DELIVERABLE REPORT
D4.1.2
“Geo-contextual Event Analysis”

MASELTOV
Mobile Assistance for Social Inclusion and Empowerment of Immigrants with Persuasive Learning Technologies and Social Network Services

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Lead contractor for this deliverable	**JR**
Editor	**Patrick Luley (JR)**
Authors	**Anna Weber (JR), Stefan Ladstätter (JR), Patrick Luley (JR)**
Quality reviewer	**Graziella Spinelli (TI), Nicoletta Bersia (TI)**

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CONTACT

Contact for feedback on this report to the editor:

patrick.luley@joanneum.at

Patrick Luley
JOANNEUM RESEARCH Forschungsgesellschaft mbH
Steyrergasse 17
8010 Graz

Contact for feedback on this report to the project coordinator:

lucas.paletta@joanneum.at

Lucas Paletta
JOANNEUM RESEARCH Forschungsgesellschaft mbH
Steyrergasse 17
8010 Graz

MASELTOV partner			organisation name	country code
01	JR		JOANNEUM RESEARCH FORSCHUNGSGESELLSCHAFT MBH	AT
02	CUR		CURE CENTRUM FUR DIE UNTERSUCHUNG UND REALISIERUNG ENDBENUTZER-ORIENTIERTER INTERAKTIVER SYSTEME	AT
03	AIT		RESEARCH AND EDUCATION LABORATORY IN INFORMATION TECHNOLOGIES	EL
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13	DAN		VEREIN DANAIDA	AT
14	MRC		THE MIGRANTS' RESOURCE CENTRE	UK

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CONTENT

1. EXECUTIVE SUMMARY

This deliverable D4.1.2 “Geo-Contextual Event Analysis” gives an overview of the components implemented for the mobile multisensory interpretation of user behaviour as a foundation to support immigrants in host urban environments. The module enables filtering of relevant context information and provides the background data for recommendations based on the situation-dependent context of the user’s environment.

The geo-contextual event analysis module can be used to determine the social inclusion of a person and in further consequence provide the information for the MASELTOV system to facilitate and foster communication. The knowledge about the current state of movement can be used to improve personalized recommendations for a user, e.g. to determine the proper moment to send information to the user by detecting idle or high activity periods. The module provides a collection of identified interests as well, which can be used to deliver targeted advice or information to the user.

The geo-contextual event analysis also incorporates geographic information of the user’s surrounding environment. The geographic information facilitates recommendations connected to places visited and places that are of special interest to a user. If the MASELTOV system detects that the user is near a specific place, common phrases for the communication or information about the place can be provided.

The first section gives a brief overview of the overall architecture of the geo-contextual event analysis module, followed by a more detailed explanation of the sub modules, the underlying data structures, methodologies and algorithms. The document elaborates on the interaction with the MASELTOV User Profile, as described in deliverable D5.2. “User Profiling and Personalization”, by giving an example on how to send the behavioural user data to it. Finally the use of the geo-contextual event analysis for the MASELTOV system is depicted.

2. OVERVIEW OF THE GEO-CONTEXT MODULES

The context module consists of the following main components, shown in

Figure 1 below: activity recognition, interest sensing, places of interest, social interaction and an interface for querying nearby POIs and nearby places of interest. The sub modules of the components are represented as rounded boxes and will be described in detail in the following chapters.

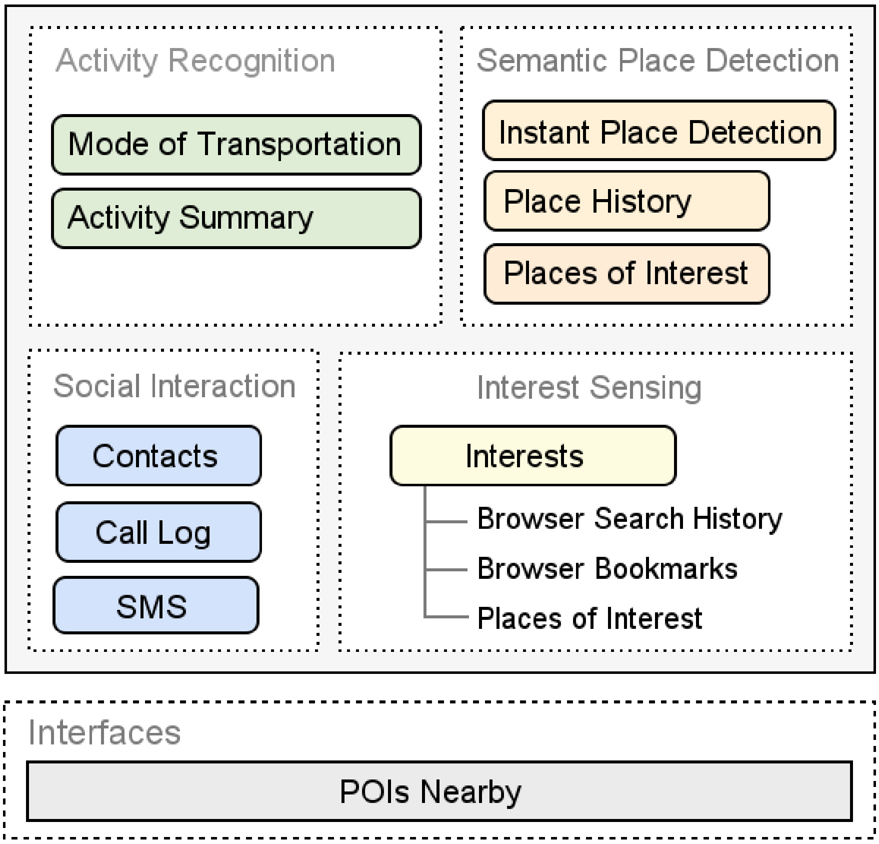

Figure 1: Main components of the context module

3. ACTIVITY RECOGNITION MODULE

The activity recognition module described in the following section determines the current state of movement of a person. It is capable of detecting the proper moment to send tasks and recommendations by notifying the user profile about idle or high activity periods. The specific modes of transportation detected by the activity recognition module are driving, biking, walking, tilting, other movements and idle time. A summary of these modes is sent to the user profile every day.

3.1 MODE OF TRANSPORTATION MODULE

The mode of transportation module returns the type of movement of a person. Modes that can be detected are on foot, on bicycle, on vehicle, still, tilting and unknown. The results also include confidence values for the detected mode. As soon as there is a change in movement detected, the information is sent to the user profile.

3.1.1 Data Structure

The following JSON data structure also includes example data. The information about the mode of transportation is stored and sent to the user profile on every change, as a single event. For every detected activity a timestamp and a confidence value describing the accuracy of the detection is sent. The activity types are described below.

Mode of Transportation


```
{
 "source": "MaseltovContext.TransportationMode",
 "timestamp": "1353417528",
 "start_time": "1353417528",
 "end_time": "13534178545",
 "type": "in vehicle",
 "confidence":"100"
}
```


Mode of Transportation types:

in vehicle on bicycle on foot	still unknown tilting

3.2 ACTIVITY SUMMARY

The activity summary module represents an overview of the detected modes of transportation during the day. With the help of this module the daily movement behaviour of a person, e.g. the overall intensity of the physical activity, can be shown. The summarized list is sent to the user profile at the end of every day.

3.2.1 Data Structure

The distance values are represented in meters. The time unit is in minutes.

Activity Level


```
{
 "source": "MaseltovContext.ActivityLevel",
 "timestamp": "1353417528",
 "total_distance" : "24851",
 "distance_onFoot": "5212",
 "distance_onVehicle" : "7212",
 "distance_onBicycle" : "6212",
 "distance_unknown" : "6214",
```

```
 "time_moving" : "45211",
 "time_still" : "45214",
 "time_onFoot" : "125",
 "time_onVehicle" : "752",
 "time_onBicycle" : "741",
 "time_unknown" : "45",
}
```

4. INTEREST SENSING MODULE

Interests are determined by analyzing the frequency of occurrences of specific terms within the browser bookmarks and browser search history on the mobile phone. In particular, nouns are detected in the text using an open dictionary API. In addition to this the categories of the places of interest are added to the interests (see sections 5.3 and 7.).
The identified interests, including their corresponding weights, are collected in a list and sent to the user profile at the end of every day, overwriting the previous list.

The ranked list of interests consists of:

- nouns occurring in browser bookmarks
- nouns occurring in the search history
- categories of places of interest

All languages envisaged for the MASELTOV UI will be supported.

4.1 DATA STRUCTURE

The following table shows the data collected for the interest sensing.

Browser Bookmarks	Browser Searches
`{ "source": "MaseltovContext.BrowserBookmarks", "timestamp": "1353417528", "url":[…] "visits":[…] "date":[…] "bookmark":[…] "title":[…] "created":[…] "favicon":[…] }`	`{ "source": "MaseltovContext.BrowserSearches", "timestamp": "1353417528", "url":[…] "date":[…] "search":[…] }`

The identified nouns/categories are merged into a list of interests including their weights. The weight is the number of occurrences of a specific item (noun/category):

Interests


```
{
 "source": "MaseltovContext.Interests",
 "timestamp": "1353417528",
 "topics":
  ["food", "sports", "summer", "restaurants"],
 "topic_weights":
  [45, 234, 25, 32 ]
}
```


5. SEMANTIC PLACE DETECTION MODULE

The semantic place detection module is composed of three sub modules, the instant place detection that delivers visited places to the MASELTOV system on detection, the place history which sends a daily summary of visited places to the user profile and a collection of places of interest containing places that are frequently visited including home and workplace.

5.1 INSTANT PLACE DETECTION

If a person stays at one place for at least 5 minutes, a notification containing the information about the place is sent to the user profile. A place contains, as key value pairs, the following: coordinates, start time, end time, duration, type (including home or work) and a list of surrounding POIs. The data structure of a POI is represented by the container class "MetaDataPoint" and is described in the section Interfaces below. If the visiting time of a detected place accumulates, its event entry in the user profile will be updated (update of end time and duration). If the place type is home or work, no POIs will be appended.

Place


```
{
 "source": "MaseltovContext.PlaceHistory",
 "timestamp" : "1353417528",
 "coordinates" : [47.1503, 15.456],
 "start_time" : "11998726607000",
 "end_time" : "1199872666098563",
 "duration" : "5214545000",
 "type" : "type",
 "pois" : [{"name":"…","address":"…","description":"…",
           "categories":"…","rating":"…","image":"…","url":"…"},
           {...}]
}
```

5.2 PLACE HISTORY

At the end of the day, a complete list of visited places is sent to the user profile. Here an update option of an already sent list (resending of the whole list and invalidating the already sent list) is needed because the user should have the option to annotate visited places by himself at a later time (e.g. when reflecting about places the next day).

Place History


```
{
 "source": "MaseltovContext.PlaceHistory",
 "timestamp": "1353417528",
 "coordinates": [
  [47.1503, 15.456],[47.1503, 15.456], [47.1503, 15.456], [47.1503, 15.456]],
 "type": [
  ["restaurant", "cafe"], ["fitness"], ["airport"], ["doctor"]],
 "start_time":
  [ [119987266607000, 119987266607000, 119987266607000],
    119987287230000,
    119987307787000,
    119987328330000 ],
 "end_time":
  [ [119987266607000, 119987266607000, 119987266607000],
    119987287230000,
    119987307787000,
    119987328330000],
 "duration":
  [ [ 66607000,66607000,66607000 ],
    87230000,
    57787000,
    32833000],
 "place_visits" : [3,1,1,1],
 "pois": [{"name":"…","address":"…","description":"…",
          "categories":"…","rating":"…","image":"…","url":"…"},
          {...}]
}
```


5.3 PLACES OF INTEREST

Constitutes a list with all places that are of interest to a person. An updated list is sent to the user profile on a daily basis. It has a similar data structure to the places history, except that it is ranked by the overall duration of the stay. In addition to this, home and workplace are appended to the data structure as well.

5.4 DETECTION OF HOME- AND WORKPLACE

With the help of the semantic place detection module, categories of places can be detected which are not possible to determine by simply querying POI databases. Categories detected by the module are “at home” and “at work”. The determination of the place semantics is realized by analysing the daily behaviour pattern of a person with the help of smartphone sensors.

6. SOCIAL INTERACTION DETECTION MODULE

The recognition of social interaction is realized by detecting the amount and duration of communications on the phone. Statistics about the call behaviour and text messages are collected and sent to the user profile once a day. The contact ID is one-way hashed for privacy reasons.

This kind of statistics can be used by the recommendation module and will be shown to the user for reflection via a user interface, as described in section "User Interface For Daily Reflection".

An example of a measure of social inclusion could be to have a look at how many *different* people were contacted, at what time of the day were they contacted and how long did the calls last. A consequence of this measure could be a recommendation to get in touch with more people.

6.1 DATA STRUCTURE

The social interaction module delivers a list of all people contacted during the day. The fields "last time contacted" and "times contacted" are set every time a user is contacted either by text message or a phone call.

Social Interaction


```
{
 "source": "MaseltovContext.Contacts",
 "timestamp": "1353417528",
 "contact_data": [
  {
   "contact_id": "215",
   "last_time_contacted": "135341724",
   "times_contacted_today": "45
   "call_duration_today" : "125",
   "calls" : ["call" : {"ts" : "254354", "duration": "14", "type": "incoming"},
              "call" : {…}]
   "sms" : ["sms_message" : {"ts" : "5354343", "type": "inbox"},
            "sms_message" : {...}, …]
 }, {...}, … ]
]}
```


Call types:

```
incoming call
outgoing call
missed call
```

Sms Message types:

inbox sent draft	outbox failed queued

7. INTERFACES

The following sections describe the provided interfaces to query POIs in the vicinity of a user and to query POIs nearby filtered according to the interests of a user. The interface for querying nearby POIs is used, besides the context module described in this deliverable, by AIT for recommendations and it is also provided for utilization by FLU with their POI service.

7.1 POIS NEARBY

POIs nearby are gathered from different data sources. Google Places represents the main source used for the POI query and is extended by geo-referenced Wikipedia articles from Geonames. The reason for choosing Google Places as the main source is the better quality of the data, however Geonames Wikipedia articles pose a very good extension in terms of additional meta-information for a POI.

The metadata used from Google Places consists of the name of the POI, the address, categories, links to websites and the rating. The rating is represented by a scale from 0 – 5. This information is enriched using additional metadata from Wikipedia articles, in particular images, a short summary and the URL pointing to the full Wikipedia article.

Google Places also provides images and reviews for POIs, created from Google users themselves. This data is not returned from the POI query because the querying of this data takes very long while the data is often incomplete or not usable (bad quality, different languages). However there is a reference key saved for on demand retrieval of this data.

Both POI data sources are accessed via a REST interface. The APIs allow a search for nearby places by providing them with a centre location and a search radius. The results are parsed and stored into a container class “MetaDataPoint” which is described in more detail in section 7.1.2 “Data Structure and Interface Definition”. Before returning the POI list to the user, the results of the data sources have to be merged. This is done by matching the POI names of Google Places with the names of Geonames using the Levenshtein distance. This is a metric for differences between two strings. If the Levenshtein distance is zero or small, the names of the two POI sources are identical or similar and can be merged. An interface which allows querying the merged POI data is provided and described in section 7.1.2.

7.1.1 List of Categories

The following table shows the list of categories returned by the nearby POIs search. The categories are taken from Google Places.

Accounting	fire_station	pass
adm1st	floor	pet_store
adm2nd	florist	pharmacy
adm3rd	food	physiotherapist
administrative_area_level_1	forest	place_of_worship
administrative_area_level_2	funeral_home	plumber
administrative_area_level_3	furniture_store	point_of_interest
airport	gas_station	police
amusement_park	general_contractor	political
aquarium	geocode	post_box
art_gallery	glacier	post_office
atm	grocery_or_supermarket	postal_code
bakery	gym	postal_code_prefix
bank	hair_care	postal_town
bar	hardware_store	premise
beauty_salon	health	railwaystation
bicycle_store	hindu_temple	real_estate_agency
book_store	home_goods_store	restaurant
bowling_alley	hospital	roofing_contractor
bus_station	insurance_agency	room
cafe	intersection	route
campground	isle	rv_park
car_dealer	jewelry_store	school
car_rental	landmark	shoe_store
car_repair	landscape	shopping_mall
car_wash	laundry	spa
casino	lawyer	stadium
cemetery	library	storage
church	liquor_store	store
church	local_government_office	street_address
city	locality	street_number
city_hall	locksmith	sublocality
clothing_store	lodging	sublocality_level_1
colloquial_area	meal_delivery	sublocality_level_2
convenience_store	meal_takeaway	sublocality_level_3
country	mosque	sublocality_level_4
country	mountain	sublocality_level_5
courthouse	movie_rental	subpremise
dentist	movie_theater	subway_station
department_store	natural_feature	synagogue
doctor	neighbourhood	taxi_stand
edu	moving_company	train_station
electrician	museum	transit_station
electronics_store event	night_club	travel_agency

embassy establishment finance	painter park parking	university veterinary_care waterbody zoo

7.1.2 Data Structure and Interface Definition

The public interface “findNearbyPois” allows specifying the starting point for the query, the search radius and the maximum number of results. The result is a list of POIs (List<MetaDataPoint>). The data structure for “MetaDataPoint” is described below.

Query method

```
public class ContextModule extends Service {
	public List<MetaDataPoint> findNearbyPois(final GeoPoint atLocation,
	float radiusM, int maxResults, ContextModule.RetrievePoisCompleteListener
	callback)
}
```

MetaDataPoint

```
public class MetaDataPoint extends GeoPoint {


	public static final String KEY_ID = "id";
	public static String KEY_NAME = "name";
	public static String KEY_ADDRESS = "address";
	public static String KEY_DESCRIPTION = "description";
	public static String KEY_CATEGORIES = "categories";
	public static String KEY_RATING = "rating";
	public static String KEY_IMAGE = "image";
	public static String KEY_URL = "url";
	public static String KEY_REFERENCE = “457742435”

	Map<String, Object> mMetaData;

	public MetaDataPoint() {
		mMetaData = new HashMap<String, Object>();
	}
}
```

GeoPoint

```
public class GeoPoint {
```

```
      /** The latitude of the point multiplied by a million. */
      @JsonProperty
      public int mLatitudeE6;

      /** The longitude of the point multiplied by a million. */
      @JsonProperty
      public int mLongitudeE6;

      /** The altitude of the point in meters above sea level */
      @JsonProperty
      private int mAltitude = -1;
}
```

7.2 PLACES OF INTEREST NEARBY

Categories of nearby places are compared to the interests collected in the user profile and can be filtered accordingly.

```
public class ContextModule extends Service {


public  List<MetaDataPoint>  findNearbyPlacesOfInterest(final  GeoPoint  atLocation,
      float radiusM, int maxResults, ContextModule.RetrievePoisCompleteListener
      callback)
}
```

8. USER INTERFACE FOR DAILY REFLECTION

The following section describes the user interface created for the daily reflection about the visited places. Within the MASELTOV application (MApp) these user interfaces should be accessible via the user profile component and via notifications (asking the user to check his daily profile and to give feedback) sent to the Android notification bar.
The user interface incorporates a map view, depicted in figure 2, with places visited represented as markers. Also the specific mode of transportation between places is shown. A more detailed view can be found when opening the list representation of the visited places (figure 3).
To add semantics to a place, two methods have been chosen. The detection of the home or workplace, as described in section 5.4, is based on statistics on daily movement patterns. Home and workplaces are marked with a special icon in the user interface. The determination of the other place categories is realized by querying multiple REST based POI databases, as described in section 0, returning the most likely POIs to the user. The result of the queried places is improved over time by user feedback. The user can edit the recognition result and choose other maybe more suitable place-detections from a list of POIs nearby. The system stores this information and uses this feedback to improve future POI suggestions.

Figure 2: Map of places visited including mode of transportation

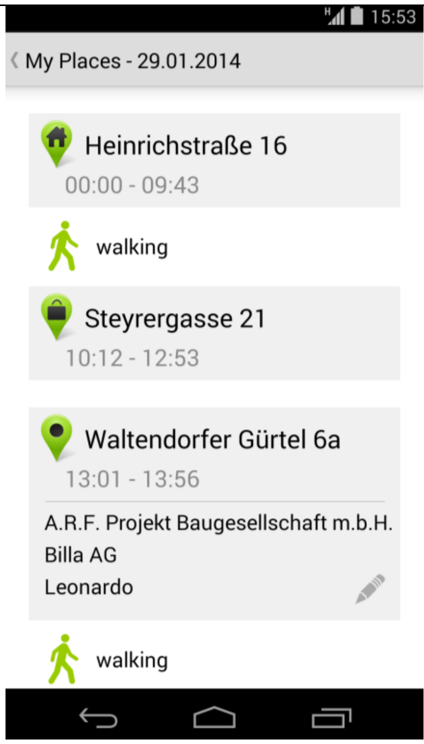

Figure 3: List of places visited including feedback option

In this daily reflection user interface, recognized statistics on other data collected by the context module e.g. social interaction and interests will be shown as well. As this part of the user interface is currently under development, unfortunately no user interface mock-ups could be included in this deliverable.

9. DATA SENT TO THE USER PROFILE

This chapter describes how the collected data from the context module is sent to the user profile using the *example* of the "Mode of Transportation" sub module. The current mode of transportation is sent to the user profile as soon as it changes.

Mode of Transportation


```
{
 "source": "MaseltovContext.TransportationMode",
 "timestamp": "1353417528",
 "event_timestamp": "1353417528",
 "type": "in vehicle",
 "confidence":"100"
```

```
}
```

According to the user profile interface specification in the document “Deliverable Report D5.2 - User Profiling and Personalization”, the transmission of the above specified mode of transportation module will look like the following:

```
String source = “MaseltovContext.TransportationMode”;
Calendar timestamp = Calendar.getInstance().setTime(“1353417528”);
HashMap<String,Object> info = new HashMap<String,Object>();


info.put(event_timestamp, "1353417528")
info.put(type, "in vehicle");
info.put(confidence, "100");
```

This also applies to the previously defined modules in the above chapter.

10. RECOMMENDATIONS BASED ON CONTEXT INFORMATION

This section describes how context info can be used for different recommendations.

10.1 IDENTIFY RELEVANT NEARBY PLACES

Context Module – Semantic Place Detection

The context module semantic place detection supports the identification of visited places as well as gathering information about the frequency and duration a place is visited. Places frequently or longer visited are assumed to be of interest to a user. Their categories are added to the list of interests which is also enriched by the interest sensing module described next.

Context Module – Interest Sensing Module

In addition to the categories of places of interest detected by the semantic place detection module, interests are determined by analysing the frequency of occurrences of specific terms within the browser bookmarks and browser search history to help personalize place recommendations for the user.

Context Module – Interface Nearby POIs

The context module provides an interface for querying nearby POIs. With the help of the interests collected by the semantic place detection and the interest sensing module, relevant nearby places can be identified and recommended to the user.

10.2 DO SOME LANGUAGE LEARNING

Context Module - Activity Recognition
Activity recognition determines when the user might have time for language learning tasks. The activity recognition module can be used to detect e.g. idle time or long rides on a vehicle (e.g. do language learning in the train). In the opposite case, recommendations can be avoided if high activity periods are detected e.g. the person is walking fast.

Context Module - Interest Sensing
Also the user can get specific language learning lessons according to the identified interests.

Context Module – Semantic Place Detection
Recommend language lessons relevant for places visited - e.g. if the system detects that the user is near an immigration office or a hospital, common phrases for the communication or emergency vocabulary is provided. Also the categories determined by the places of interest module can be used to adapt the recommendations for language learning sessions.

Context Module - Social Interaction
The social interaction module can be used to enforce communication and recommend some language learning e.g. on small talk.

10.3 FIND RELEVANT INFORMATION IN THE WIKI

Context Module - Activity Recognition
Same as for language learning - activity recognition detects when the user might have time to get recommendations for wiki articles.

Context Module - Interest Sensing
The identified interests can be used to adapt recommendations for user. The user can get targeted advice and articles of interest from the wiki.

Context Module – Semantic Place Detection
Recommend wiki articles relevant for places visited. Also the categories determined by the places of interest module can be used to adapt the recommendations.

11. PRIVACY

Most of the sub modules do not store or send data directly associated with the user, e.g. the social interaction module uses one-way hashing of the contact id, the subject or body of text messages is never stored. However other modules like the interest sensing module will only be able to deliver personalized recommendations by analysing plain text in order to find recurring terms. In order to protect the privacy of the user, the different sub modules of the geo-contextual module can be configured according to the user's preference. To inform the user about the data collected by the modules, a short description along with a toggle option for the module will be available in the user profile of the MASELTOV app.

12. CONCLUSION

This deliverable D4.1.2 "Geo-Contextual Event Analysis" provided an overview of the components implemented for the mobile multisensory interpretation of user behaviour.
While most of the components delivered satisfactory results, there is still room for optimizations.

The localization of the mobile phone is based on Wi-Fi fingerprinting and delivers sufficient accuracy at around 30 meters, when used in urban areas. However, when entering rural surroundings, sparse coverage of Wi-Fi networks causes positioning inaccuracies. Another issue is that the localization method employed in urban areas expects the received signal strength to fade to a certain level for a specific position. In some cases more Wi-Fi networks than typical for a certain location have been detected. This is particularly the case when scanning for radio fields at local peaks or at the upper levels of multi-storey buildings.
To overcome these problems, the GPS module of the mobile phone could be activated on demand, as an additional positioning method. Since the Wi-Fi fingerprinting method requires an internet connection to resolve the location, this would also guarantee continuous positioning in case connectivity is lost.

Poor Wi-Fi positioning would diminish the quality of context module considerably, with two error cases being the most prevalent:
(i) Position is fluctuating: In this case, the place recognition prerequisite would never be met.
(ii) Position is stable, but inaccurate: False places visited would be recognized.

If no Wi-Fi networks are available, the positioning method currently falls back to cell positioning, which has a poor accuracy around 1-2 kilometres. With no places detected, no instant recommendations for places can be given, no daily self-reflection on places visited can be done and no interests derived from place categories can be determined.
However, since MApp is mainly developed for urban environments and will be tested in three of the biggest cities of Europe (Madrid, London, Vienna) we could start form the premise that a high density of Wi-Fi networks will be available, which will result in a very good positioning accuracy.

Determining the social inclusion of a person is solely based on the statistics of the amount and duration of communications on the mobile phone. Information about the call behaviour, text

messages and contacts are collected and sent to the user profile once a day. Face-to-face communication however is not considered by the social interaction module. A further improvement could be to monitor the surrounding noise of the user with the help of the mobile phone's microphone and detect possible communications.
The modules described in this deliverable will be used for the MASELTOV system to deliver relevant context information and provide background data for recommendations based on the situation-dependent context of the user's environment.

The **social interaction module** will be used to determine the social inclusion of a person and in further consequence provide the information to facilitate and foster communication. The knowledge about the current state of movement implemented by the **activity recognition module**, will be used to optimize the timing of the delivery of recommendations. The **interest sensing module** will provide identified interests, which will be used to deliver targeted advice or information to the user. The geo-contextual event analysis also incorporates geographic information of the user's surrounding environment. This information is provided by the **semantic place detection module** and enables the delivery of recommendations, information or tasks connected to places visited.