Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Proposal of the SHR and SFD structure]
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Re: [Proposed Resolution of D0 Comments S10-13, S10-24, S10-467, S10-468, S10-469]

Abstract: [Definition of SHR for IEEE 802.15.6 UWB PHYs.]

Purpose: [Proposal for the SHR and SFD structure.]

Proposed Resolution of D0 Comments S10-13, S10-24, S10-467, S10-468, S10-469 (SHR and SFD structure)

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D0 Comments S10-13, S10-24, S10-467, S10-468, S10-469

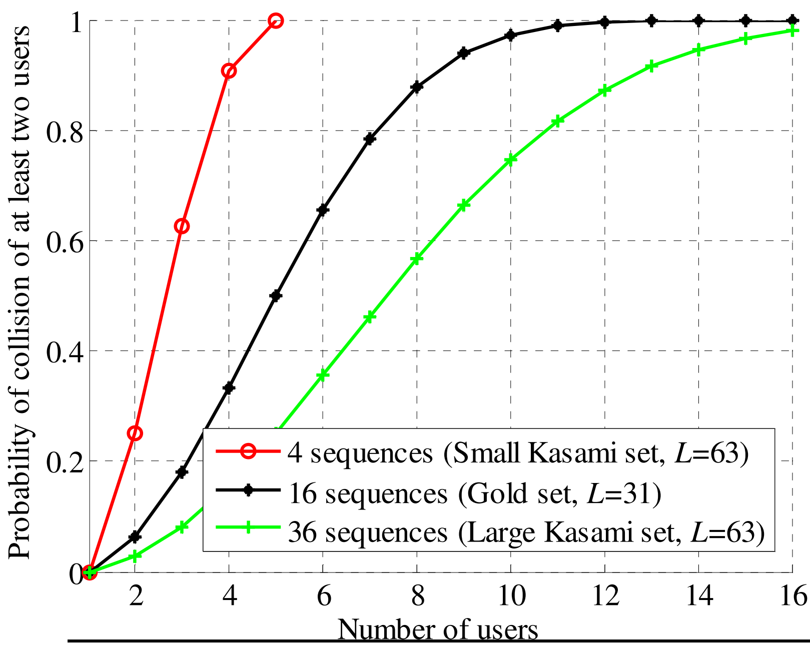
- S10-13: Figure 116: "S_0" is not defined anywhere in the text. Defined SFD signal structure.
- S10-24: 171 10.7 17 N_sync = 4 is not large enough to accomplish all the necessary assessment, acquisition, and estimation at the receiver. Find the optimized repetition number (N_sync) considering all the receiver functionalities and procedures, and detailed simulation study.
- S10-467: 171 10.7 3 Sequence length of 63 Shorter sequences (eg 31) would simplify the receiver implementation, especially in presence of large time drifts
- S10-468: 171 10.7 3 Number of sequences Ns = 4 More sequences of smaller length would benefit the performance and the receiver implementation
- S10-469: 171 10.7 6 8 sequences in the proposed Kasami set A larger set (eg Gold codes, which has nearly as excellent crosscorrelation properties than Kasami sequences) could be used to improve coexistence according to the TG TRD, and would offer a large choice for the SFD specification

Proposed Resolutions (options considered)

- SHR structure:
  - Gold Sequences of length L=31.
  - Large Kasami set of length L=63.
- *N_sync:* Depends on the L used.
- SFD structure:
  - One inverted sequence from SHR, i.e:
    SHR: $\boldsymbol{S}_i, \boldsymbol{S}_i, \ldots, \boldsymbol{S}_i$
    SFD: $-\boldsymbol{S}_i$
  - Different sequence from the same set as SHR, i.e:
    SHR: $\boldsymbol{S}_i, \boldsymbol{S}_i, \ldots, \boldsymbol{S}_i$
    SFD: $\boldsymbol{S}_k$

Proposed Resolution – SHR sequence sets comparison.

Set name	Length	Total number	Number per channel	Maximum circ. x-corr. (dB)
Small Kasami	63	8	4	-9.54
Large Kasami	63	72	36	-6.2
Gold	31	33	16	-6.46



Probability of users using same preamble sequence, i.e. users' sequences collision, grows rapidly with the number of users for the Small Kasami set. Situation gets better with the increase in the sequence set size.

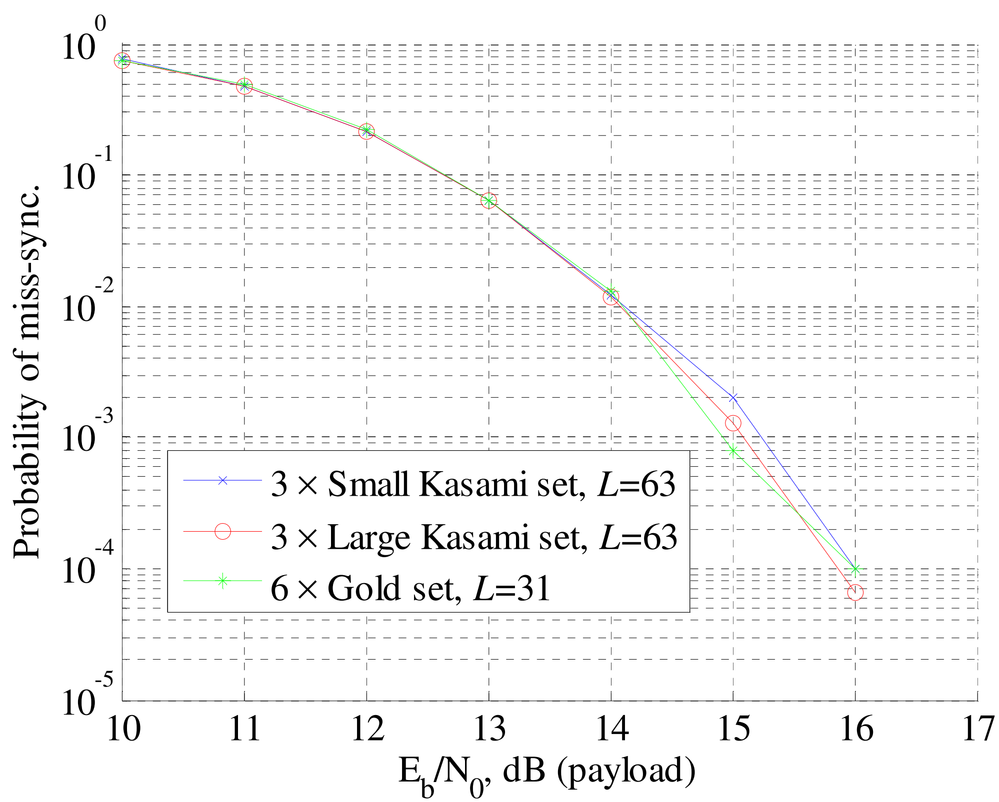
Proposed Resolution – SHR sequence sets comparison (cont'd).

Synchronization performance comparison.

- *N_sync*= 4 for *L*=63 (as in D0).
- *N_sync*= 8 for *L*=31.
- Differentially encoded PHY with short-pulse bursts in mandatory data rate.
- Sampling receiver:
  - P_FA= 1e-9
  - Infinite sampling resolution.
  - 16 samples per SFD symbol.
  - 32 samples per payload symbol.
  - Sample-wise DPSK (S-DPSK) detection
  - Payload size: Random: 1- 256 octets.

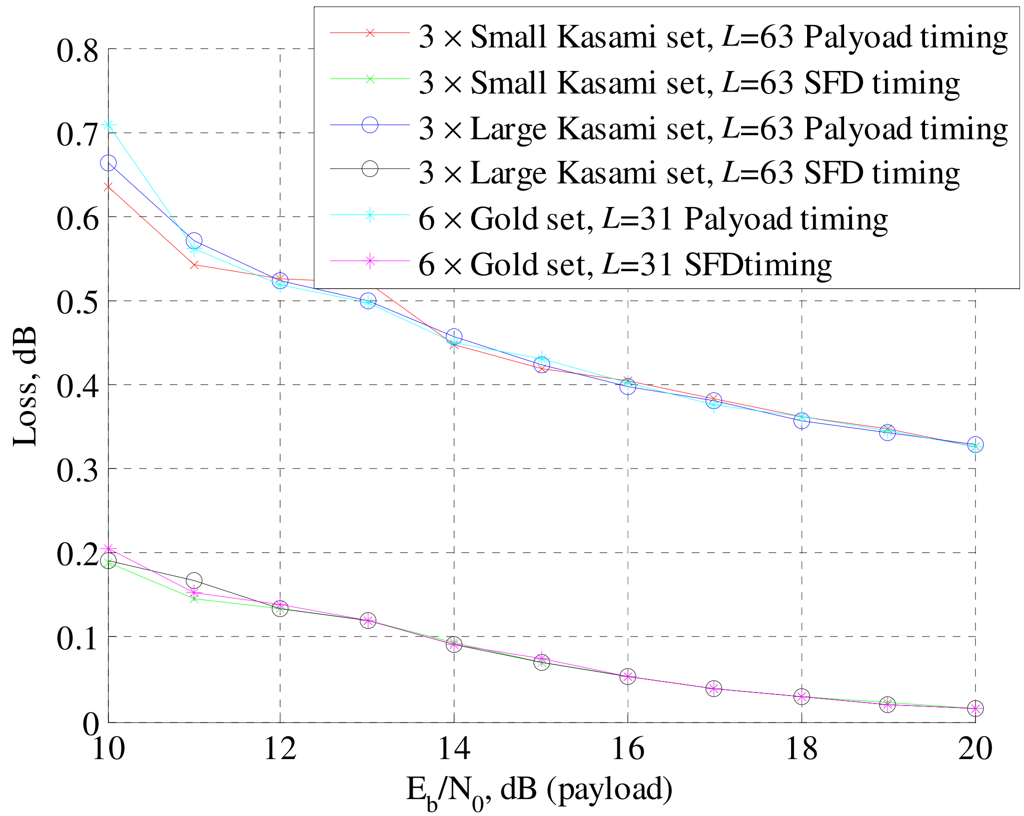
Proposed Resolution – SHR sequence sets comparison (cont'd).

- Synchronization performance comparison.



Proposed Resolution – SHR sequence sets comparison (cont'd).

- Synchronization performance comparison.

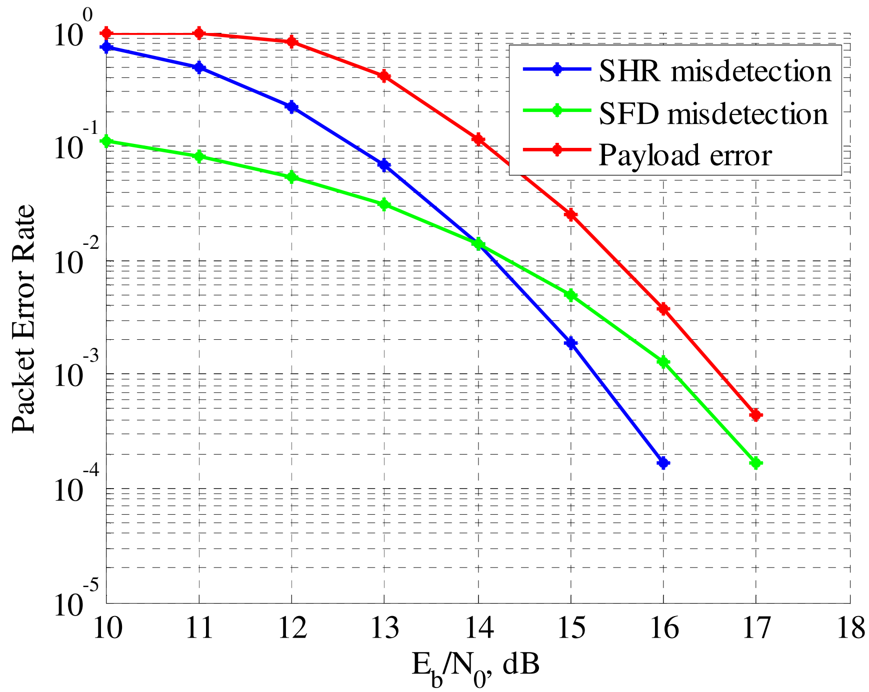


Proposed Resolution – SHR sequence type

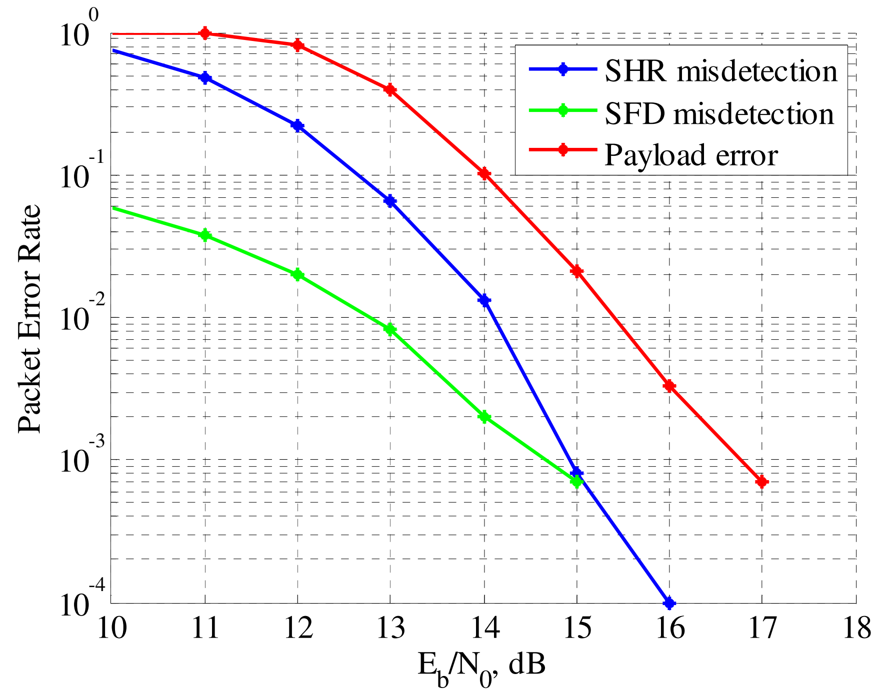
- All sequences considered show similar performance.
- There is a large benefit in using shorter Gold sequences in smaller correlator size, thus roughly twice lower digital back-end computational complexity for synchronization.
- Large Kasami set has an advantage in the set size, i.e. number of sequences and thus lower collision probability.

Proposed Resolution: SFD (Gold set)

- Using different sequence than SHR

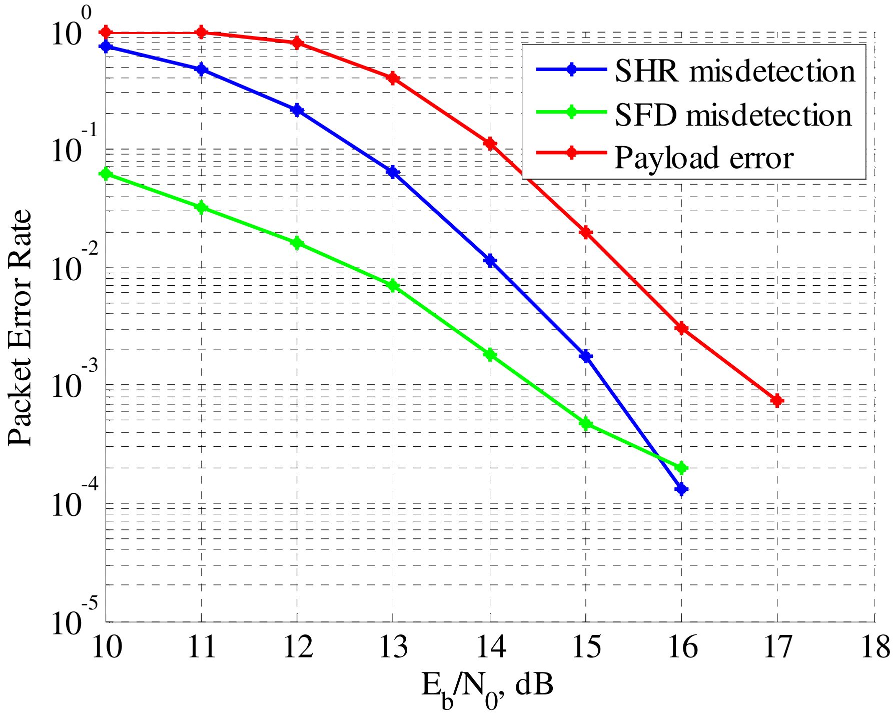


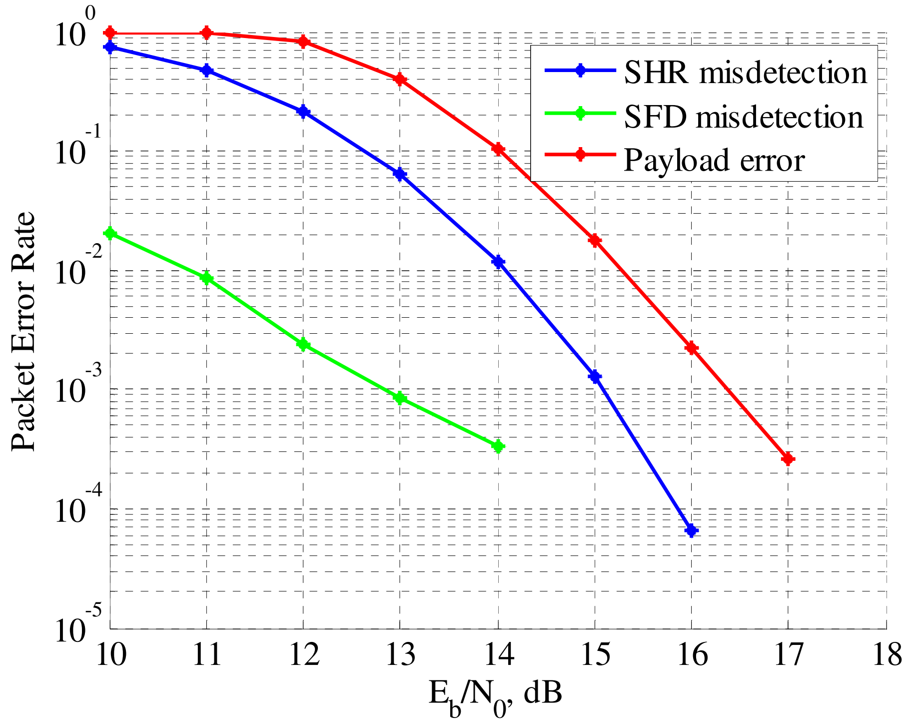
- Using inverted sequence from SHR



Proposed Resolution: SFD (Large Kasami set)

- Using different sequence than SHR
- Using inverted sequence from SHR





Proposed Resolution: SFD

SFD should be a single inverted sequence from the one used in SHR.

- It yields optimum (orthogonality) between two decision hypothesis in SFD detection:
  1. Another SHR sequence is present.
  2. SFD is present.
- It is economical on reuse of sequences, yielding less interference among users during sync.
- SNR for SFD detection is about enough for Gold sequences of length 31, while for the length 63 of Kasami sequences there is a significant margin.

Proposed Resolution: *N_sync*

From previously shown results for differentially encoded PHY:

- *N_sync* = 4 should be enough for *L*=63.
- *N_sync* = 8 should be enough for *L*=31.

These results are dependant on a receiver architecture. Some architectures with less parallel processing capabilities will probably need larger *N_sync* .