

I. Context

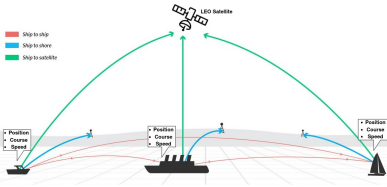
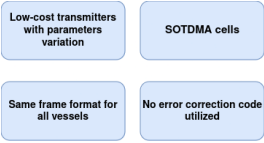


Figure 1: AIS communications

- The Automatic Identification System (AIS) [1] was mainly designed for nautical and short range communications.
- Satellite AIS emerged from the beginning of 2008's.

Problematic:

➢ Characteristics of the AIS System:



➢ Difficulties of Sat-AIS receivers :

- Multiple Access Interference - Figure 2 [2]
- Satellite Propagation Delay ≈ 2-10 ms
- Satellite Doppler Shift ≈ ±3.8 kHz

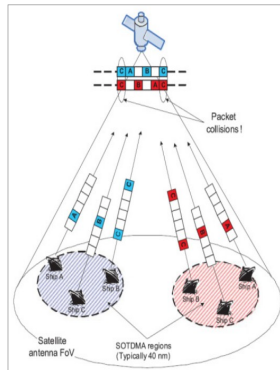


Figure 2: AIS multiple access interference [2]

Objective:

- Our main focus is to cope with the overlapping messages issue to improve the success rate of detected AIS messages.
- This could be achieved through satellite interference management.

II. Interference Management

- The multi-user received signal model during a given AIS time slot:

$$r(t) = \sum_{i=1}^N \alpha_i s_i(t - \tau_i, \mathbf{a}) e^{j(2\pi f_{d,i}(t) + \phi_i)} + n(t)$$

$$f_{d,i}(t) = f_{d,i} + \eta_i t / 2$$

- Several approaches have been implemented for the purpose of interference management of AIS signals:

- Phased Antennas Array Approach
- Bandwidth Separation in Sub-zones Approach
- Interference Cancellation Approach (PIC, SIC)

- Interference Cancellation approach using SIC (Successive Interference Cancellation) is considered.

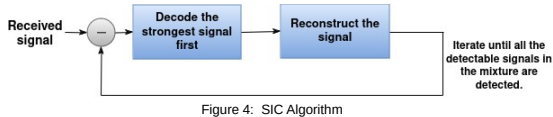


Figure 4: SIC Algorithm

- To mitigate the effect of interference and to improve the detection rate using SIC, the main goals are:

- Improvement of all the iterations of detection
- Robust reconstruction of the modulated signal (Future work)

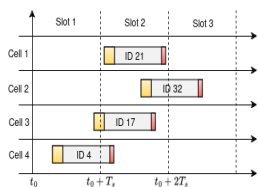


Figure 3: AIS Messages collision

IV. Conclusion

- Exploiting the **a priori information** improves the probability of correct detection robustly with respect to the position of interference.
- The **optimized List Viterbi Algorithm** enhances the success rate of detection. It could be very efficient when combined with the a priori information exploitation method.
- Future Perspectives include robust reconstruction of the correctly detected signal.

III. Methodology

- For improving all the iterations of detection, two main methods are investigated:

1. Exploiting the a priori information about AIS signals in the mixture

- Utilizing the training sequence and start flag of the AIS packet in Figure 5.



Figure 5: AIS packet

2. Increasing the diversity of candidates

- List Viterbi (LV) algorithm is exploited [3].

- For each state at each time instant, store these parameters:

- Cost Metric
- Path history (previous state and path rank)

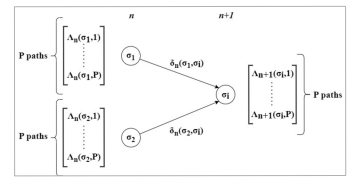


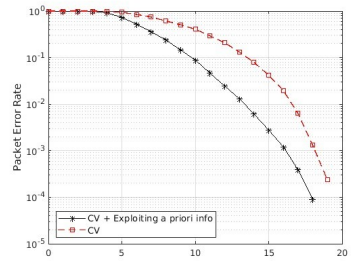
Figure 6: Cost Metric of LV algorithm

- To ensure better performance and less complexity, the parameters of LV algorithm are optimized.
- More details could be found in [4].

IV. Results

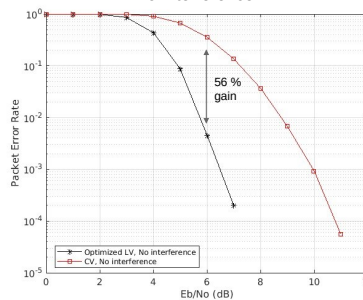
i.

- Performance of exploiting the a priori information with the CV algorithm shows remarkable gain ≈ 2 dB at PER= 10⁻³

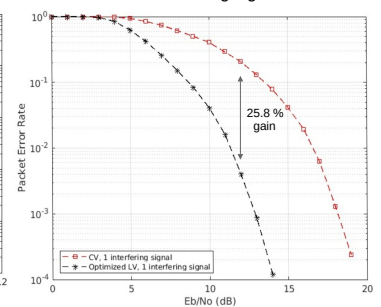


ii.

- Classical Viterbi (CV) and List Viterbi (LV) No Interference

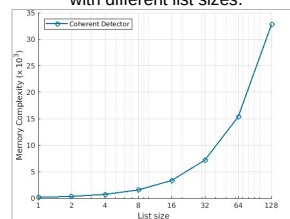


- Classical Viterbi (CV) and List Viterbi (LV) 1 Interfering signal



iii.

- Memory complexity of the LV algorithm with different list sizes.



- The memory requirements increases rapidly for higher values of the list size.

- Utilizing the optimized parameters of the LV algorithm can significantly improve PER at the cost of a **limited** increase of the complexity.

IV. References

- [1] ITU, Technical characteristics for an automatic identification system using time division multiple access in the VHF maritime mobile frequency band - recommendation ITU-r m.1371-5, Feb. 2014.
- [2] M. A. Cervera and A. Ginesi, "On the performance analysis of a satellite-based AIS system," 2008 10th International Workshop on Signal Processing for Space Communications, Rhodes, Greece, 2008, pp. 1-8, doi: 10.1109/SPSC.2008.4686715.
- [3] N. Seshadri and C.-E. Sundberg, "List viterbi decoding algorithms with applications," IEEE Transactions on Communications, vol. 42, no. 234, pp. 313-323, 1994
- [4] L. Kanaan, K. Amis, F. Guilloud and R. Chauvat, "Application of List Viterbi Algorithm for Satellite-based AIS Detection". Submitted.