Gaussian Selection Applied to Text-Independent Speaker Verification

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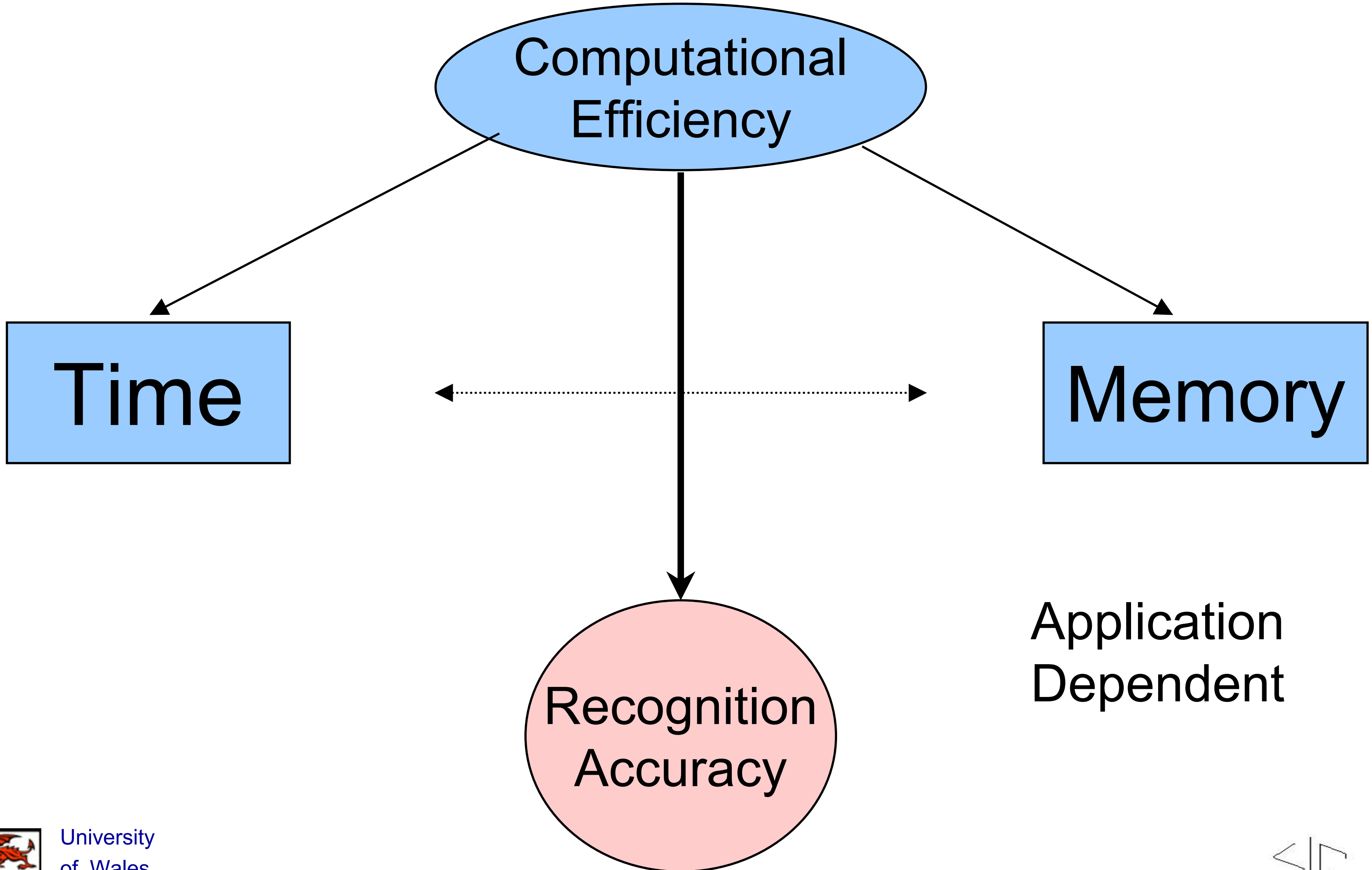
Overview

- Computational Efficiencies in GMM SV
- Application Environments
- Gaussian Selection
- Experimental Results on GS
- Conclusions

Background

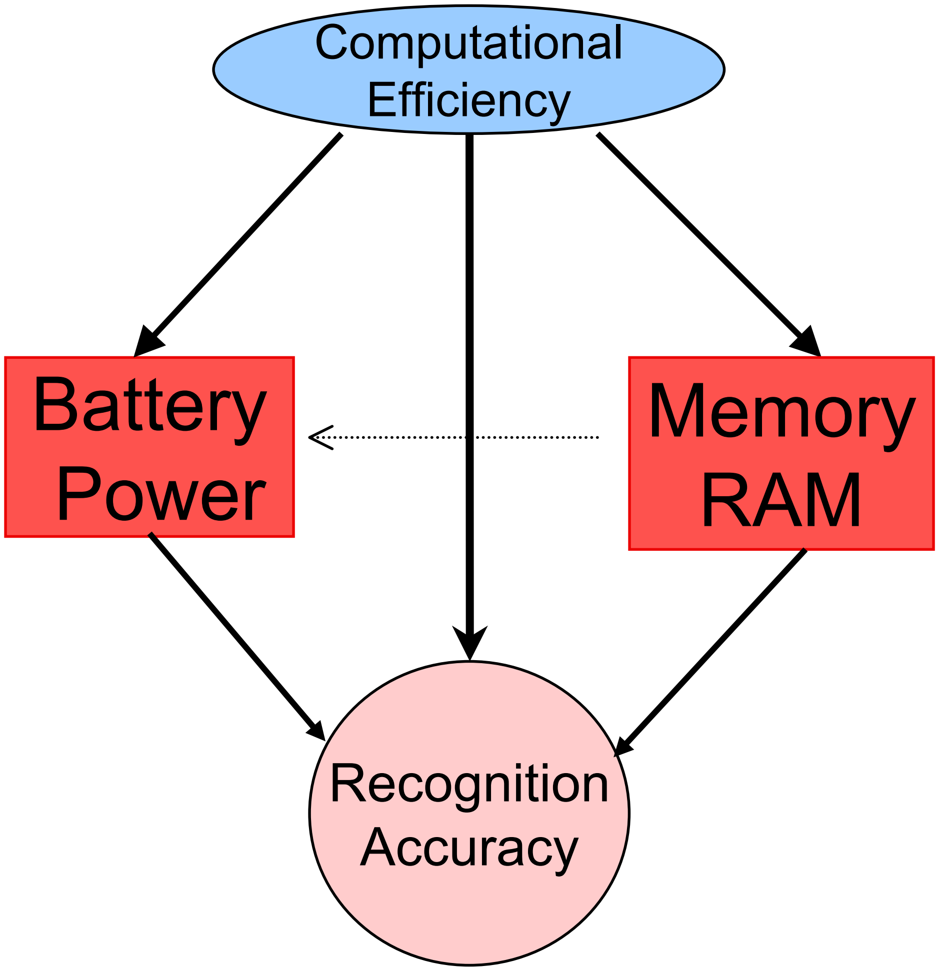


Application
Dependent

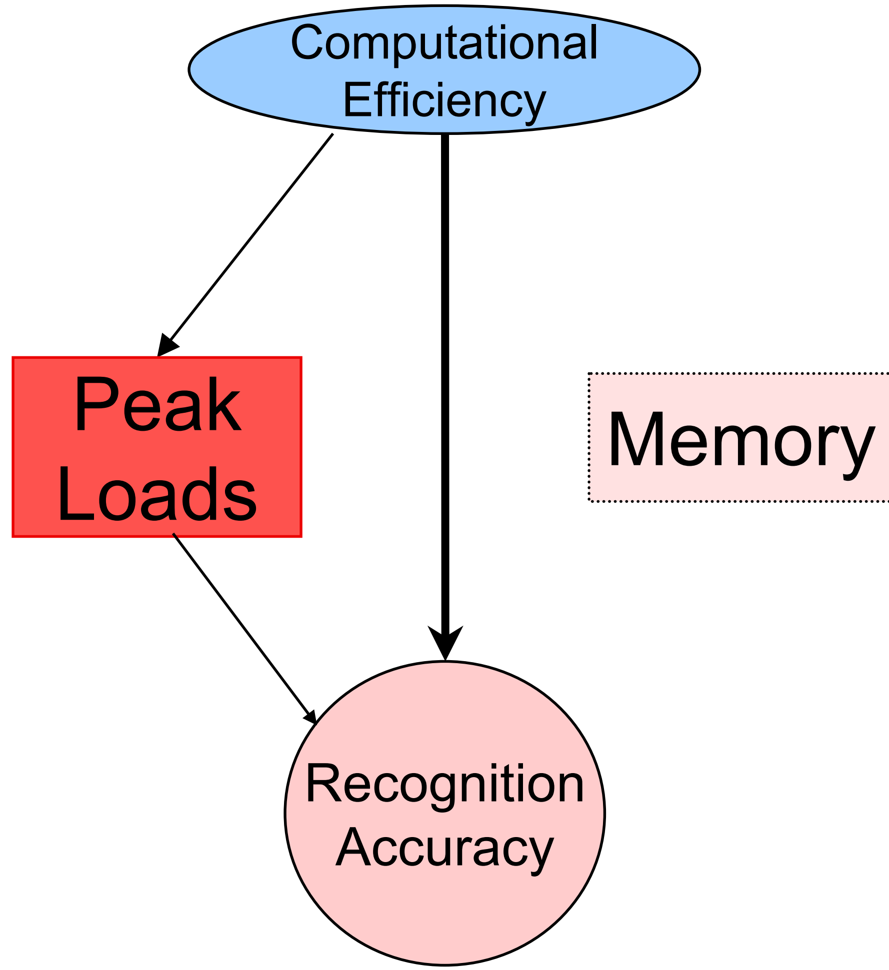
Application Environments

- **Network, Multiple Streams**
  - Multiple simultaneous requests - variable load
  - Computation **Time**, at peak loads
- **Wireless (Mobile), Single Stream**
  - Predictable rates
  - Computation **Time** (Power) and **Memory** (RAM)

Wireless



Network

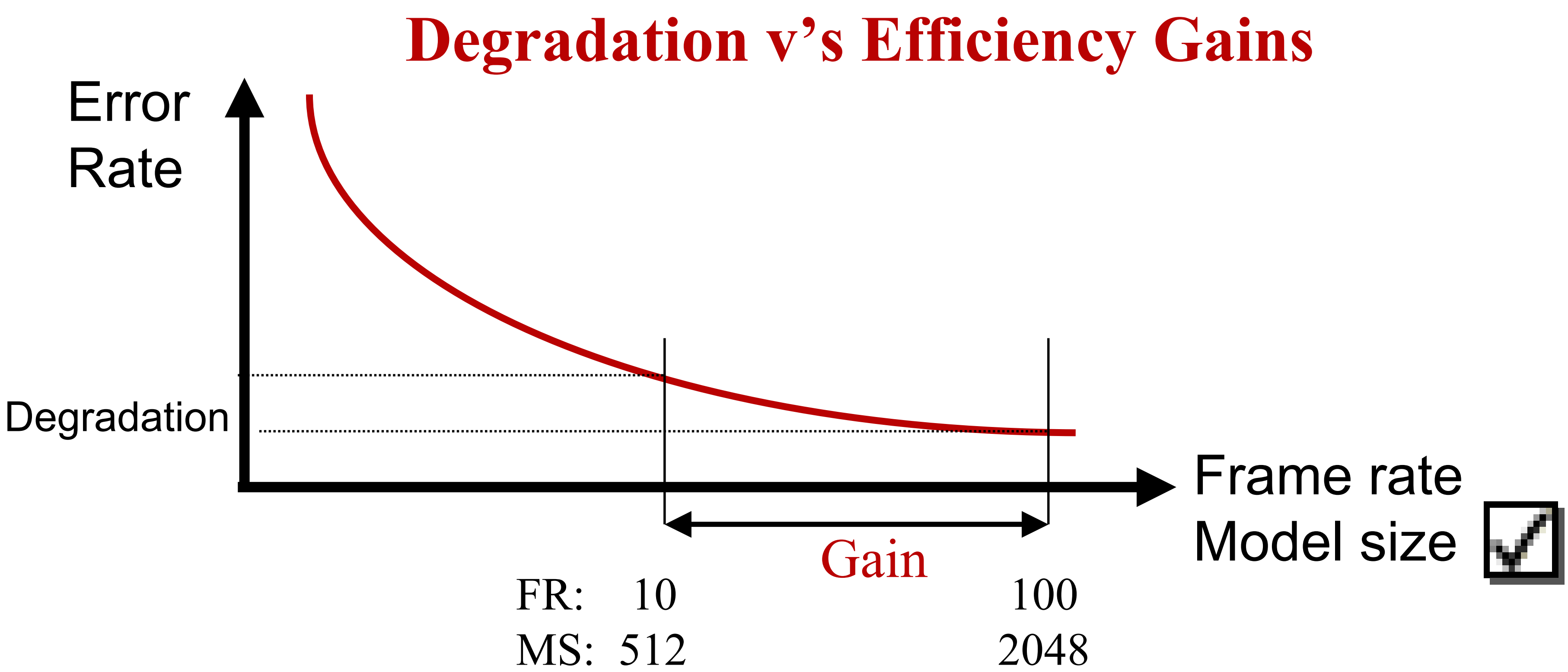


Two General Approaches:

- **Time Sequence** – frame rate
- **Model Size** – search resolution
- Some Previous Work:
  - van Vuuren & Hermansky RLA2C 98, ICSLP98
  - McLaughlin *et al* Eurospeech-99
  - Auckenthaler *et al* ICSLP-99
- Conclusions:
  - 100 frames/sec much faster than necessary
  - ~ 1024 GMM mixture components is "enough"

NB: Text-*independent* and data dependent

The Inevitable Trade-off:

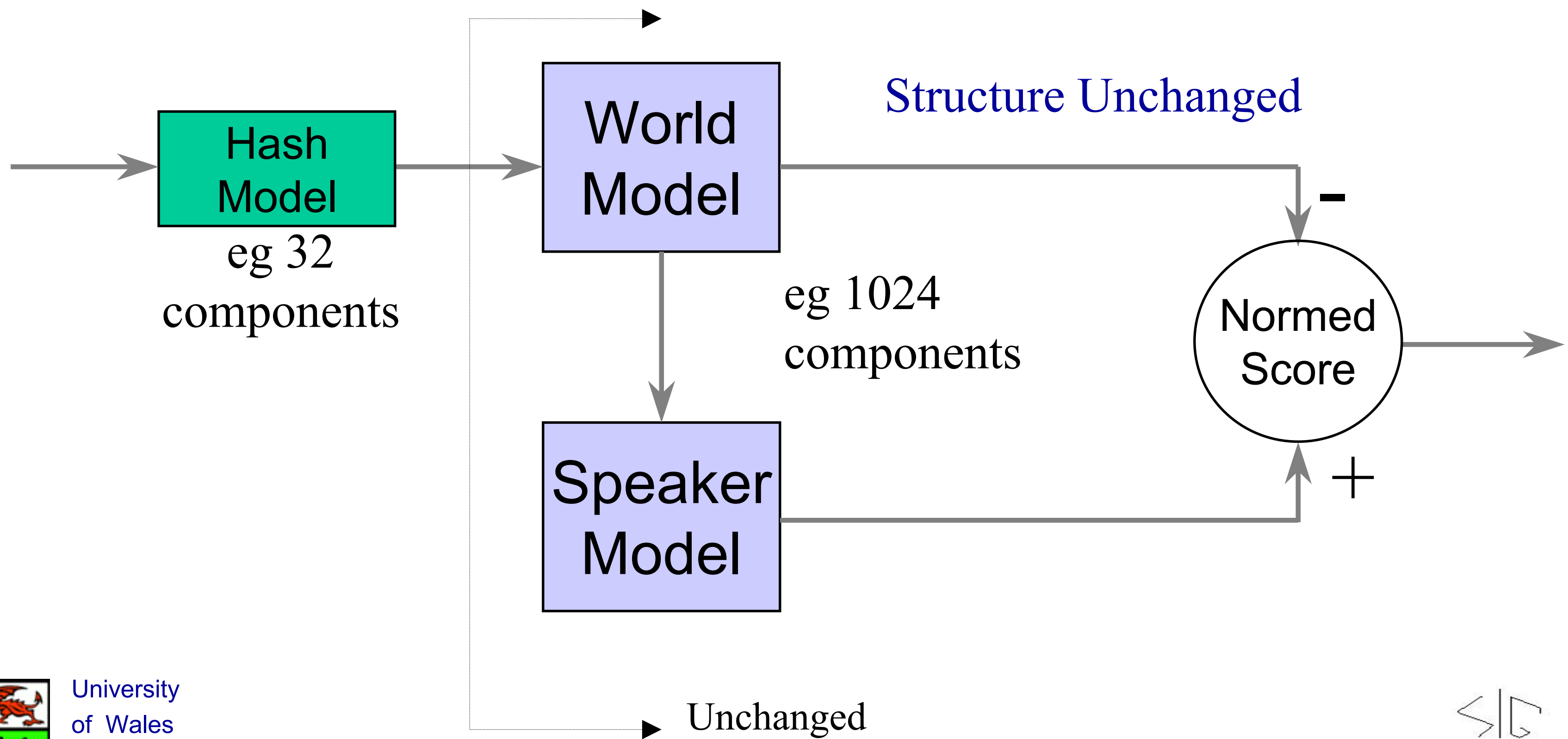


Acoustic Space Resolution

- **> 90% Computation Time in Scoring**
- **Reduce Search Space**
  - Direct Model size - also reduces memory overheads
  - ***Effective*** model size - clever searching
- **Gaussian Selection**
  - Applied in ASR
    [Bocchieri, ICASSP 93, Gales *et al* IEEE Trans SAP 99]
  - Indexing via low-resolution ***hash*** table
    Reduced (sub-optimal) search
- **Degradation v's Search Reduction ?**

Gaussian Selection in a GMM

- GMM SV System with World Model
- Search via a ***Small*** Front-End Hash-GMM



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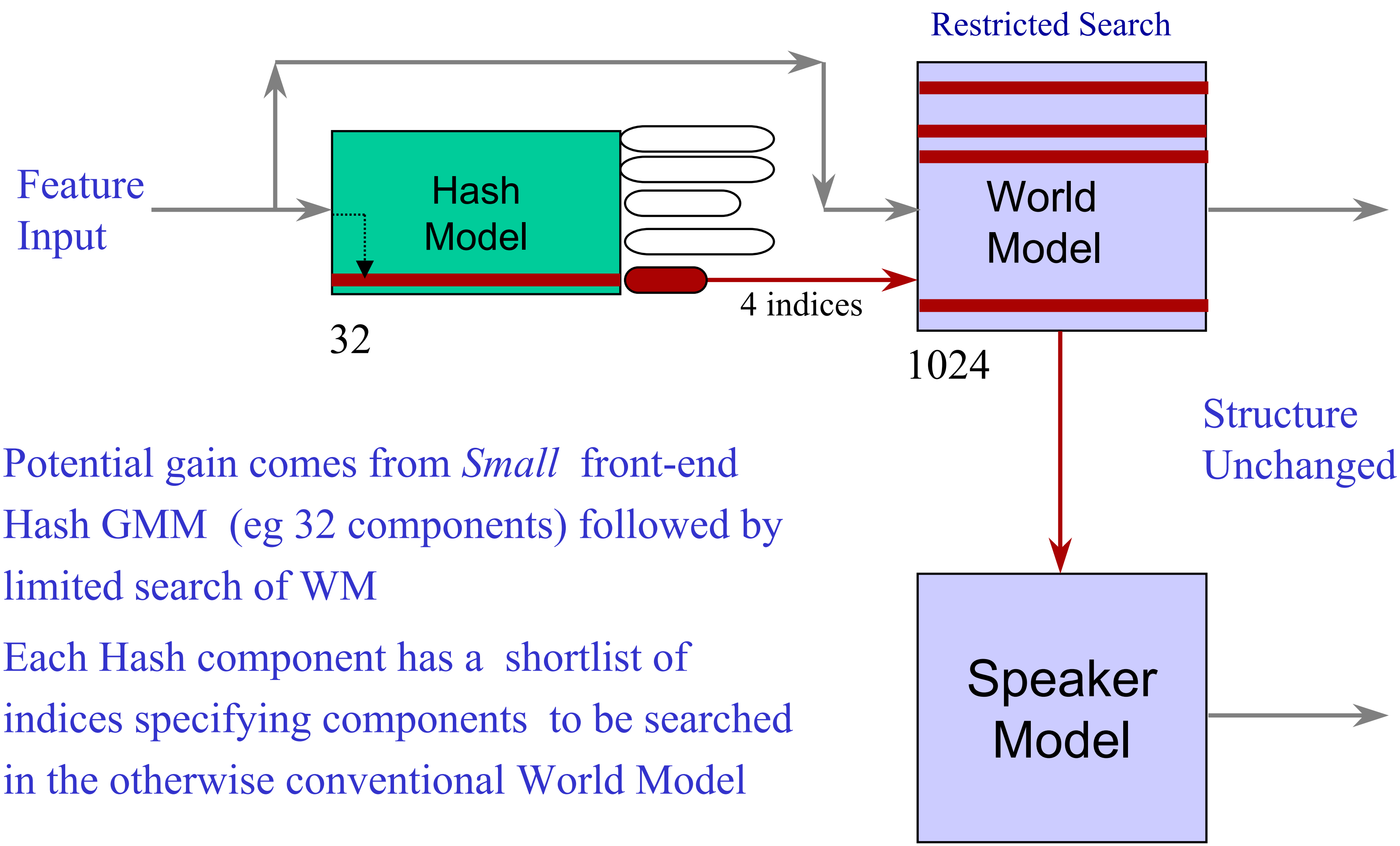
Hash-GMM Operation



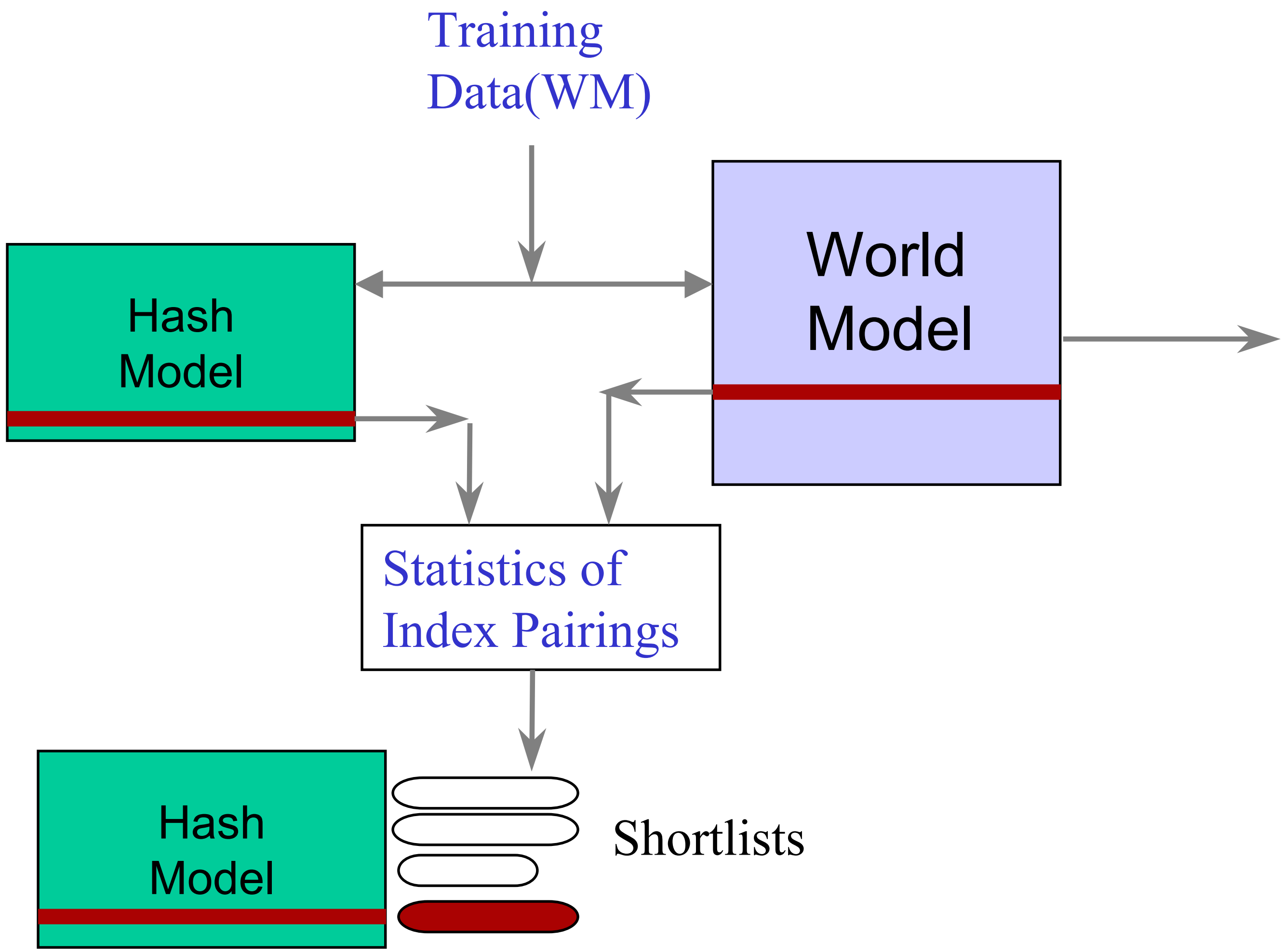
- Potential gain comes from *Small* front-end Hash GMM (eg 32 components) followed by limited search of WM
- Each Hash component has a shortlist of indices specifying components to be searched in the otherwise conventional World Model

Questions:

- *Training of the Hash Model?*
- *Number/Distribution of Indices?*
- *Performance Degradation?*

The first 2 determine computation saving

Hash-GMM Training



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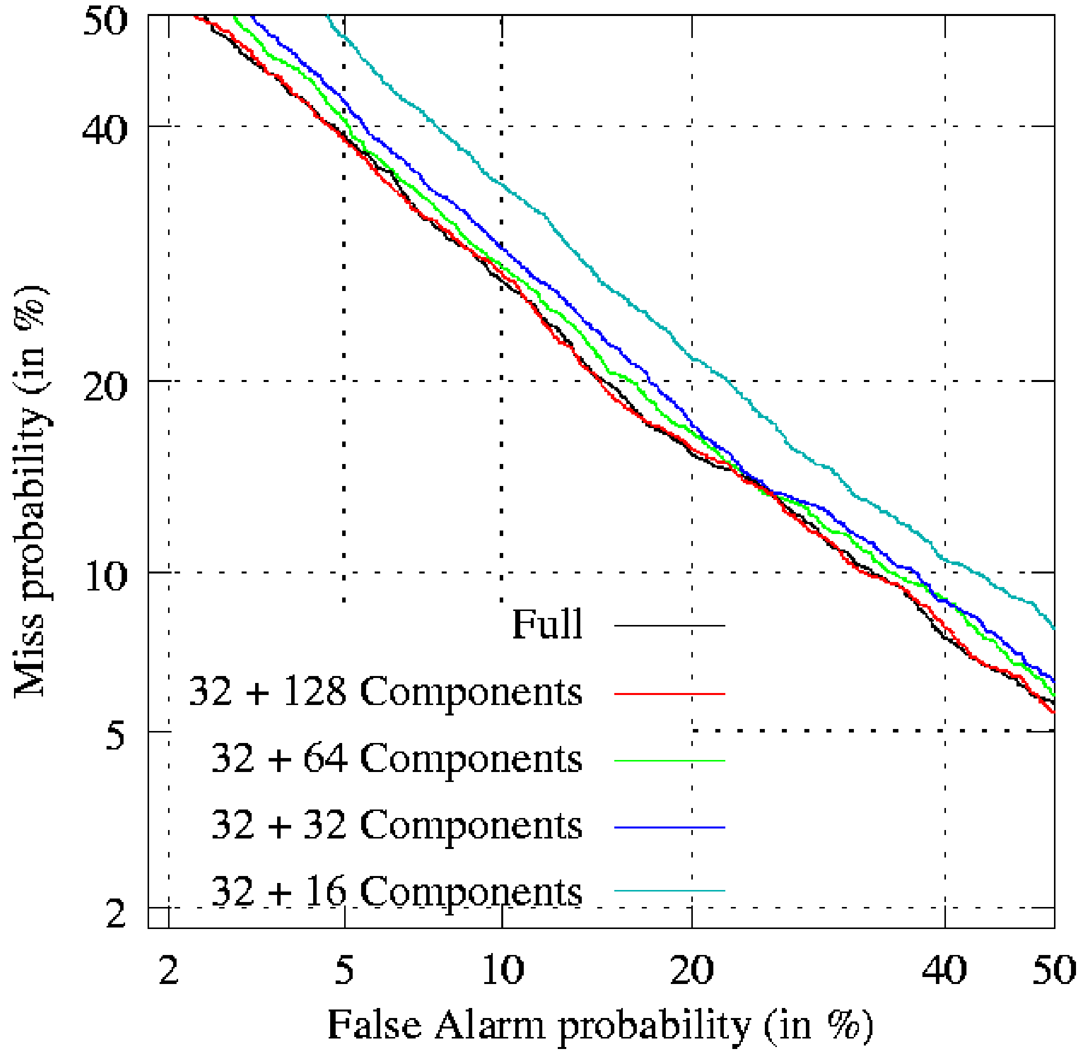
Hash-GMM Training

- **3 Approaches Considered**
  - Capped Histogram ***(GS)***
  - As above but assign each WM component once only ***(GS1)***
  - Train Hash Model on World Model components and assign each to nearest Hash component ***(GS2)***
- **Rationale behind *GS1* and *GS2* is Coverage of WM**
- **GS2 is the Original Strategy of Bocchieri, ICASSP 93**

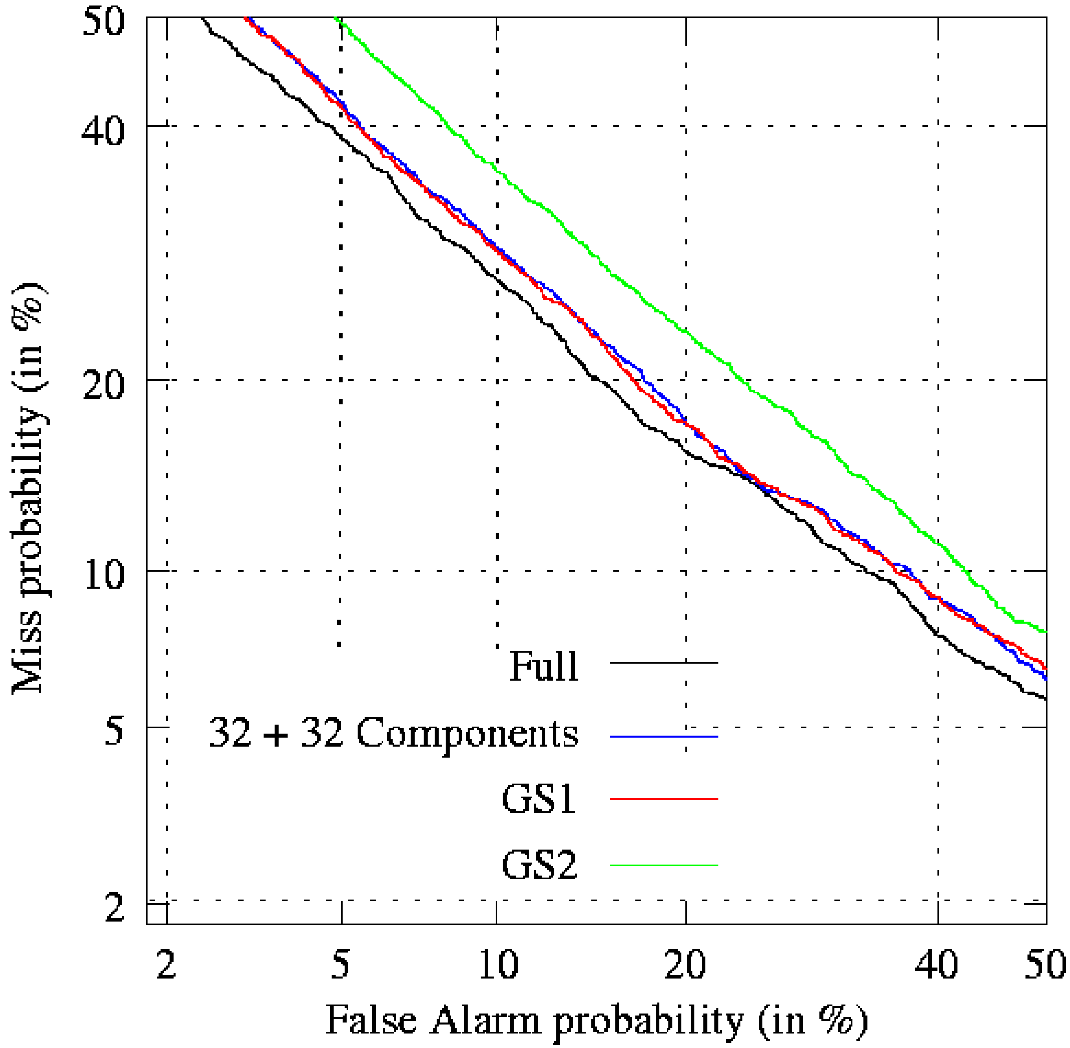
Experimental Set-up

- **1024 component WM**
  - UK telephony DB (M + F)
- **16 static + 16 delta spectral coefficients**
  - frame rate 62.5 /sec
- **Odyssey 2001 evaluation set (males only):**
  - 3 mins training
  - 15 ~ 46 sec. Test, different handset
- **Hash model 32**
  - Index shortlist: 16, 32, 64, 128

Hash Model 32, Varying Shortlist:



Covering the World Model:



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Comments & Conclusions

- **Capped Histogram Training:**
  - Shortlist size: 128, no discernable loss of accuracy

    efficiency gain ratio ~ 6
  - Shortlist size: 32, small loss of accuracy (1 in 17 EER)

    efficiency gain ratio ~ 16
- **Efficiencies in Computing Time**
  - both application environments (Note shortlist memory can be ROM)
- **Hash Model Covering the World Model:**
  - Seems Unnecessary: 32 Hash + 32 Shortlist similar results
  - ASR Original: Hash derived from mixture means seems inferior
- **Finally, with *no* shortlist capping: ~500 index pairs, suggesting a reduction in search by ~50% without loss of accuracy**