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Supervised Hierarchical Clustering using Graph Neural Networks for Speaker Diarization

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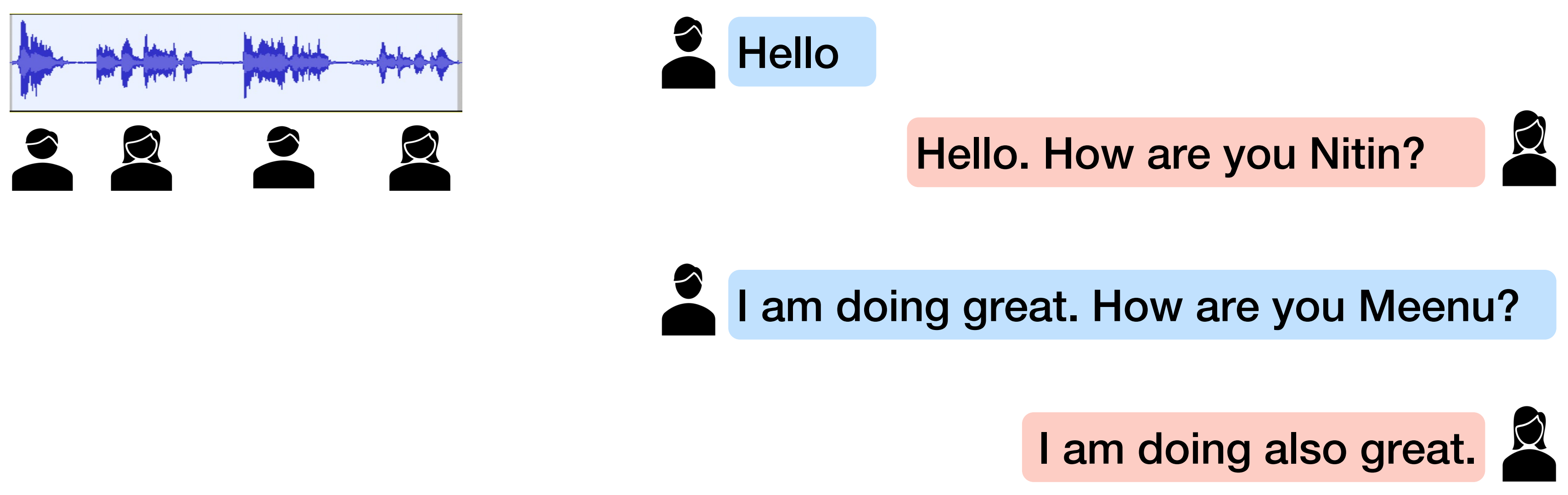
Introduction

- **Conversational audio** contains multiple speakers engaged in a conversation.
- **Transcribing audio into text** using **speaker information** generates much meaningful text.



Hello

Hello. How are you Nitin?

I am doing great. How are you Meenu?

I am doing also great.

Speaker diarization: the task of partitioning and labelling an input audio file into segments based on speaker identity.

Prior work- Drawbacks

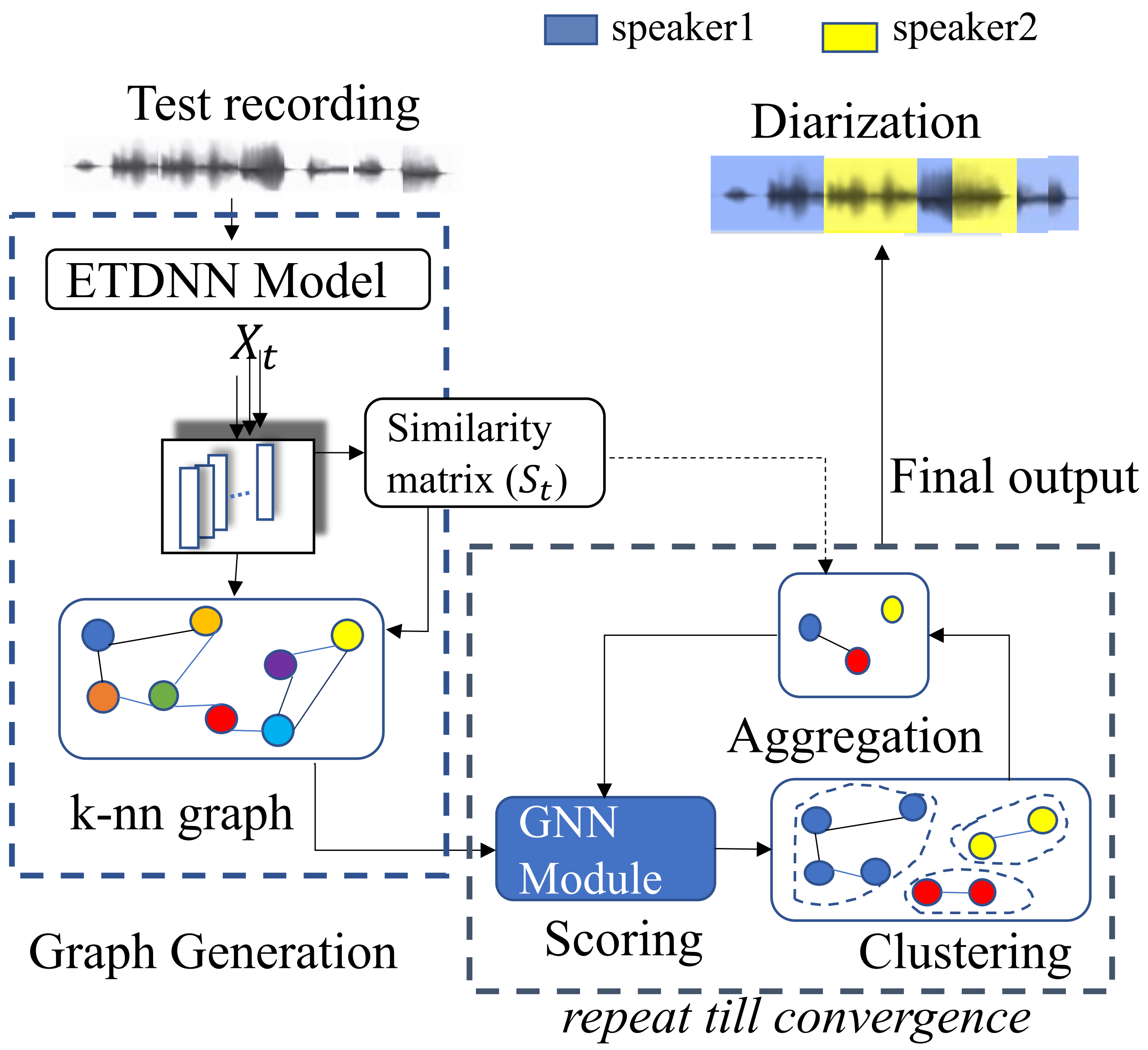
- Conventional X-vector clustering is a multi-step approach where each component is optimized independently.
- The end goal is to minimize the clustering errors to improve performance so why not to train a model with same objective.

Proposed Approach

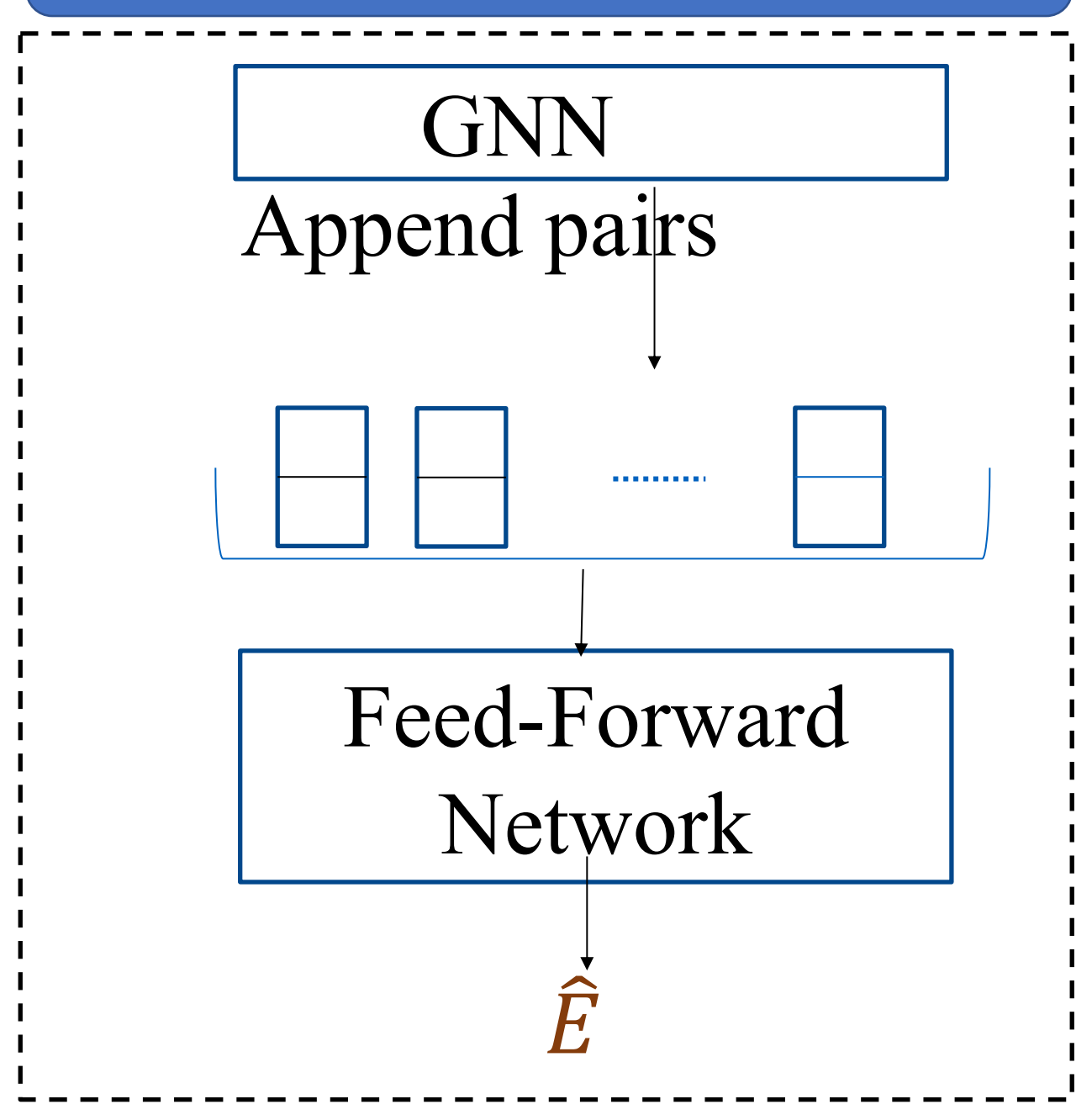
Supervised HierArchical gRaph Clustering algorithm (SHARC)

- Performs **supervised clustering** using **Graph Neural Networks (GNN)**.
- Represents the speaker embeddings using graph
- **Clustering loss** is used to update edges of the graph
- Generates node labels based on clustering performed on updated edges.

SHARC Inference



GNN Module



$$\hat{e}_{ij} = 2p_{ij} - 1 \in [-1,1] \forall j \in N_i^k$$

Clustering

Predicted node density $$\hat{d}_i = \frac{1}{k} \sum_{j \in N_i^k} \hat{e}_{ij} \boldsymbol{S}_r(i,j)$$

Groundtruth node density $$d_i = \frac{1}{k} \sum_{j \in N_i^k} e_{ij} \boldsymbol{S}_r(i,j)$$

$$\varepsilon(i) = \{j | (v_i, v_j) \in E_m, \hat{d}_i \le \hat{d}_j \;\; p_{ij} \ge p_\tau\}$$

SHARC Training

Loss: $L = L_{conn} + L_{den}$

$L_{conn} = BCE\left(p_{ij}, q_{ij}\right) ; L_{den} = MSE\ loss\left(d_i, \hat{d}_i\right)$

q_{ij}- Ground truth edge labels,

p_{ij} - predicted edge labels
$\forall i, j \in V$

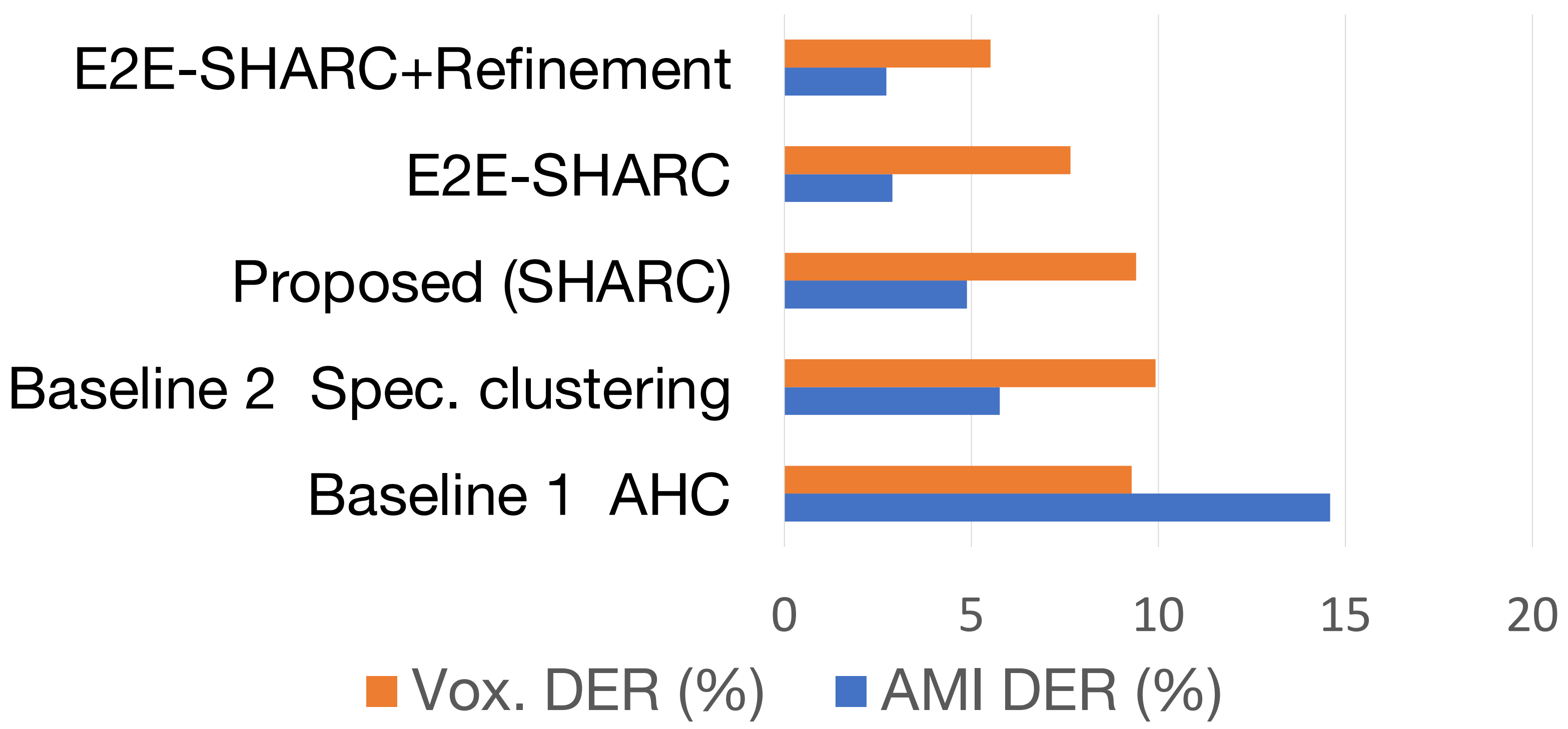
Database

- **AMI:** Meeting dataset containing 20-60 mins audio files with 3-5 speakers, dev set: 18 and eval set:16.
- **Voxconverse**: Conversations extracted from YouTube videos containing 22s - 20mins audio files with 1-21 speakers. dev: 216 and eval: 232.

Results

Diarization Error Rate (DER): Miss + False alarm + Speaker confusion errors
Hyper parameters: k-nn: 60 (AMI), 30 (Vox.)
p_τ**:** 0 (AMI), 0.8 (Vox.)

DER Performance comparision



AMI MDM	Eval DER (%)
ECAPA-TDNN	3.01
SHARC + VBx	2.11
Voxconverse	**Eval DER (%)**
Wang et. al.	5.82
E2E SHARC + VBx	5.51

Conclusions

- Introduced supervised hierarchical clustering for speaker diarization.
- Designed an end-to-end approach to perform speaker diarization using Graph Neural Networks.
- 53% and 41% rel. improvement on AMI and Voxconverse datasets

References: Yifan Xing et. al, “Learning hierarchical graph neural networks for image clustering,” in Proc. IEEE ICCV, 2021,
Hossein Zeinali et. al., “BUT system description to vox- celeb speaker recognition challenge 2019,” *arXiv preprint arXiv:1910.12592*, 2019.