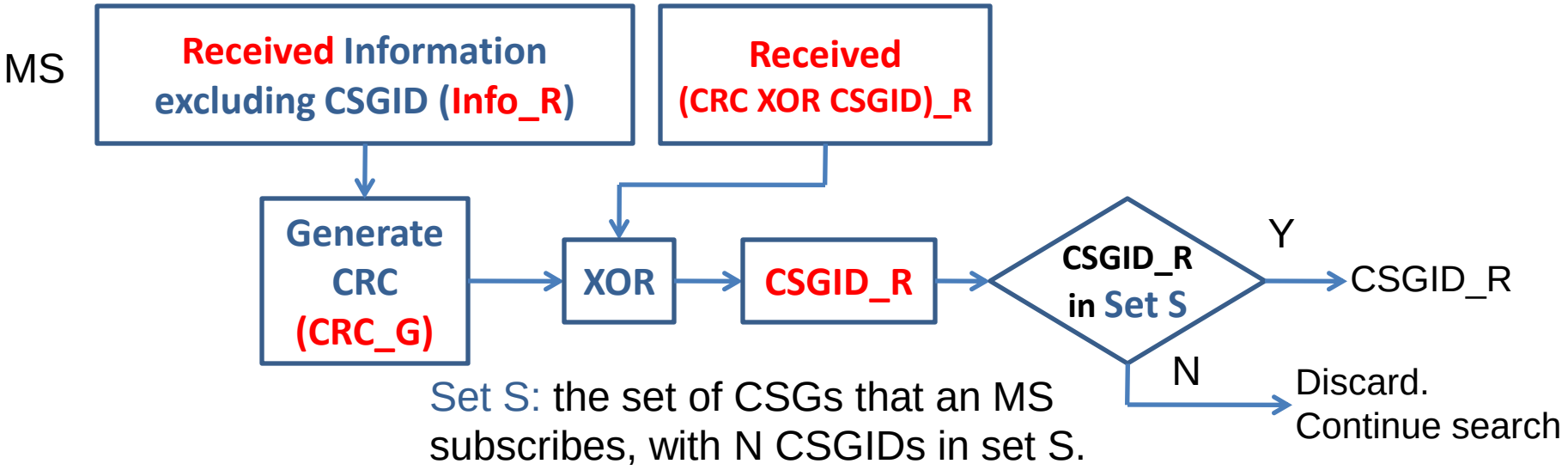
Challenges

- Given potential large number of subscriber groups, CSG ID may need quite a few bits.
- CSG ID needs to be broadcast by femtocells.
- The additional bits in SFH to identify femtocells may consume the expensive SFH payload.
  - Consider approaches to avoid/reduce the payload consumption, such as by using the CRC scrambling with different masks on SFH.

Subscriber Group ID Differentiated by SFH CRC Scrambling (1/2)

- Illustration of femto BS operation
  - CSG ID is carried by scrambling CRC.

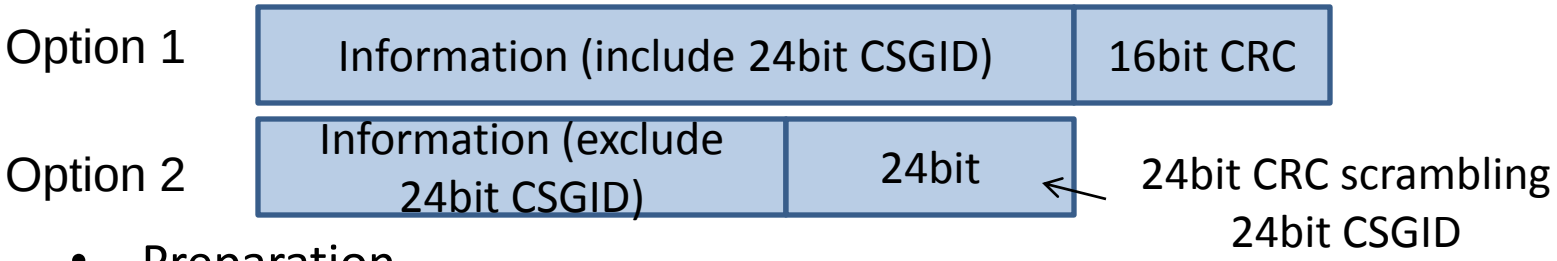
- Illustration of MS operation
  - MS recovers CSGID.



Subscriber Group ID Differentiated by SFH CRC Scrambling (3/3)

- Rationale:
  - An MS may only subscribe a few CSGs among the entire CSGID space. In information theory prospective, this gives the chance of compressing, e.g., reducing the overhead by scrambling CRC.

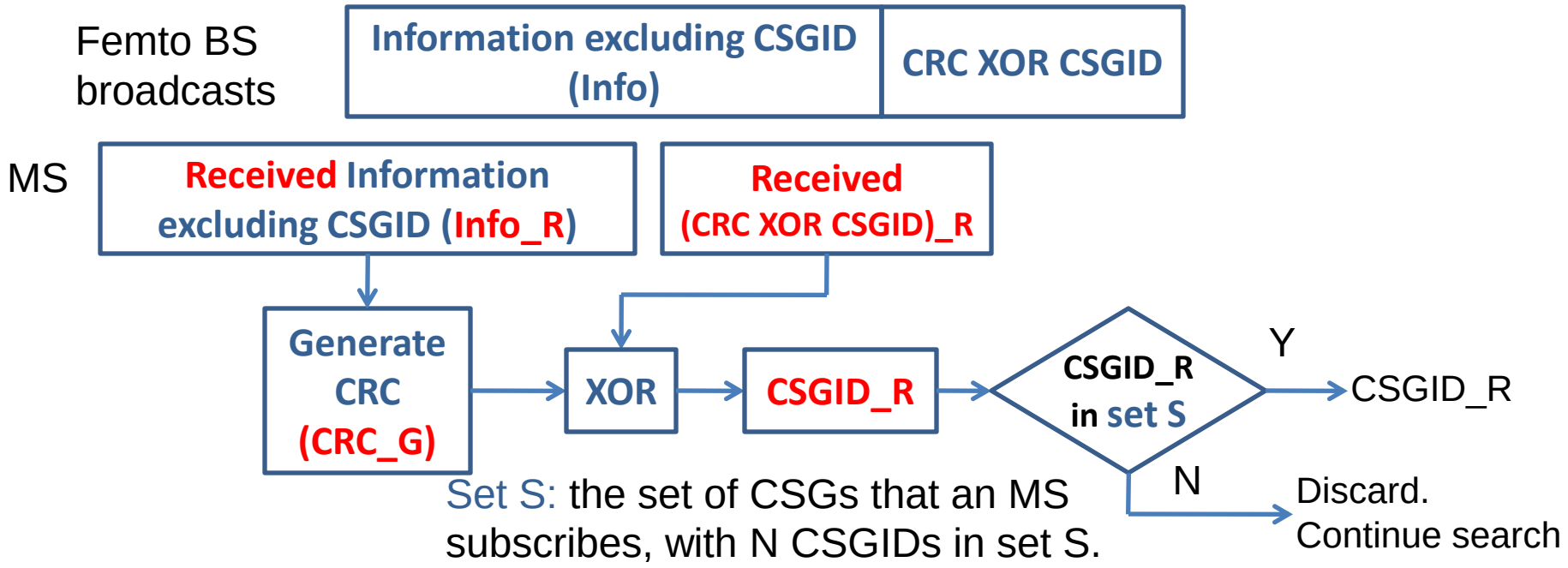
Analysis and Comparison (1/4)



- Preparation
  - Denote p1a, p1b as Pr{ received not equal to sent} for information part (not including CRC16) and CRC part, respectively, in option 1
  - Denote p2a, p2b as Pr{ received not equal to sent} for information part (not including last 24bits) and last 24bits, respectively, in option2
  - Assume that any corruption of data affects data in a completely random way, i.e., such that the corrupted data is totally uncorrelated with the original data.
- For Option 1, there are two error events
  - Mis-detection: information part (not including CRC16) received is correct, but it does not pass CRC check.
    - Not a big issue: discard the message and wait for next chance
    - Probability: (1-p1a)*p1b
  - False-alarm: information part received is in error, but it passes CRC check.
    - This type of error is not desired. Repeated transmission may be used to overcome this.
    - Probability approx.: p1a*2^{-16}=p1a*1.5e-5

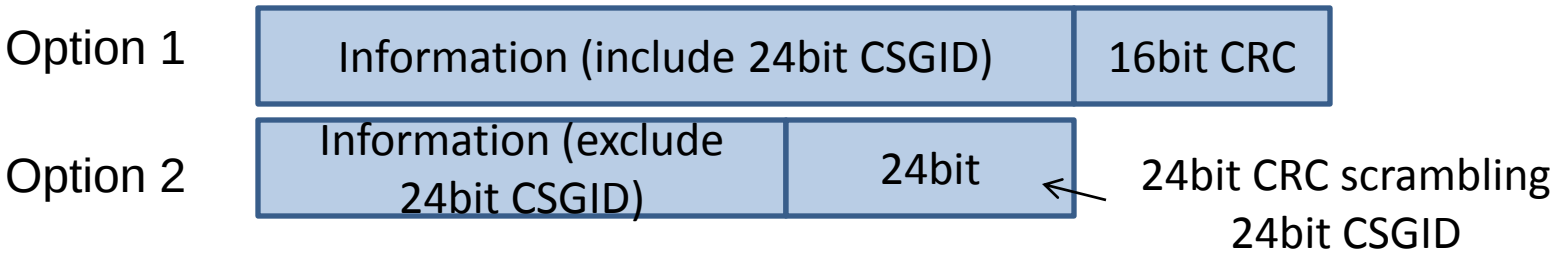
Analysis and Comparison (2/4)

- For option 2



	Scenarios	Issues
1	Info_R ≠ Info, CSGID_R not in Set S	/
2	Info_R ≠ Info, CSGID_R in Set S	False alarm , not desired
3	Info_R =Info, CSGID_R = CSGID	/
4	Info_R = Info, CSGID_R not in Set S	Mis-detection, discarded, no big issue
5	Info_R = Info, CSGID_R in Set S, CSGID_R ≠ CSGID	CRC not affected, accessibility not affected, but may affect operations (if any) which use CSGID

Analysis and Comparison (3/4)



- Consider that an MS has subscribed a set S of N CSGs, with N CSGIDs in set S.
- For Option 2, there are three error events
  - Mis-detection: information part (not including last 24bit as shown in the figure) received is correct, but the recovered CSGID is not in set S hence CRC check is not passed.
    - Not a big issue: discard the message and wait for next chance
    - Probability approx. (1-p2a)*p2b*(1-(N-1)/(2^{24}-1)) ≈ (1-p2a)*p2b*(1-N*2^{-24})
  - False-alarm: information part received is in error, but it gives CSGID in set S.
    - This type of error is not desired. It may be corrected in next repeated SP1s in SFH.
    - Probability approx. p2a*N*2^{-24}=p2a*N*5.96e-8
  - CRC not affected but CSGID wrong (if N>=2): information received is correct, and recovered CSGID lies in the set S, but the recovered CSGID is different from the CSGID sent.
    - This type of error will NOT affect the accessibility of CSG femto check, since the recovered CSGID is still in the allowable femto set S. It does NOT affect CRC either since CRC check is passed correctly.
    - It may only impact the operations (if any) which uses CSGID as input parameters.
    - It may be corrected in next repeated SP1s in SFH.
    - Probability approx. (1-p2a)*p2b* ((N-1)/(2^{24}-1)) ≈ (1-p2a)*p2b*N*2^{-24}

Analysis and Comparison (4/4)

Option 1

Option 2
(our design)

- **Save 16bits in transmission and mostly enhanced CRC**

	Mis-detection [information received is correct, but it does not pass CRC check]	**False alarm [information received is in error, but it passes CRC check]**	**CRC not affected but CSGID wrong [information received is correct, recovered CSGID lies in set S, but different from the CSGID sent**
Option 1	(1-p1a)*p1b	p1a*2^{-16} =p1a*1.5e-5	/
Option 2	(1-p2a)*p2b*(1-N*2^{-24})	p2a*N*2^{-24} =p2a*N*5.96e-8	(1-p2a)*p2b*N*2^{-24} =(1-p2a)*p2b*N*5.96e-8

p1a, p1b: Pr{received not equal to sent} for info and CRC, respectively, in option 1
p2a: p2b: Pr{received not equal to sent} for info and last 24bits, respectively, in option 2.
An MS has subscribed a set S of CSGs, with N CSGIDs in set S.

If N<=256, the false alarm p2a*N*5.96e-8 is less than p1a*1.5e-5. **Enhanced CRC!**
In option 2, CSG wrong probability is less than False alarm, since usually p2b<p2a
N<=128 : (False alarm + CSG wrong) in option 2 less than False alarm in option 1.

The error events may be corrected in next repeated SPs in SFH.

Advantages of Our Proposal

- Advantages
  - Fast: CSGID can be carried in SFH SP.
  - Reliable: If an MS subscribes less than 2^8=256 groups (which may be in most cases), the CRC is enhanced compared to 16bit CRC.
  - Efficient: Reduce 16bits in payload compared with having 24bit CSGID in payload.

Summary

- CSG ID of femtocells is carried by using CSG ID as the mask to scramble CRC
- The operation is for femtocell only. *No change for macrocell*.
- The approach reduces overhead, and enhances CRC capability.

Proposed Solution

Femto ABS S-SFH SP2 IE uses 24-bit CRC, which is scrambled with 24-bit CSG ID.