AMIDA RT07s speaker diarization system

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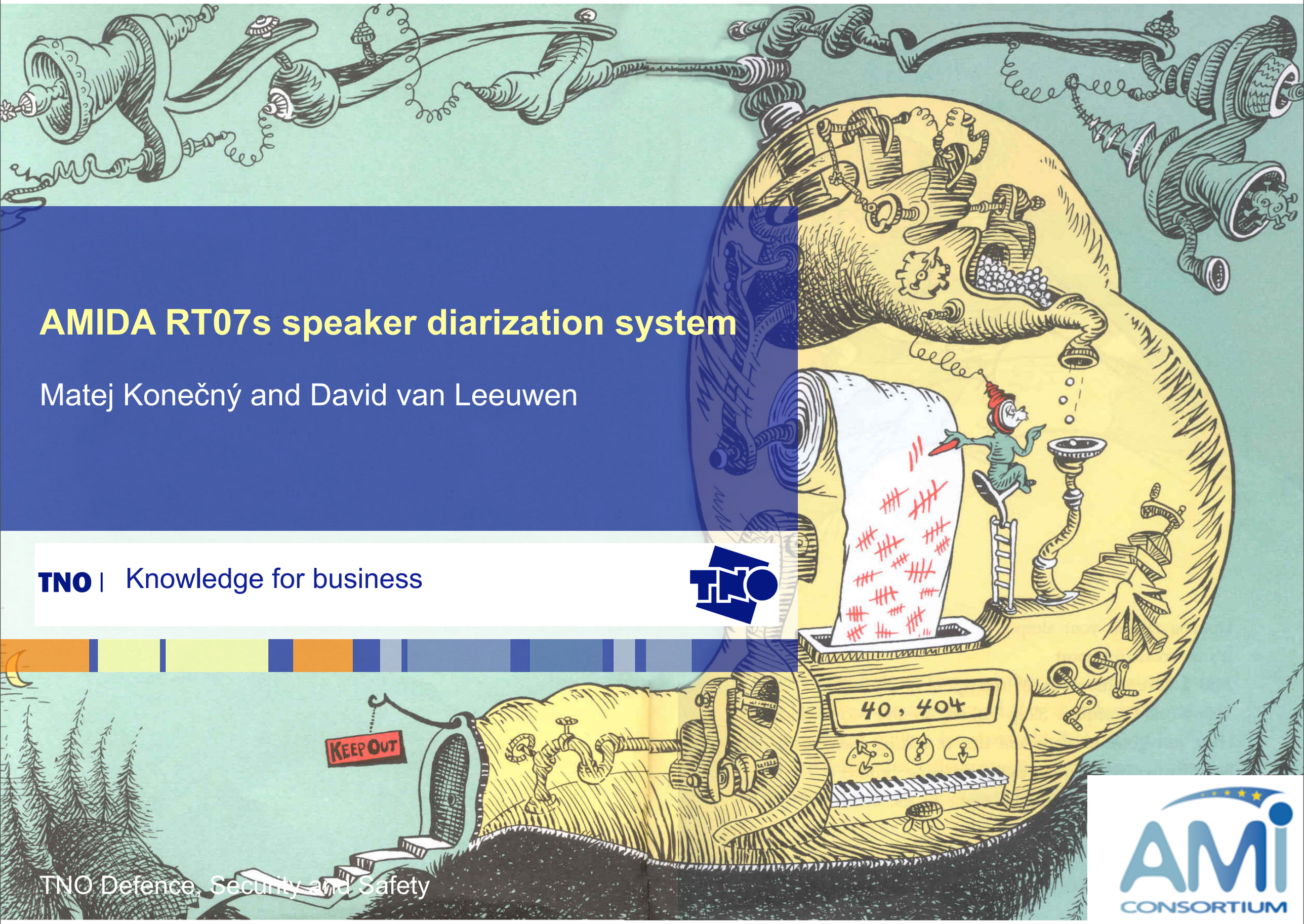
TNO | Knowledge for business



TNO Defence, Security and Safety

AMI CONSORTIUM

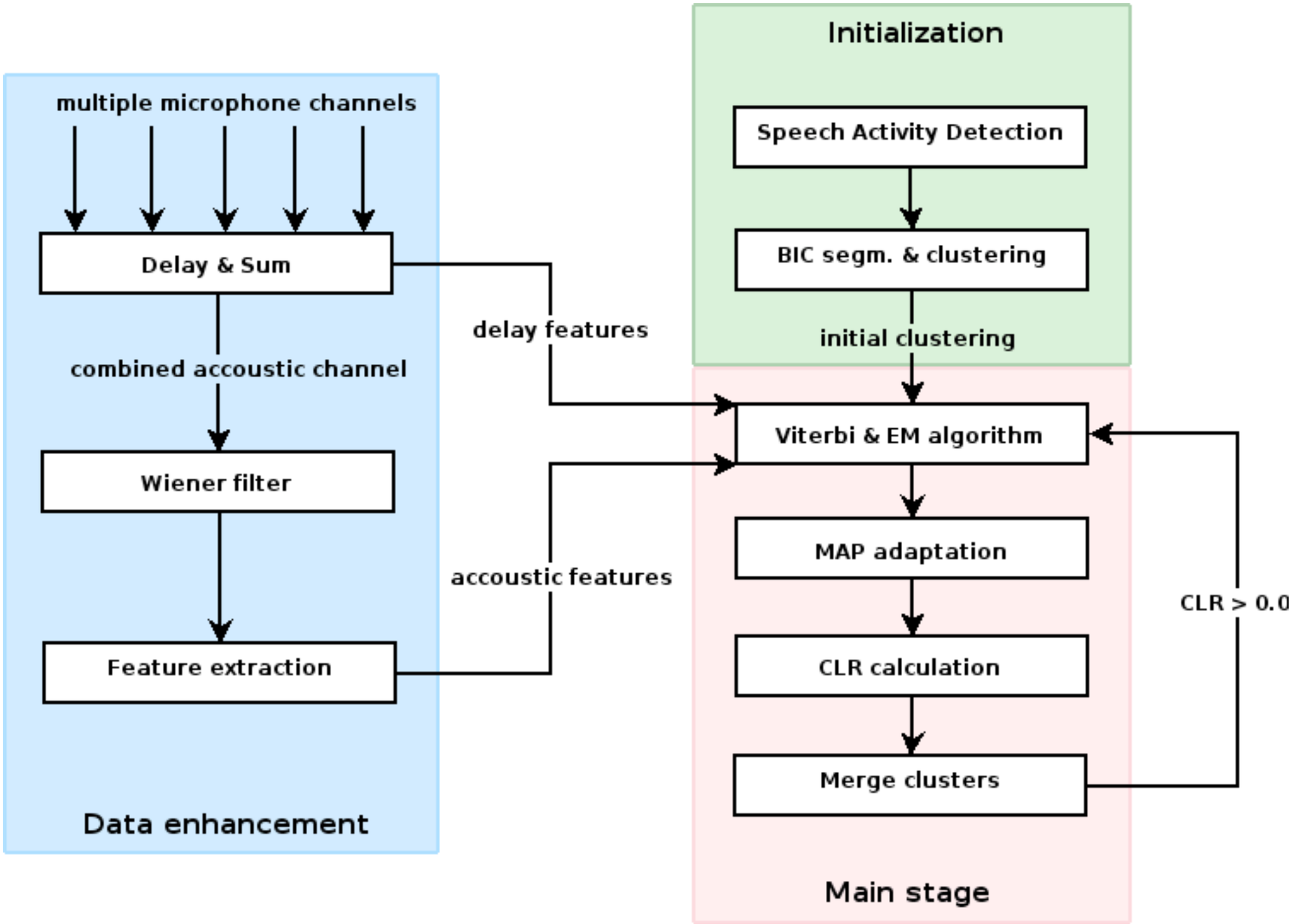
Changes w.r.t. RT06s

- Project, name
  - EU AMI ended, EU AMIDA started
    - DA: Distant Access (not like MDM:)
- Personel
  - Marijn Huijbregts went from AMI to ICSI
  - Matej Konečný AMI/DA trainee from Brno with TNO
- Algorithm
  - Use MDM beamforming
    - signal enhancement
    - delay parameters
  - Cross Likelihood Ratio-based clustering (SID)
    - ‘no more tunable parameters’
  - Minimum duration Viterbi-decoder
- Tasks
  - No lecture room, no more SAD :(,
  - Segmentation/clustering for STT, SASST

Overview

- Differences
- This overview
- Overview SPKR approach
- SAD experiments
- Overlap detection experiments
- Conclusions

AMIDA System design (Matej)

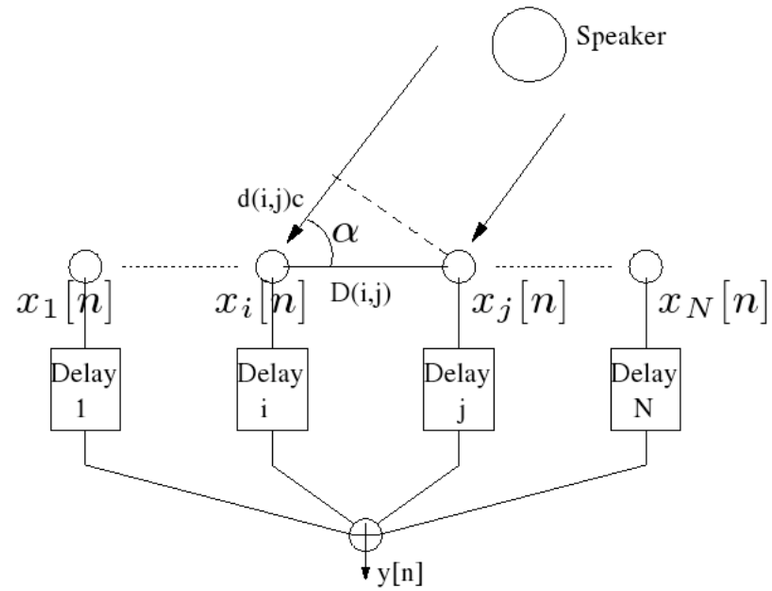


RT07s system: mix of choices

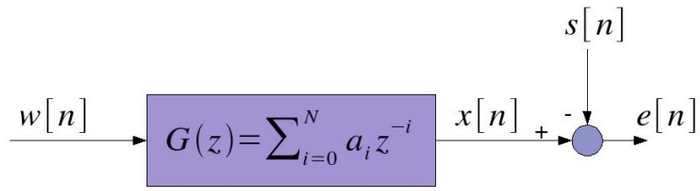
- Speech activity detection
  - Wiener filter
  - Initial segmentation
  - Re-segmentation / clustering
- Speaker/cluster modeling
  - Segmentation
    - Gaussian Mixture Models, #Gaussians(size data)
  - Cluster criterion
    - UBM-GMM, Cross-Likelihood Ratio

System design: front end processing

- Delay and sum beamforming
  - Use Xavie's BeamformIt 2.0
  - use only 32 ms window and 16 ms stepsize
    - different from 500 ms / 250 ms default
    - aligned with PLP feature extraction



- Use Wiener filtering noise reduction
  - *after* beamforming
  - Qualcomm-ICSI-OGI toolkit
  - SAD from toolkit



- Use SAD trained on
  - 10 AMI meetings from RT05s development, SDM
  - not beamformed/filtered

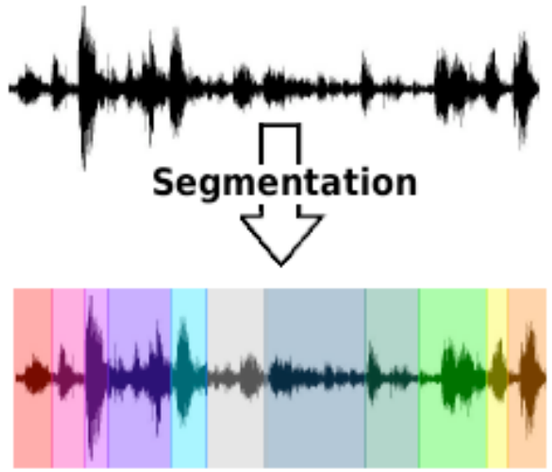
System design: features and modeling

- 13 PLP features (no derivatives)
  - ICSI / Dan Ellis' `rasta` tool
- *N*–1 delay parameters from delay&sum
  - *N* microphones in MDM

- Speaker/cluster modeled by Gaussian Mixture Model
  - 1 Gaussian for delay parameters
  - 1–64 Gaussians for PLP features
    - Cluster complexity ratio ~ 300
      - 4.8 sec speech / Gaussian

- Initialization of GMMs
  - doubling N_G until power of 2 below desired N_G
  - Iteratively increasing N_G by one

Segmentation



- Initialization
  - Generate initial segments using BIC segmenter / clusterer
    - λ_{BIC} = 1 for both
    - many short segments
    - many small clusters

- Use segmentation for training initial GMMs for diarization

- Viterbi re-segmentation (5x)
  - decode
  - keep track of N_G for each cluster dependent on amount of data
    - 4.8 sec / Gaussian
  - grow N_G by splitting
  - reduce N_G by retraining GMM from scatch

Clustering

- Build 64 Gaussian UBM from entire meeting (once)
- MAP adapt UBM to data found by segmentation
- compute cross likelihood ratio for each pair of clusters

$$R_{ij} = \frac{1}{n_i} \log \frac{p(x_i|\lambda_j)}{p(x_i|\lambda_{\mathrm{UBM}})} + \frac{1}{n_j} \log \frac{p(x_j|\lambda_i)}{p(x_j|\lambda_{\mathrm{UBM}})}$$

- Merge clusters *i* and *j* for which
  - R_{ij} is largest and
  - positive
- Stop if maximum $R_{ij} < 0$

Progress, effect of delay parameters

System	DER RT05s (overlap)	DER RT06s (overlap)	DER RT07s (overlap)
AMI RT06s	21.7%	32.4%	26.2%
AMIDA RT07s primary	16.3%	18.1%	**22.0%**
AMIDA RT07s *no delay params*	20.5%	24.3%	

- System has become slightly more robust
- But there still is high variability along dataset
- Delay parameters seem to help quite a bit

Another SAD story

- Good history in Speech Activity Detection performance
  - using 10 AMI meetings for modeling non/speech
  - SDM

- This year using Forced Aligned reference non/speech
- Also using Beamforming/MDM

- Two sets of non/speech models
  - (1) original SDM AMI RT05s-dev
  - (2) new RT05/RT06 FA MDM beamformed

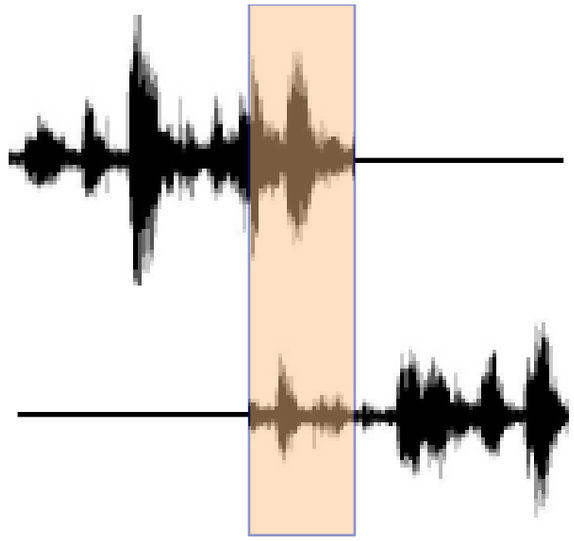
- Best results (mixsad)
  - using (1) for BIC segmentation/clustering
  - using (2) for final frame selection

Results 2006/2007, effect of Speech Activity Detection

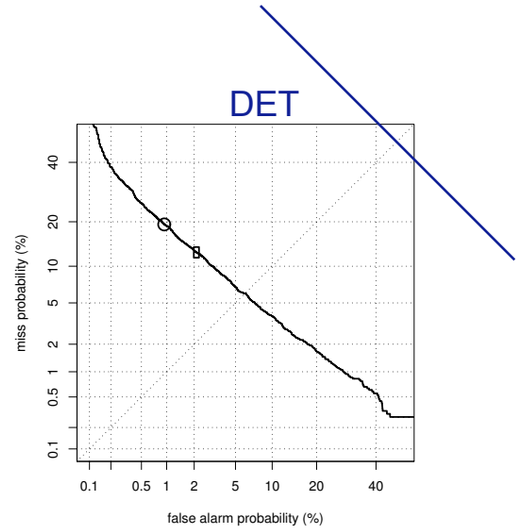
BIC seg/ clust SAD	Final SAD	DER RT06s (overlap)	DER RT07s (overlap)	DER RT07s (no overlap)	SAD err
AMI	AMI	18.1%	22.0%	18.9%	6.7%
AMI	RT forced alignment	20.1%	17.0%	13.4%	2.9%
RT forced alignment	RT forced alignment		18.6%	15.3%	2.9%

- DER very dependent on SAD
- Still no consistent behaviour between RT years
- Still a lot depends on initialization of GMMs

Overlapping speech approach



- Two steps:
  - overlap detection
  - overlapping speaker attribution
- Cheating experiment:
  - perfect overlap detection
  - assign most talkative speaker as 2nd speaker
  - about 2% reduction in DER
- Overlap detection
  - BeamformIt: 6.65% FA @ 85.7% miss
    - *d'* = 0.2, or EER = 46%
    - not good enough detection
  - Training GMMs with/out overlapping speech, decode
  - Building 'overlapping' GMMs from 'single' clusters



Conclusions

- Front-end processing finally pays off
  - SNR improvement
    - delay&sum
    - Wiener filter
  - Modeling of Delay parameters helps

- Initialization of GMMs seems to be important
  - used deterministic estimation this year

- Hardly any ‘tunable parameters’
  - Cluster complexity ratio

- SAD still very important

- Overlapping speech still is a challenge