

**ISS World 2007**

**DUBAI, UAE – February 27, 2007**

# **THE SEARCH FOR RESULTS IN VOICE ANALYSIS: how different identification technologies can work together effectively**

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# Loquendo Voice Technologies for COMINT



Forensics



LEA  
investigation



Counter Terrorism  
Intelligence



Battlefield

**Loquendo**  
VOCAL TECHNOLOGY AND SERVICES

- **Speaker Recognition** through Voice-Print comparison of free speech
- **Language Identification** – also for dialect/accent recognition
- **Keyword spotting** to detect words of special interest to investigators

# Different scenarios for Speaker Identification applications

## Intelligence/CounterTerrorism

- Huge volume of intercepts
- Various targets (sometimes several hundred)
- Different languages spoken
- Emphasis on spotting targets as calls come in
- Limited accuracy usually sufficient
- Strict time constraints
- Usually no need to gather evidence

## Criminal Investigation

- Limited number of intercepted calls
- Fewer targets
- Spoken language generally known in advance
- Each call can be analyzed
- High accuracy required
- Looser time constraints
- Intercepts may have to be produced as evidence

## Intelligence Agencies

## Law Enforcement Agencies

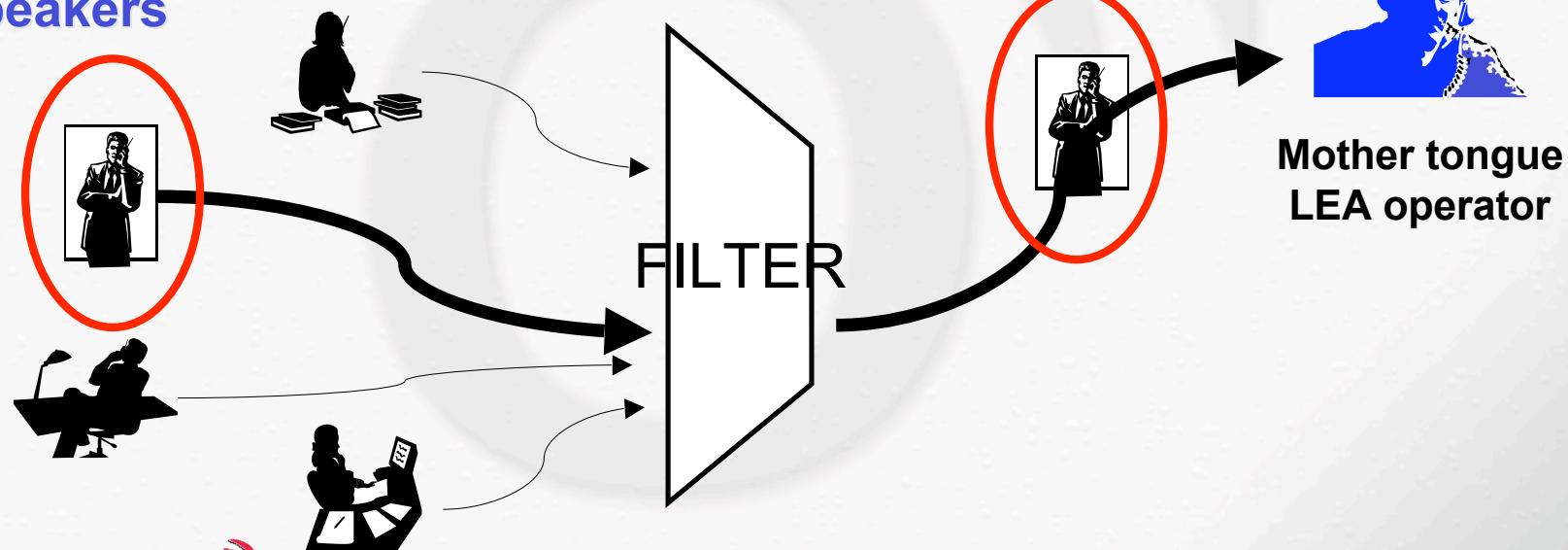
# Intelligence / Counter-Terrorism



- Huge volume of telephone intercepts
- Hundreds of target speakers
- Different languages spoken
- Spotting of targets as calls come in
- Multiple investigation scenarios

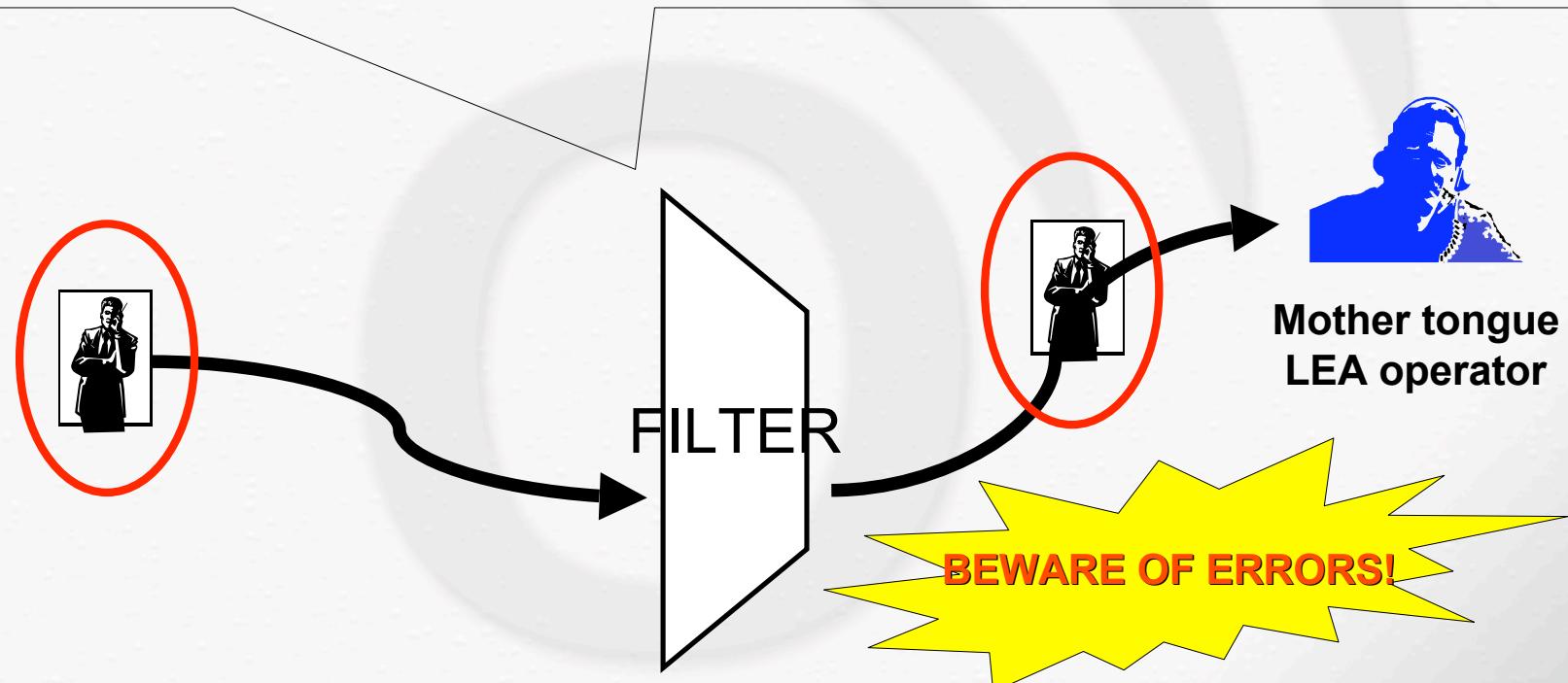
## Objective:

Rapid identification of calls made by specific speakers



# Elements used for Filtering

- 1) Investigative knowledge
- 2) Network parameters (CLI, DN, IMEI code,...)
- 3) Speech content (spoken language, keywords,...)
- 4) Speaker features (biometrics, gender, emotion, ...)



## LEA Investigations – An example

### Finding for a phone call in an international trunk traffic



- ↔
- Int'l trunk
  - ...
  - PABX



How can I spot the right calls without infringing other people's privacy?

Automatic real-time extraction of calls matching target Voice Prints



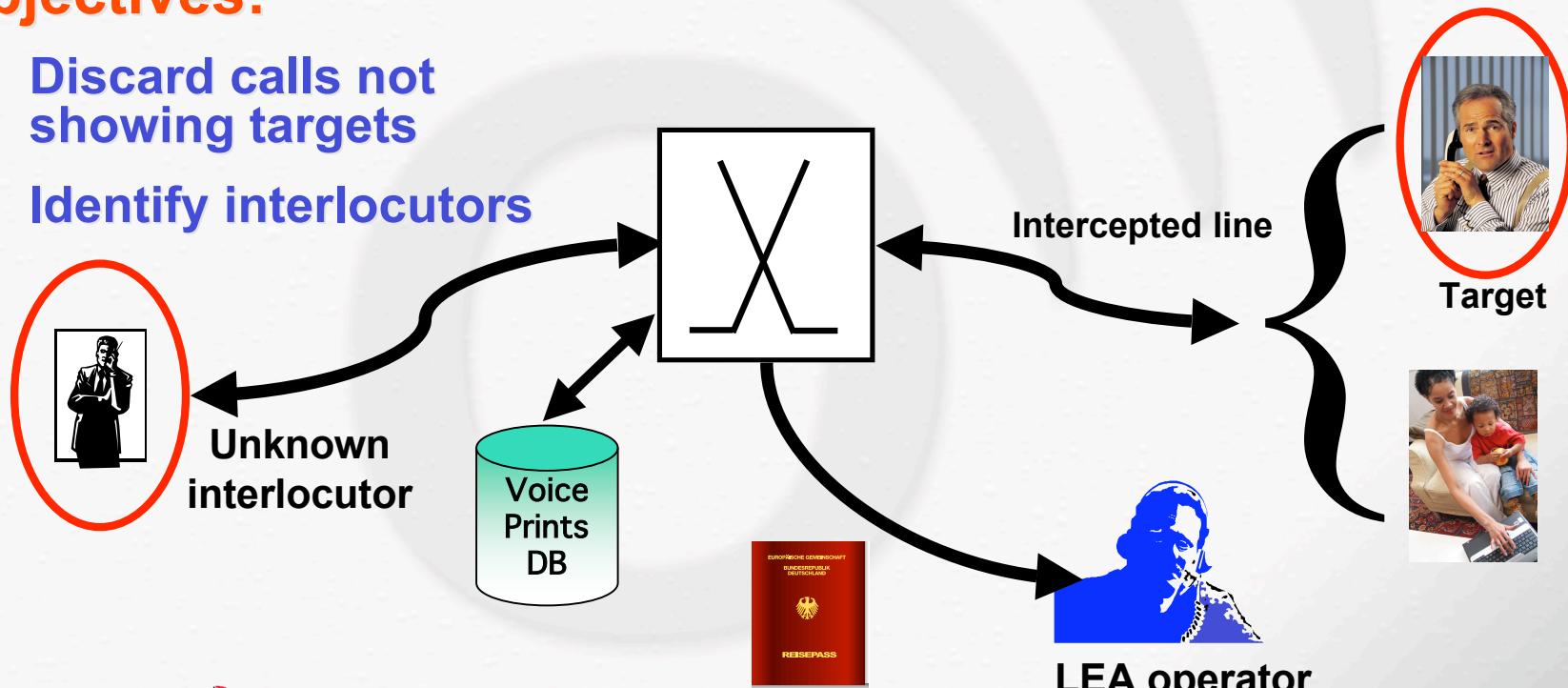
# Criminal Investigations



- Limited volume of telephone intercepts
- Dozens of target speakers
- Spoken languages known in advance
- Ranking of intercepted calls
- Usually narrow investigation scenarios

## Objectives:

1. Discard calls not showing targets
2. Identify interlocutors



# **Speaker Identification through Biometrics**

- ¬ Every voice contains acoustic-phonetic features that can be extracted, amplified, stored and used to build Voice Prints (VPs)
- ¬ VPs are based on “certified” audio recordings
- ¬ Like fingerprints, VPs can also be used for comparison with elements gathered in the field
- ¬ Accuracy scores are intrinsically statistical ( $P_{\text{Err}} > 0$ )
- ¬ In telephone intercepts, voice is the only “signature” that can be assessed



**Each individual can be assigned a Voice Print to determine his/her identity**

## LFSI – Loquendo Free Speech Identification

- Software technology allows the identification of speakers in natural speech telephone calls
- Phonetic GMM recognition
- Search for several targets at the same time
- Real time processing of audio files
- Provides normalized scores for every “voice print – audio file” pairing
- Language independent
- Channel independent (mobile, fixed, VoIP)
- Excellent accuracy results (obtained at NIST '06 SRE)

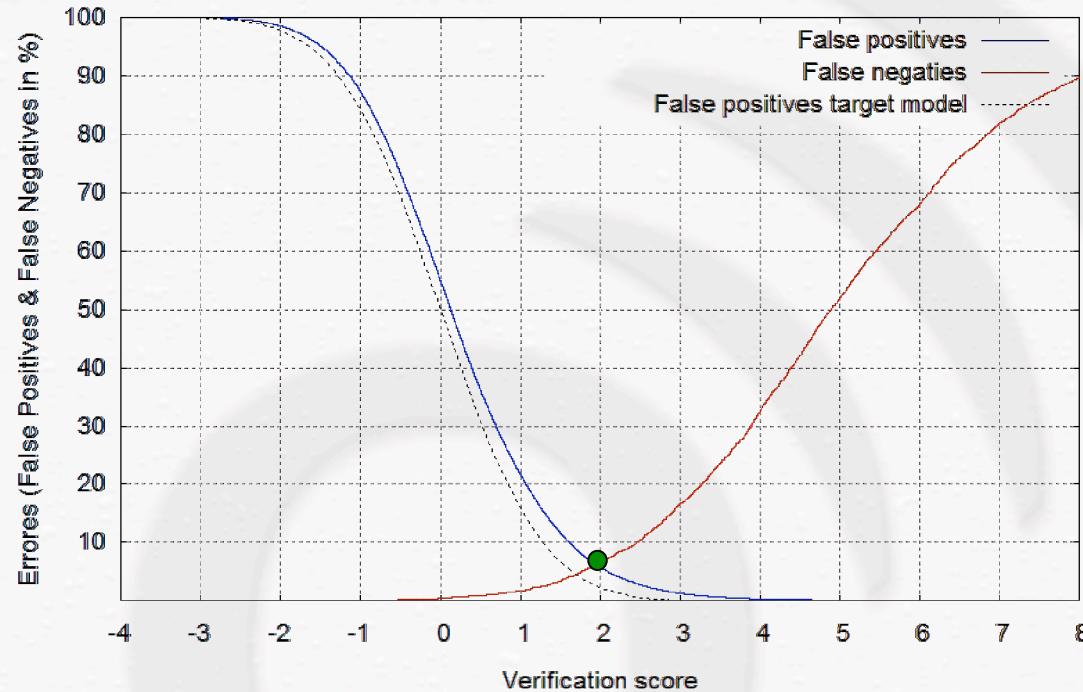
# What about the accuracy?

## Elements to consider:

- 1) **A priori probability of correct target interception**
- 2) **False Alarms (False Positives)** FA
  - 1) Should tend to zero in authentication applications
  - 2) May be more acceptable in Intelligence applications
- 3) **False Miss (False Negatives)** FM
  - 1) Normally unacceptable in Intelligence
  - 2) More acceptable in authentication applications
- 4) **Impossibility of optimizing both error rates (FA and FM) at the same time**

# System Characterization (1)

LFSI Error Rate Plot



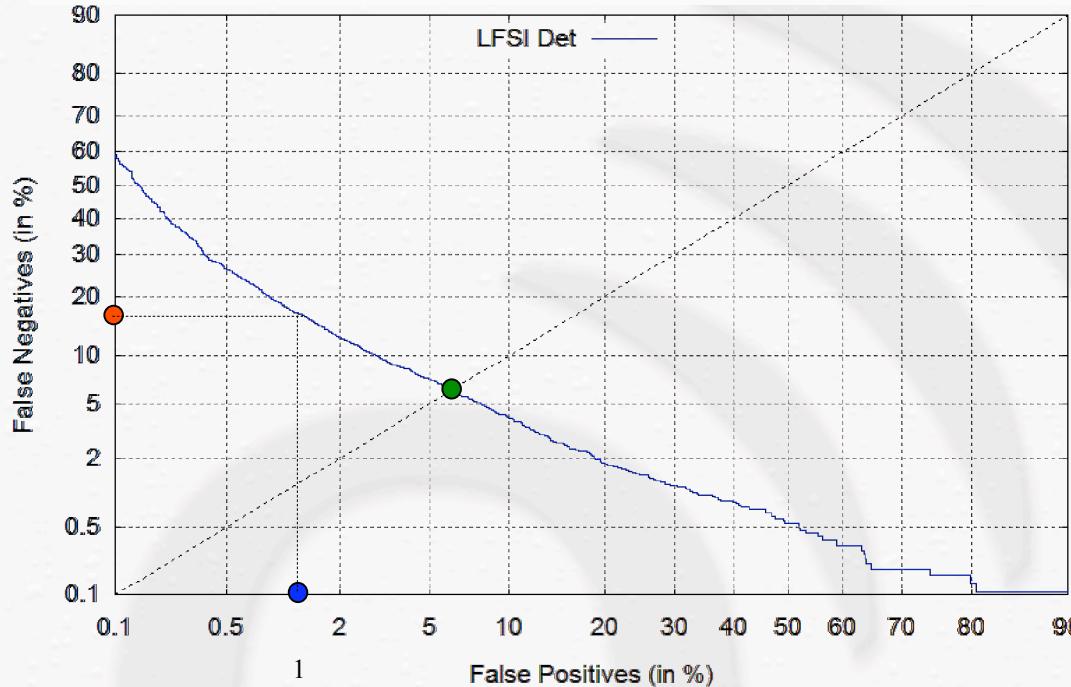
**False Positives = False Alarms**

**False Negatives = False Miss**

**Equal Error Rate**

## System Characterization (2)

LFSI Detection Error Tradeoff Plot



**False Positives = False Alarms**

**False Negatives = False Miss**

**Equal Error Rate**

## Enough accuracy? An example

a) Working Point where  $P_{FA|1\text{target}} = 1\%$

↔ then an average of 1 call out of 100 will be wrong  
with reference to each specific target

If you look for 100 targets

$$P_{FA|100\text{targets}} = 1 - P_{\text{right}} = 1 - (0,99)^{100} = 63\%$$

**USUALLY UNACCEPTABLE**

b) Working point where  $P_{FA|1\text{target}} = 0,1\%$

$$P_{FA|100\text{targets}} = 9\%$$

**MUCH BETTER**

## How to improve accuracy

# What's next?

We have only considered point 4): Voice Prints comparison

- 1) Investigative knowledge
- 2) Network parameters (CLI, DN, IMEI code,...)
- 3) Speech content (**Spoken Language**, keywords,...)
- 4) Speaker features (**VP biometrics**, **gender**, **emotion**, ...)

So now let's consider point 3): **Spoken Language** and 4) **Gender**

## **Language Identification (L2I)**

- A model of each individual language can be made using its characteristic features
- A likelihood score can be calculated from comparing speech recordings to language models
- The likelihood scores indicate which language is being spoken
- Based on sufficient speech recordings in a specific language coming from a variety of speakers, the language identification engine can be trained to recognize new languages
- Also suitable for dialects (may be less precise)
- Suitable for Accent Identification (development in progress)

## Gender Identification

- A model of each gender (male/female) can be made using general voice features
- A likelihood score can be calculated from comparing speech recordings to gender models
- Suitable for filtering calls (men are often targets)

## **Example of combinations of different filters (1/2)**

### **Investigative assumptions**

**Example involves an Italo-American company**

**One branch in the US, one in Italy**

**Drug-trafficking involved**

**Bad guys are Italian (could be located in Italy and USA)**

**1000 calls a day on that link**

**50% involve women**

### **Voice Print library knowledge/assumptions**

**100 targets related to drug trafficking:**

**10 women**

**90 men, of which**

**30 Americans**

**60 Italians**

## Example of combinations of different filters (2/2)

### Technology assumptions

$$FA_{\text{Gender Id}} \cong FA_{\text{Speaker Id}} \cong FA_{\text{Language Id}}$$

Then the comparison will be made between:

60 VPs belonging to Italian men involved in drug trafficking

The percentage of the 1000 calls/day where only men are present

The system will first perform a comparison to check gender  
and then if only men are involved in the call  
it will perform the Italian male VPs comparison

Therefore:

60 VPs instead of 100  $\Rightarrow FA_{\text{total}} = 5,8\%$  (instead of 9%)

Applied to 500 calls instead of 1000 per day

Without any classification there would be an average of 90 FA/day

WITH THE FILTERS  $\Rightarrow 29$  FA/day

# **CONCLUSIONS**

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**Intelligent adoption of different filtering criteria may improve the chances of a successful search and reduce time wasted on analysis of irrelevant material**

**The search for specific targets (based on Voice Print comparison) can be enhanced if individuals are also grouped according to the languages they speak/ their gender**

**Loquendo provides solutions combining Speaker Identification and Language Identification as well as Gender Identification**

## CONTACTS

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**LOQUENDO booth  
at ISS World exhibition**

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**THANK YOU !**