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Cell-ID location technique, limits and benefits: an experimental study.

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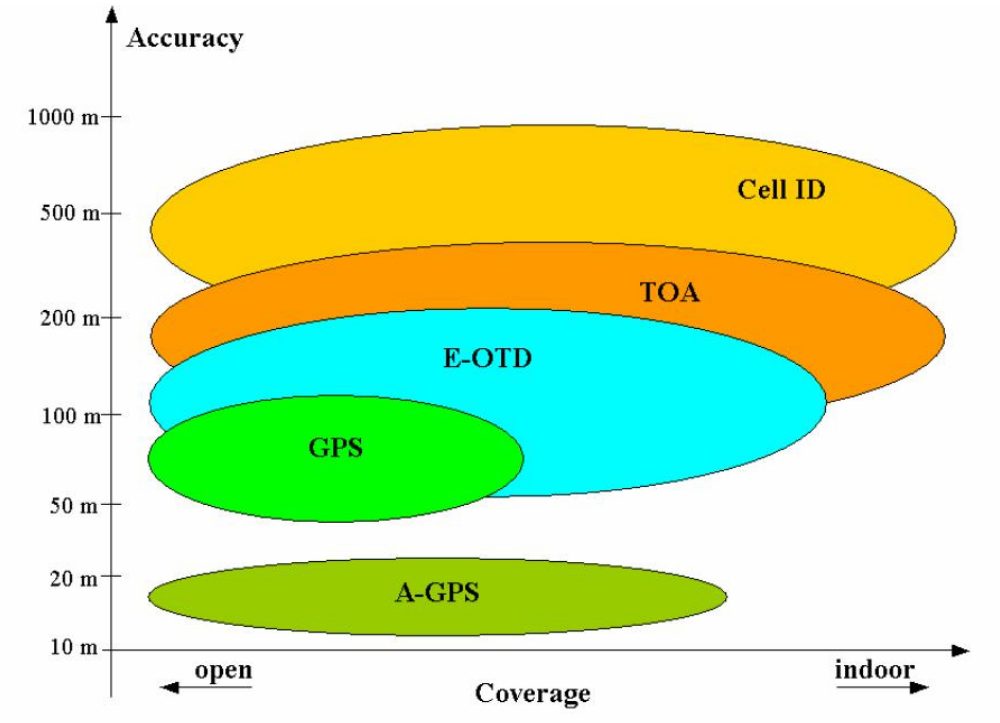
Overview

- Motivation
- Cell-ID Background
- Contribution
- Cell-ID performance
- Summary
- Cell-ID and VXML
- Conclusions and future works

Motivation

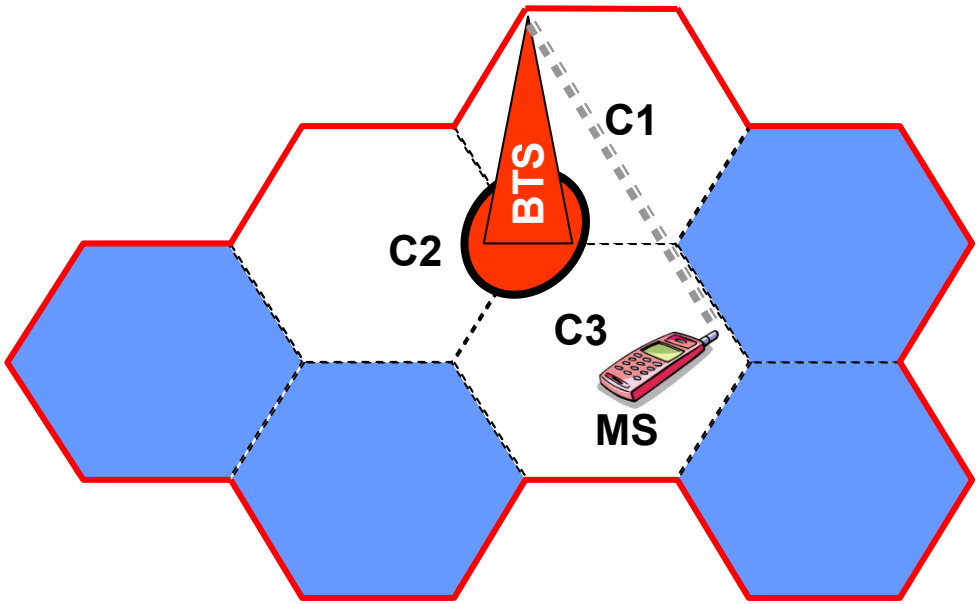


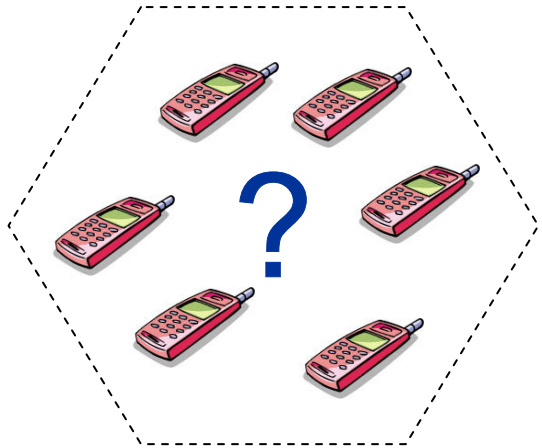
E911

E112

- Location techniques providing good accuracy, require substantial technological and financial investment.
- Cell-ID positioning is low cost and it is available now!
- "We all know that cell-id is too coarse and too uncertain to be of much use as a source of user location", but there are very few preliminary study evaluating Cell-ID performance by experiments.

Background





PRO:

- ❑ Low cost
- ❑ No upgrades
- ❑ Privacy
- ❑ Now

CON:

- ❑ Accuracy (cell size may range from some meters to some kilometers)
- ❑ Proximity (effectivness)
- ❑ You must know cell planning

Contribution

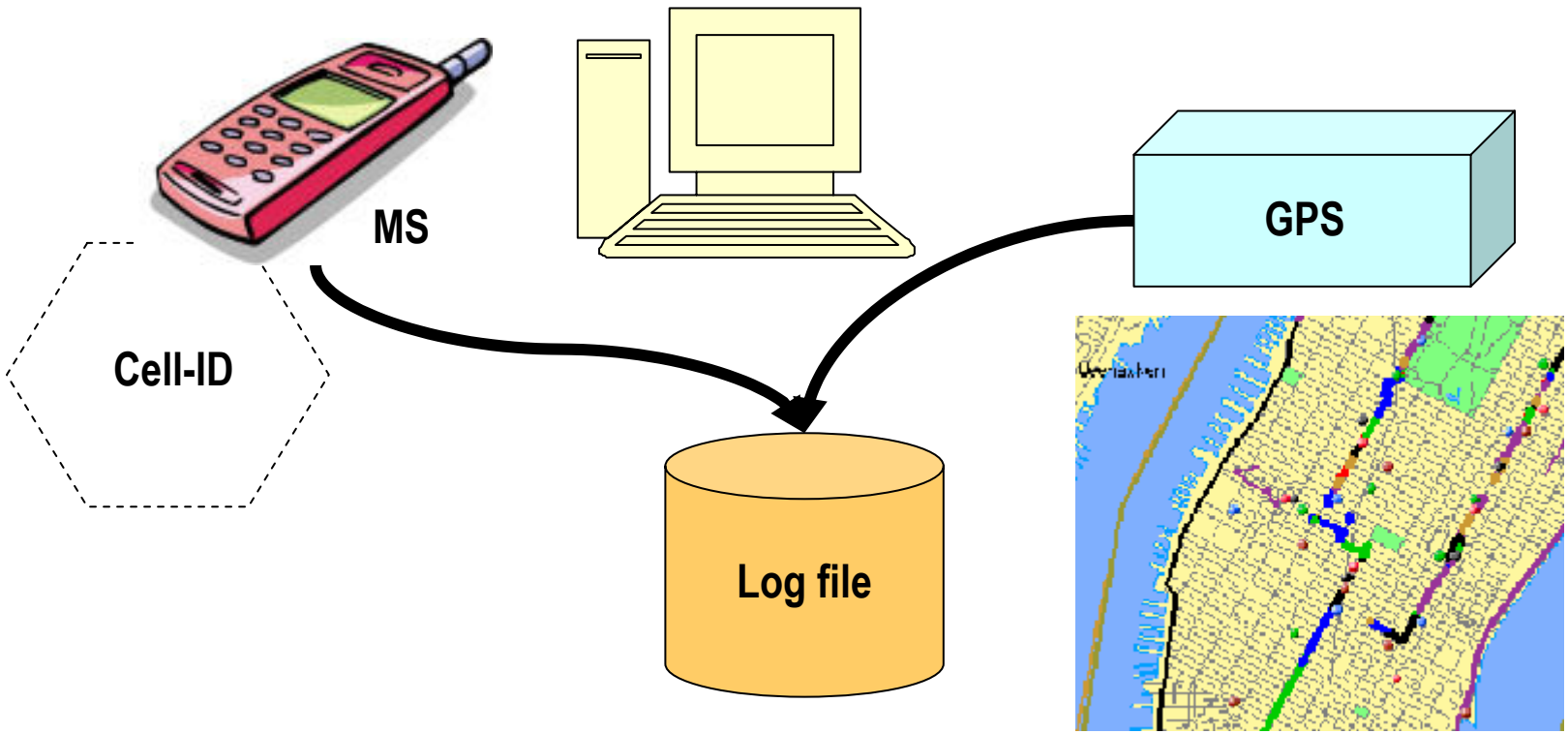
- We present the results of some experiments on Cell-ID performances ran both in U.S. (NY area) and in E.U. (Rome area) and in three distinct contexts: urban, suburban and highway

- Our experiments do not try to be complete, our goal rather is providing a framework in which Cell-ID performance can be objectively assessed.

- We show how Cell-ID can be effectively exploited in the context of Voice Location Based Services.

Cell-ID performance

- Evaluated by experiments in cooperation with AT&T in US (CDPD) and WIND in Italy (GSM) in three contexts:
  - URBAN (high density of BTSs, small/medium cell size)
  - SUBURBAN (average density of BTSs, medium/big cell size)
  - HIGWAY (low density of BTSs, big cell size)



Cell-ID performance: Average distance

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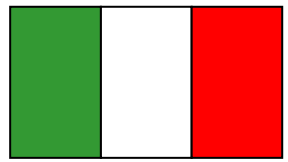
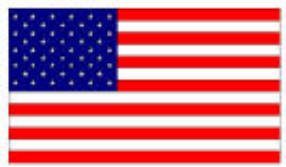
❑ **Average distance $E(\Delta d)$ between the GPS position ("actual position") and the estimated Cell-ID position calculated over all the samples in the log file.**

- SPOT of connectivity in populated areas
- MS at the boundary of 2 loc. areas
- Net. planning.
- CDPD is allowed to transmit only when freqs. are not used by voice
- SHADOW SAT: NY skyscreapers (canion effect) and NJ forests

	URBAN	SUBURBAN	HIGHWAY
Samples	2075	2114	636
Useful	96%	94%	97%
σ	0.36Km	0.82Km	0.64Km
Min.	0.03Km	0.05Km	0.19Km
Max.	2.68Km		3.67Km



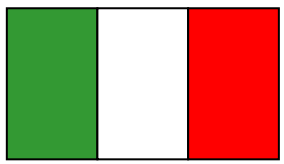
	URBAN	SUBURBAN	HIGHWAY
Samples	2237	665	1188
Useful	82%	57%	44%
σ	0.39Km	0.38Km	2.00Km
Min.	0.02Km	0.11Km	0.95Km
Max.	1.85Km	1.70Km	8.35Km



Cell-ID performance : Proximity

- **Cell-ID works under the implicit assumption that the MS is always connected to the closest BTS, but …**
  - **Multipath propagation**
  - **BTS transmission power (defined at cell planning)**
  - **Cell selection algorithm choices.**

	URBAN	SUBURBAN	HIGHWAY
Samples	1775	1820	295
$\overline{Close}$	43%	32%	39%



Cell-ID performance: Discovery Accuracy ann Discovery Noise

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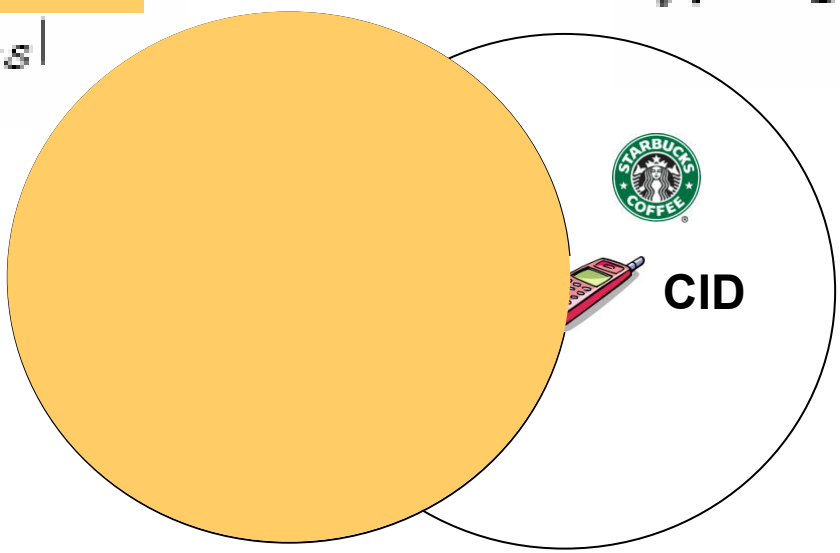
- **Resource discovery services: to locate a set of resources close enough to the customer's location**
- *"Where are Chinese restaurants in my neighborhoods?"* **... not the closest restaurant, but restaurants close enough.**
- **Discovery Accuracy counts the fraction of resources near the actual position of a user, that can be either localized using his approximate position.**
- **We also require that resources in the surrounding of** *the approximate position of the user* **are almost the same as those close to** *his actual position*

$$\mathcal{A} = \frac{|R^d_{CID} \cap \quad|}{|R^d_{GPS}|}$$

$$\mathcal{N} = 1 - \frac{|R^d_{CID} \cap R^d_{GPS}|}{|R^d_{CID}|}$$



A=2/4

N=1-2/3=1/3

Cell-ID performance: Discovery Accuracy and Noise

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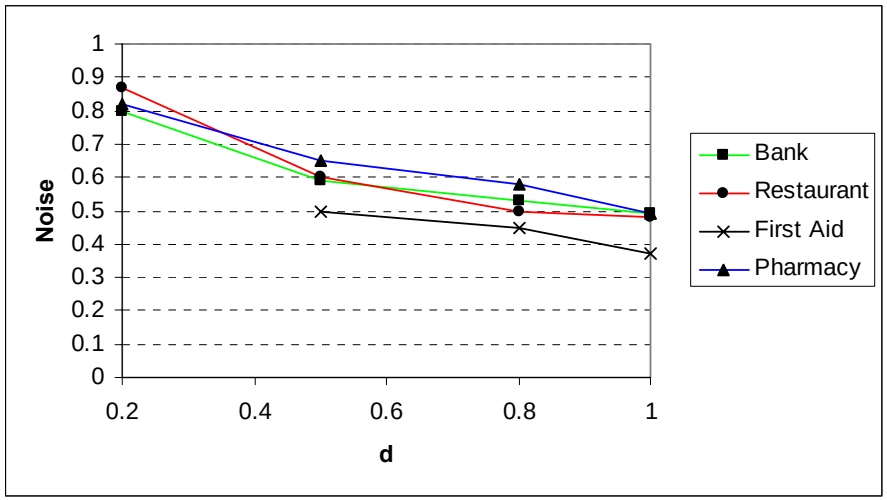
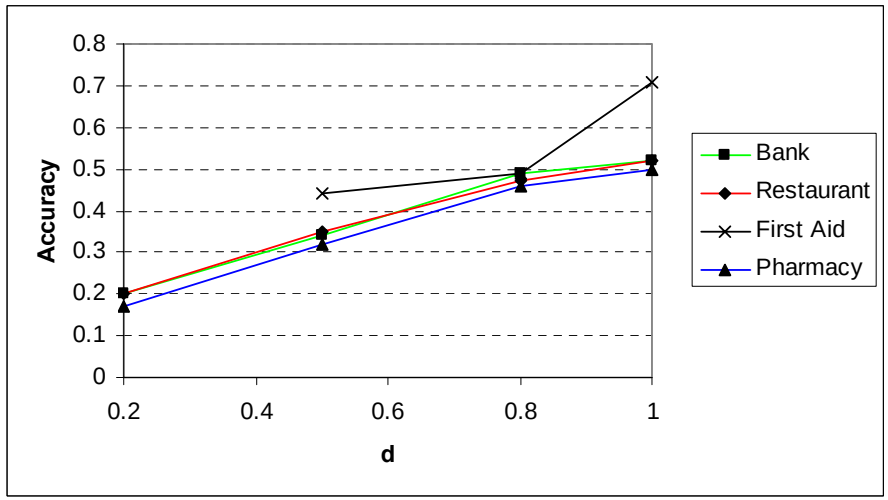
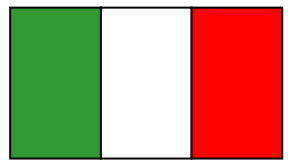
- We would: A→1 and N →0





- spread resources - bank and restaurants, average spread resources – pharmacies, low spreadresources – first aids.
- d ≤ 0.8 Km: Accuracy is always smaller than noise
- d > 0.8 Km: A ~ N ~ 0.5

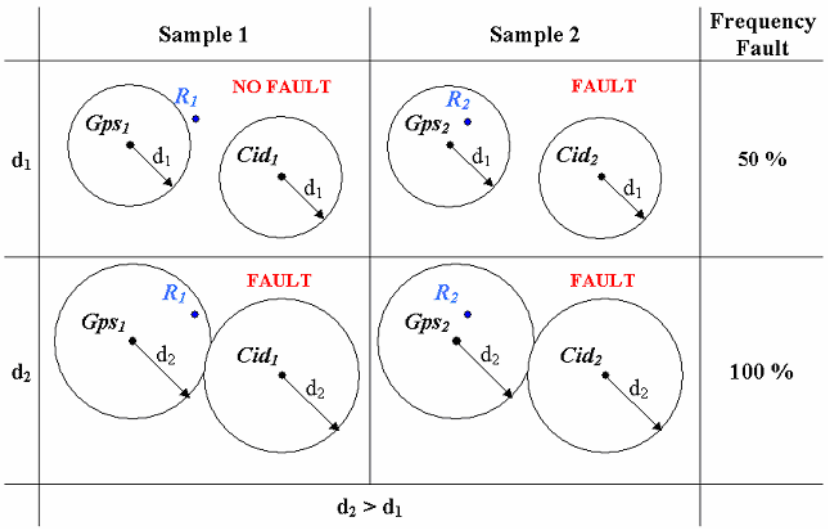


Cell-ID performance: fault frequency

- Percentage of samples with A = 0 but R^d_{Gps} not empty
- Fault frequency is about 30%

d	1 Km	0.8 Km	0.5 Km	0.2 Km
Bank	32%	31%	31%	41%
Restaurant	28%	32%	35%	31%
First Aid	12%	18%	7%	1%
Pharmacy	29%	26%	36%	43%

- Fault frequency may increase with distance d



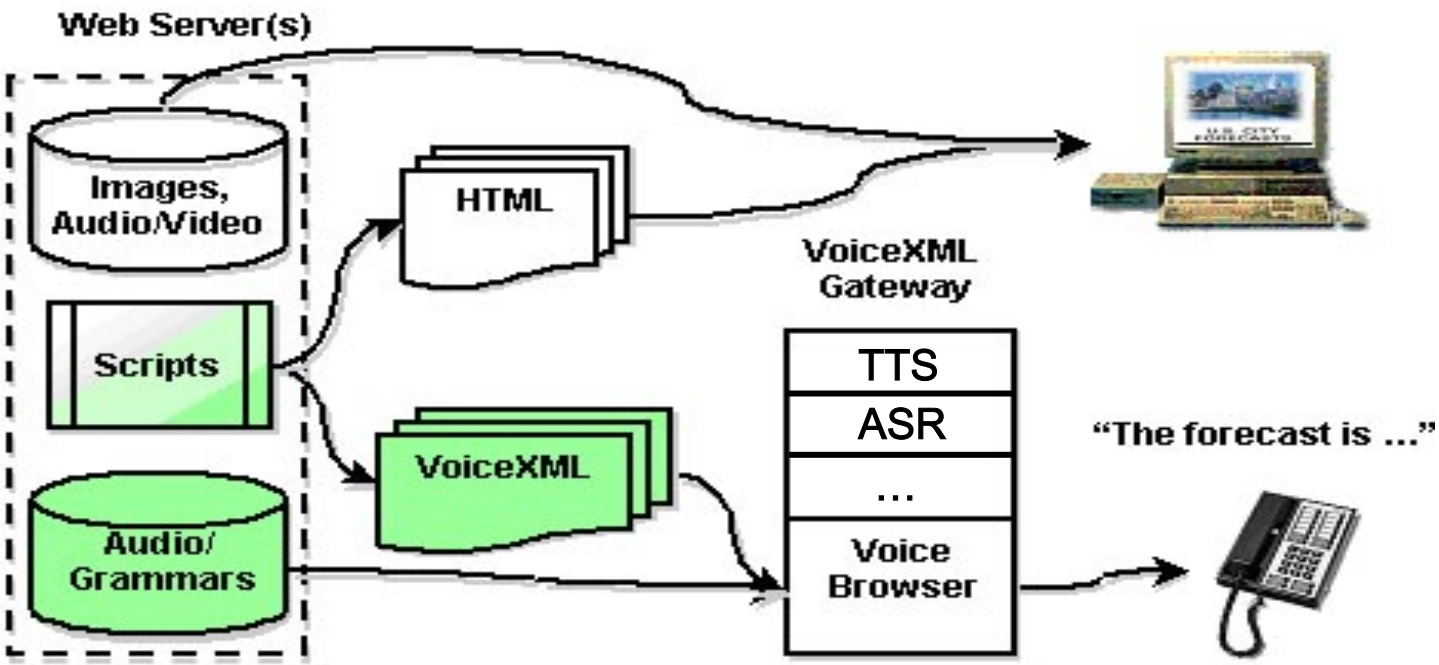
Summary

- Motivation
- Cell-ID Background
- Contribution
- Cell-ID performances

All the above results show that Cell-ID is often too poor to provide location based service, but… We now show a new Voice XML (VXML) solution which takes a great advantage from the knowledge of Cell-ID.

- Cell-ID and VXML
- Conclusions and future works

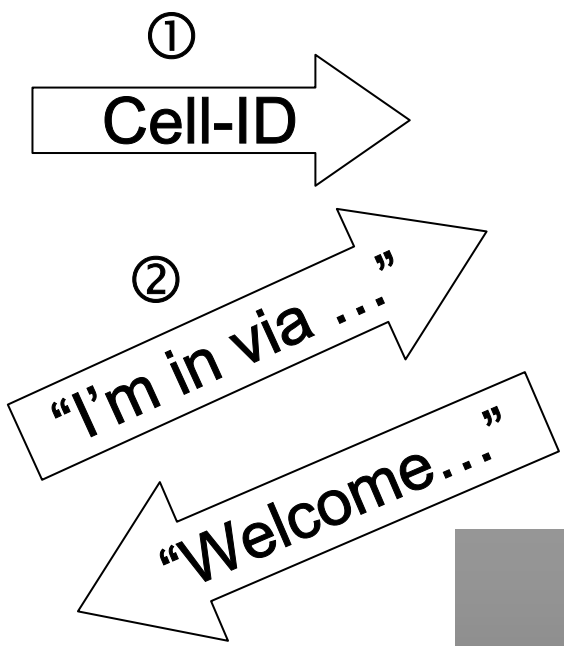
VXML background

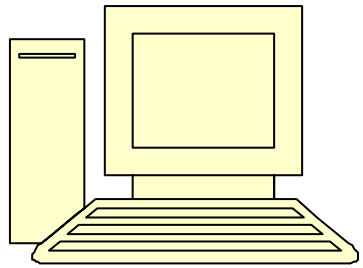


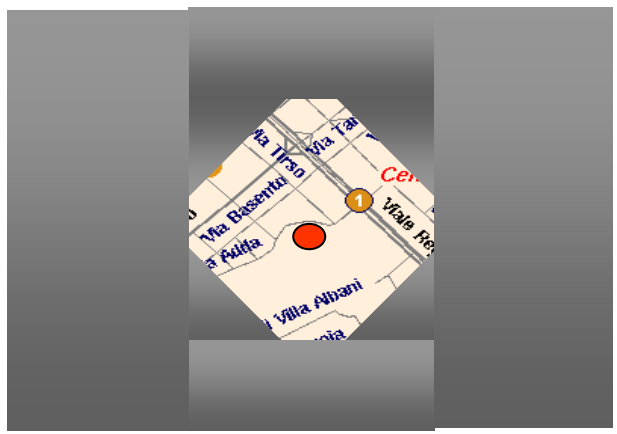
- VoiceXML is the HTML of the voice web
- Grammar defines what is valid user input.
- Effectiveness and efficency of the Authomatic Speech Recognizer (ASR) strongly depend on the grammar size.

Cell-ID and VXML

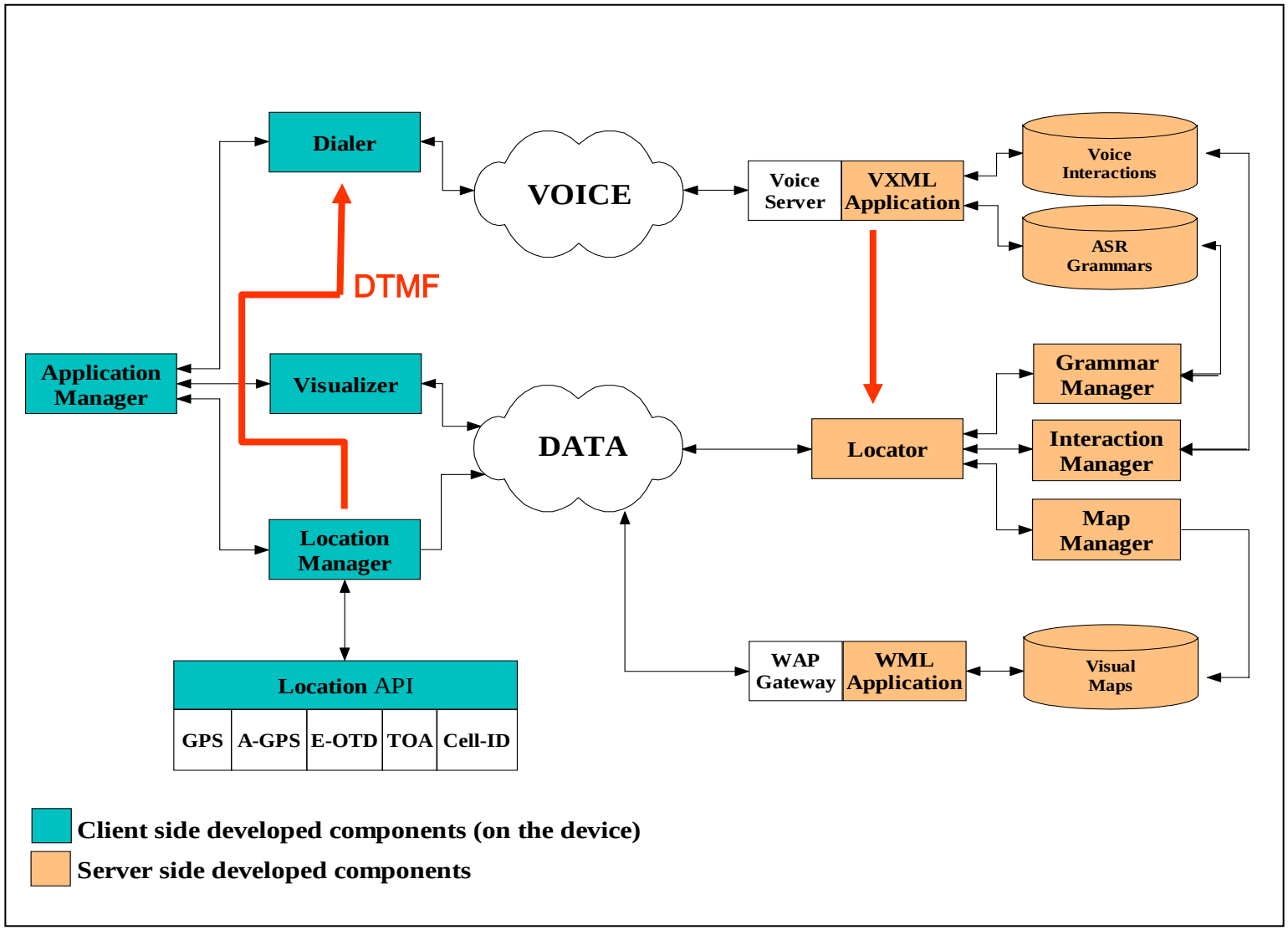
- The grammar of all the addresses in a city is big (thousand of addresses)
- IDEA: Limit the grammar size by Cell-ID







A multimodal architecture (more)



Cell-ID and VXML: experiments

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- Correct and complete vocal inputs ("via Margutta 45")
- Cell-ID can speed-up the recognition process by more than a factor 10

Addresses	T upload	T rec
3405	7 sec.	2 sec.
21	0.6 sec.	0.2 sec.

Cell-ID

720 cells

Cell-ID and VXML: experiments

- Incomplete ("Margutta") and partially correct ("viale Margutta") inputs
- Grammar size (more than 45000 elements) is too big
- Reduced to 10000 elements, only 20% of inputs are recognized
- With Cell-ID 100% of inputs are recognized.
- Cell-ID can speed-up the recognition process by more than a factor 10

Addresses	T upload	T rec
45619 10000	- 40 sec.	- 7 sec.
314	1.2 sec.	0.6 sec.

Conclusions and future works

- Cell-ID positioning is inexpensive and it does not require any upgrade of network or terminal equipments.
- Our experiments show that the quality of Cell-ID is often not appropriate to deploy even very simple location based services.
- Cell-ID can be exploited to provide more effective and efficient Voice Location-Based Services.
- Indeed, using Cell-ID we can considerably reduce the size of the recognition grammar, speeding up the recognition process by a factor larger than ten.
- Self localization on visual maps indexed by Cell-ID.