

Proposal for Incorporating Single-carrier FDMA into 802.16m

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IEEE 802.16m-07/047. Contribution pertains to:

Multiple access and multi antenna techniques.

Base Contribution:

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Purpose:

This proposal requests inclusion of appropriate sections in the SDD for SC-FDMA.

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Motivations

- In the current WiMAX system, OFDMA is used in both UL and DL as the access technique.
- single-carrier FDMA with cyclic prefix (CP) provides additional advantages [1][2][3]:
 - significantly lower peak-to-average power ratio (PAPR) or cubic metric (CM), which will be translated to improvements in power-amplifier efficiency and coverage area.
 - Insensitive to the frequency offset.

Principle of SC-FDMA

- SC-FDMA with cyclic prefix, which utilizes the single carrier modulation and frequency domain equalization.
- the data is passed through a DFT operation before the subcarrier mapping.
- With this change, compared to OFDMA, SC-FDMA can reduce significantly the envelope fluctuations in the transmitted waveform.

SC-FDMA

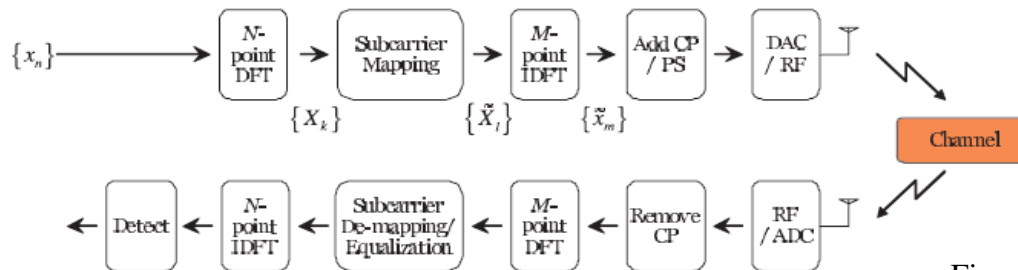
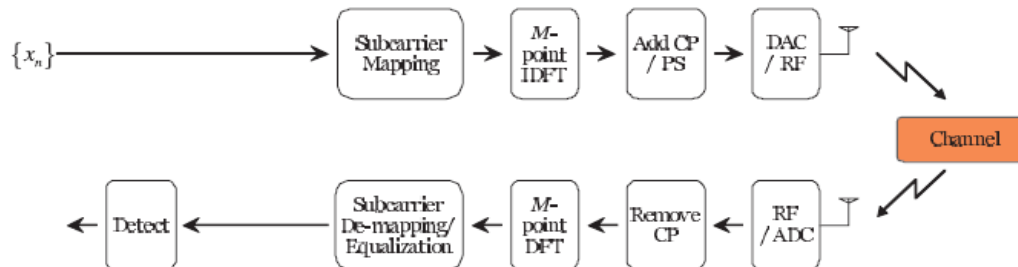


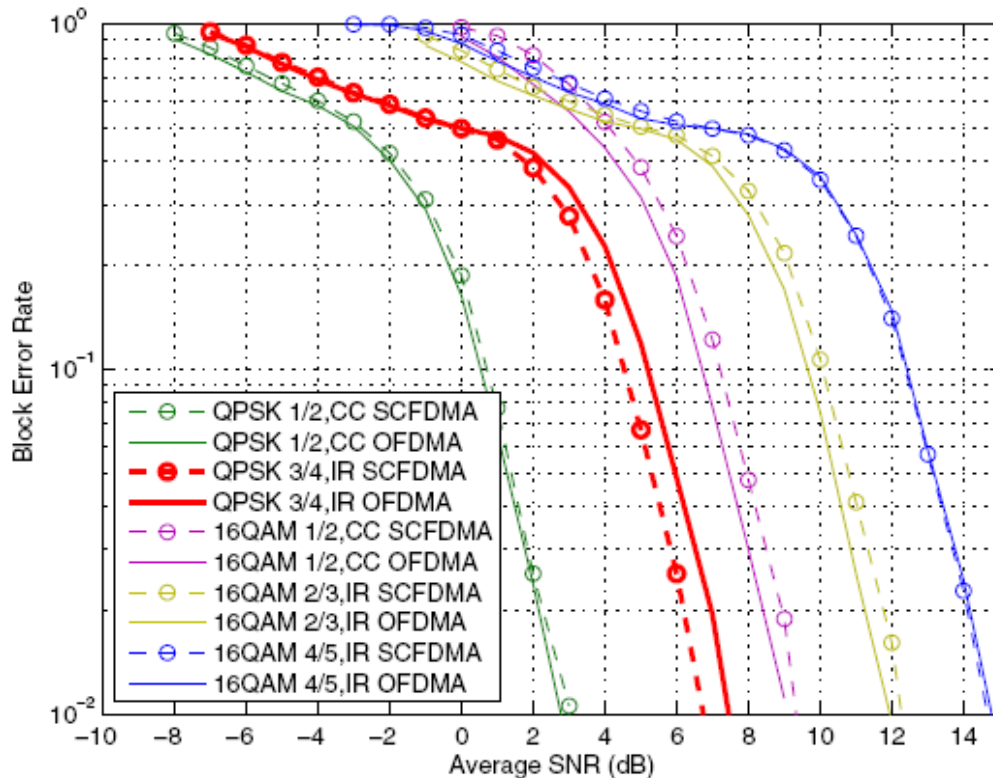
Figure 1. Comparison of transmitter and receiver structure (SC-FDMA vs. OFDMA)

OFDMA



BLER performance comparison

- Performance comparison between OFDMA and SC-FDMA has been carried out in [5]-[6].
- Figure 2 from [6] presents the block error rate (BLER) performance for SC-FDMA and OFDMA with HARQ in the SIMO case.
- The performance for the two schemes is very similar with gaps usually less than 0.5 dB, for some MCSs.

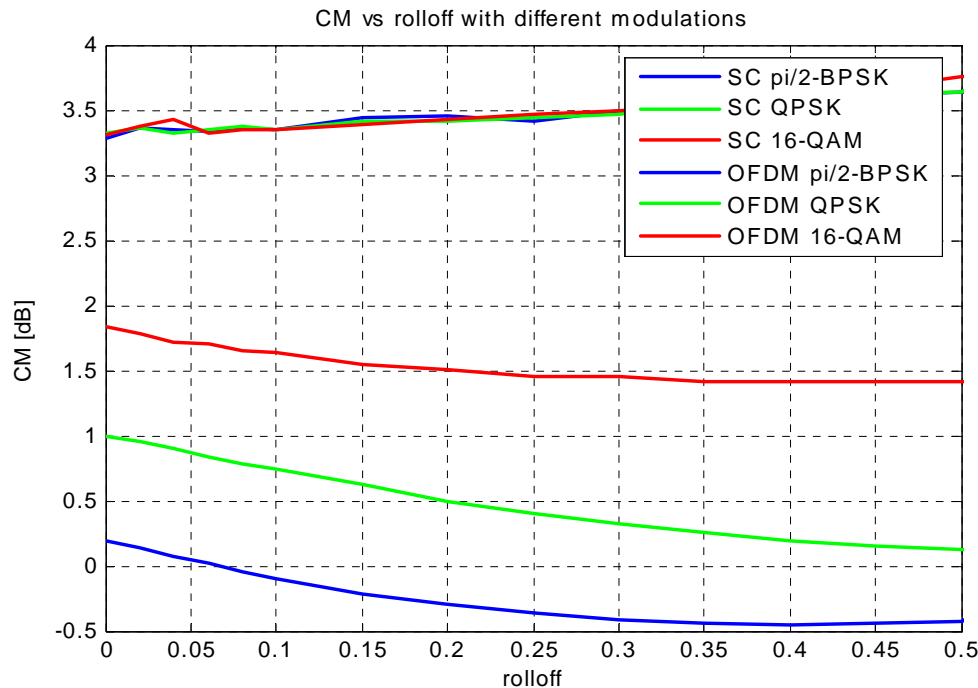


- Advanced non-linear receiver could be used in BS to boost the link performance, e.g. Turbo equalization which performance is quite close to the matched filter bound (MFB).
- The increased complexity is reasonable. More importantly it is in BS side.
- Conclusion: there is almost no equalization loss if proper receiver algorithm is used.

Figure 2. SC-FDMA vs. OFDMA for various modulation and coding sets

CM/PAPR comparison

- The cubic metric (CM) is a more effective measurement of a typical power amplifier in a mobile handset [7].
- Similar to PAPR, the higher the CM is, the lower the transmitter efficiency.
- The cubic metrics of SC-FDMA and OFDMA with different roll-off factors and for different modulations are shown in Figure 3 [5], where the CM of SC-FDMA shows a consistent lower value than their corresponding OFDM system.

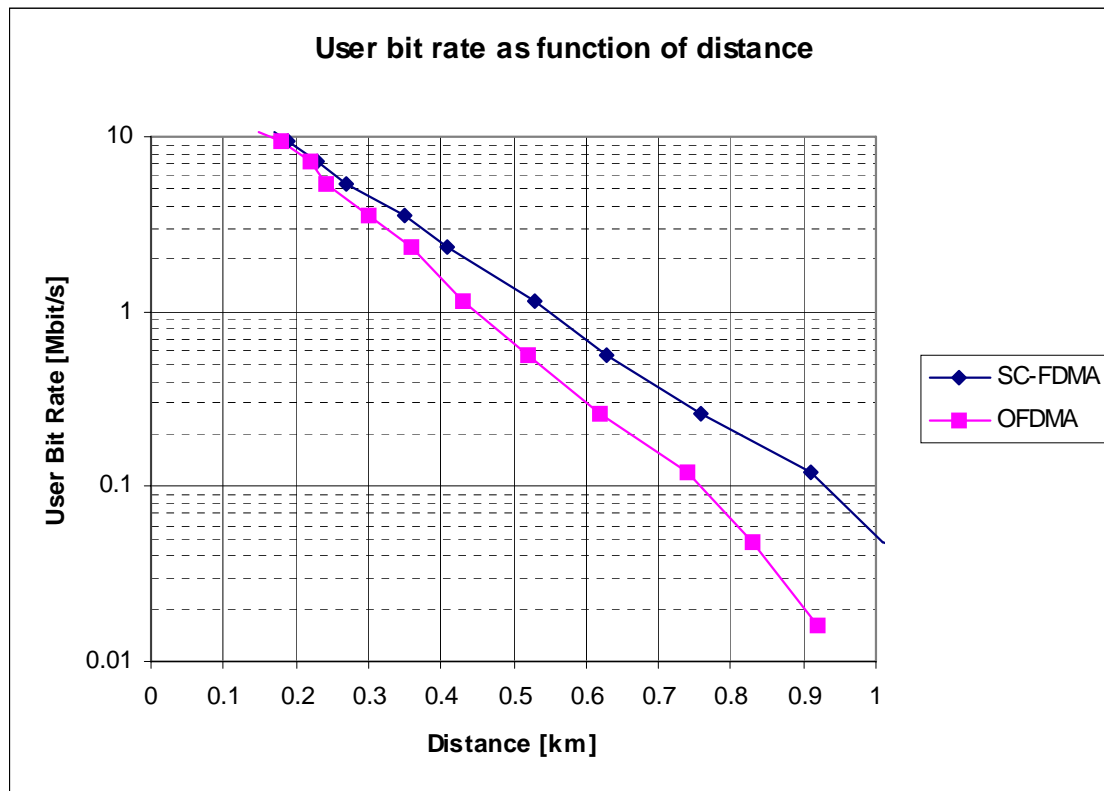


- The gains from lower CM/PAPR for SC users;
 - translated to coverage gain. E.g. it increases the cell edge coverage, and also increase the high bit rate coverage.
 - Low CM/PAPR \rightarrow low needed output backoff (OBO) \rightarrow high power amplifier efficiency \rightarrow lower power consumption \rightarrow longer battery life.

Figure 3. Cubic metrics as function of roll-off

Coverage comparison

- The coverage area are shown in Figure 4 [4].
- The typical-urban channel is used in the simulation.
- From the figure, it is clear that SC-FDMA provides a consistent higher data rate for the same coverage than OFDMA.



- Within the distance range of 0-900 m, SC-FDMA gives up to 400 % higher bit rate than OFDMA

Figure 4. User bit rate at 90 % availability as function of distance

Multiplexing method for single carrier users

- Considering the legacy support, there are basically two methods to multiplex single carrier users with 16/16e users, i.e. time division multiplexing (TDM) and frequency division multiplexing (FDM). Of course, the combination of these two is one option as well.
- TDM:
 - The conventional OFDMA users and SC-FDMA users will be separated by time.
 - As shown in Figure 5. Thus a new zone will be defined as SC-FDMA zone which is exclusively reserved for SC users.
- FDM:
 - As shown in Figure 6, in which the data from SC-FDMA users and OFDMA users are mapped onto different sub-carriers.

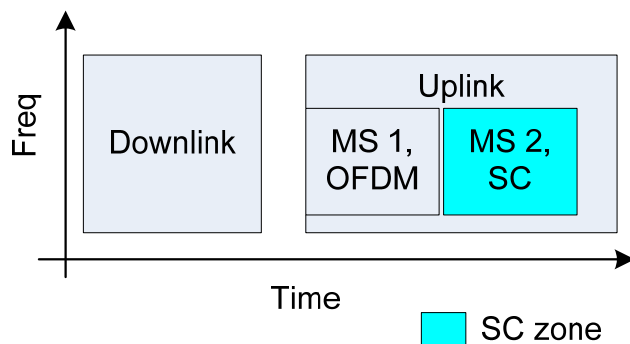


Figure 5. TDM method of multiplexing SC-FDMA into 802.16m

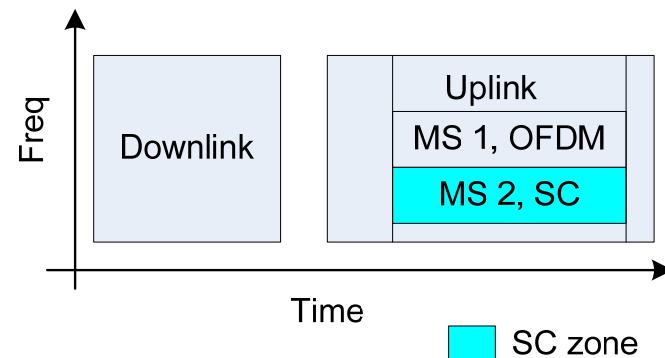


Figure 6. FDM method of multiplexing SC-FDMA into 802.16m

Conclusion

- SC-FDMA has similar link performance than OFDM, if proper receiver algorithm is selected.
- SC-FDMA has much lower PAPR/CM than OFDM, which could be mapped to coverage gain and lower power consumption. On the other hand, for OFDM user it means expensive while low efficiency PA.
- SC-FDMA provides a consistent higher data rate for the same coverage than OFDMA.
- We propose to incorporate the single-carrier FDMA into 802.16m.

Proposed changes

- *[Insert in the ToC in the PHY layer in the appropriate sections (like Multiple Access Scheme, PHY Processing, Subcarrier Allocation, etc) provisions for SC-FDMA.]*
- *x.x.x.x Single Carrier FDMA*

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