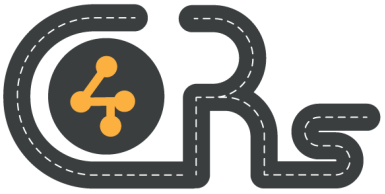

CROWD4ROADS

CROWD sensing and ride sharing FOR ROAD Sustainability

Project Number: 687959

D2.3 — System requirements and performance indicators

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Abstract:	Specifications and requirements of the CROWD4ROADS platform at all stages of its development. Operative definitions of the key performance indicators to be used for validation, assessment, and evaluation.
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Executive summary

This document corresponds to Deliverable 2.3 of the CROWD4ROADS project and gives an overview of internal specifications and requirements of the project's platform at all stages of its development.

This deliverable includes the project's roadmap and development principles, to be applied throughout each development phase by all members of the project's consortium. Moreover, operative definitions of the project's Key Performance Indicators (KPIs) are included in this document, to be used for validation, assessment, and evaluation purposes.

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1. Preface

Work Package 2 of the CROWD4ROADS project is primarily focused on analysing the socio-economic framework and the sustainability threats of passenger road transportation that can be addressed by means of crowd-sensing and ride sharing. Task 2.3 in particular has the purpose of identifying and specifying the functional and non-functional requirements of the CROWD4ROADS platform, according to the different scenarios and use-cases.

Functional requirements and specifications will be treated at three different levels, according to the major milestones of the project's roadmap, detailed in Chapter 2.

Design metrics and principles to be used as founding principles throughout the development, that will drive the design and support testing and validation, will be outlined in Chapter 3.

In Chapter 4 operative performance indicators, making reference to the Key Performance Indicators (KPIs) introduced in D1.2, D5.2, and D5.3, will be defined, together with the measurement protocols to be adopted during development.

2. Roadmap and specifications

The aim of the CROWD4ROADS project is to harness collective intelligence to contribute to the solution of sustainability issues of road passenger transport. As thoroughly explained in D3.1 the project leverages two already existing platforms owned by two of partners of the project consortium to accomplish its objective namely *SmartRoadSense* and *BlaBlaCar*. While the large community of *BlaBlaCar* users will going to be exploited to help in further increasing the average car occupancy rate by means of targeted communication campaigns, the *SmartRoadSense* platform will be the technological backbone on top of which the road monitoring task will be developed.

In the following sections the project's roadmap and specifications will be described, distinguishing between the high level integration steps to be undertaken and the lower level technological roadmap to be tackled by *SmartRoadSense* in particular.

2.1. Integration roadmap and specifications

Both principal communities involved in CROWD4ROADS, users of *SmartRoadSense* and users of *BlaBlaCar*, are mainly focused on people using private vehicles for transportation, and thus can have a large interests overlap. As detailed in D3.1, *SmartRoadSense* and *BlaBlaCar* communities can clearly take advantage of each other and of the results of the CROWD4ROADS project.

In accordance to the integration plan presented in D3.1, the principal integration guidelines to be adopted throughout the course of the project are the following:

A. No direct data-sharing between *SmartRoadSense* and *BlaBlaCar* other than publicly available data, in order to comply with the project's data protection requirements as described in D1.3;
B. *SmartRoadSense* and *BlaBlaCar* mobile applications will not be merged and thus keep their distinguishing identities and existing user base;
C. *SmartRoadSense* and *BlaBlaCar* mobile applications and web presences may integrate project references and pointers in order to stimulate their respective communities;
D. Integrate gamification aspects into the *SmartRoadSense* service in order to motivate users, possibly with the integration of a virtual currency system.

At a high level, the integration process of the project's components is thus structured as follows:

1. **Intersection and spontaneous interaction between existing communities:**
   The existing BlaBlaCar and SmartRoadSense communities will be stimulated in order to increase awareness of the CROWD4ROADS project and its components, as detailed in the D5.2 Communication Plan.
   a. Publication of the CROWD4ROADS website;
   b. Press notes on major milestones;
   c. Publication of Open Data;
   d. Targeted communication to the BlaBlaCar community on social media, newsletters, and other channels;
   e. Involvement of other stakeholders, including partner in the project's Advisory Board.
2. **Integration of initiatives:**
   Integration of communication activities and other outlets, including web services and mobile applications, as detailed in the D3.1 Carpooling and Crowd-sensing Integration Plan.
   a. Targeted pilots on specific geographical regions, which will be carefully deployed, monitored, and analyzed, as described in D4.3 Pilots Definition and Community Building Strategy;
   b. Targeted monitoring and public awareness campaigns operated in coöperation between partners, members of the Advisory Board, and partners involved in the operation of pilots;
   c. Introduction of single-user social sharing tied to the crowd-sensing efforts of individual users, in order to further stimulate user participation and involvement.
3. **Advanced coöperation incentives:**
   Advanced features through closer coöperation of all partners of the consortium.
   a. Introduction of gamification elements to server-side and client-side aspects of the *SmartRoadSense* system, in order to incentivize user participation and grow awareness of the project's intent;
   b. Introduction of multi-user gaming elements to the crowd-sensing aspects of *SmartRoadSense*;
   c. Introduction of virtual currency incentives to further reward user participation and to grow awareness of the project beyond communities

taking part in the project itself, possibly involving stakeholders in the Advisory Board.

2.2. Technological roadmap

Before the beginning of the CROWD4ROADS project, the *SmartRoadSense* system was available only for users on the Italian territory. During the course of the project, the entire platform will be progressively enhanced and adapted to support larger number of users and to integrate more territories of operation.

Moreover, the system will be enhanced in order to detect cars occupancy rates and introduce gamification elements.

The enhancement operations will adhere to the following cursory roadmap:

1. **Development of server-side scalability enhancements.**
   Starting from the *SmartRoadSense* basis, both the server and the client sides of the platform need to be updated to sustain requests from a large number of users and to make the storage space and technologies able to cope with greater fluxes of data.
2. **Cars occupancy rate monitoring.**
   Mobile clients will be made able to anonymously collect statistics about how many passengers are inside each tracked vehicle. Carpooling information will be collected by mean of privacy preserving techniques.
3. **Development of a single-user gamification layer solely based on data local to the device.**
   The gamification functionalities will be gradually introduced in the course of the project. The first step will be to integrate some basic gamification features in the *SmartRoadSense* mobile clients. These initial gamification layer will rely only on data already available to the mobile applications, and it will not entail any structural changes for the privacy-preserving client-server communication protocols developed for the *SmartRoadSense* platform.
4. **Development of a multi-user, full-fledged gamification layer.**
   Further gamification functionalities will make the platform able to leverage the presence of many people in the same car during a journey. Multiple users in the same car will be able to form a team and by playing with the *SmartRoadSense* mobile application during the trip, they will help to collect additional information and to improve the overall data quality.

5. **Development of a social sharing framework of user's achievements.**
   To make the gamification experience more engaging the user will be able to share their achievements and status with others, through the major social platforms.
6. **Development of a monetization framework.**
   The final step will be to develop a monetization framework based on an original virtual currency system, tentatively called GeoCoin. The users will earn units of virtual currency in exchange for their efforts contributing to the data collection endeavor. The virtual currency can be traded for online or offline services such as free time in paid parking spaces, free wifi connection at the airport, or premium membership for online services.

3. Principles of project development

In order to keep the project's development in line with the DOA document, the project's desired outcomes and use-cases, the quality assurance metrics outlined in D1.2, and the ethical requirements defined in D1.3 and D6.1, the project will follow a set of principles and guidelines for all aspects of development.

A. **Anonymity:** at all levels of the system and its development, including monetization and virtual currency implementation, the user's anonymity will be guaranteed. Full anonymity will be enforced through privacy-preserving techniques. Only voluntary disclosure of information (e.g., voluntary sharing of information or efforts tied to the project by the user her/himself) may violate this principle.
B. **Data quality:** gathered data about infrastructure and driving habits that is of interest to stakeholders, partners, and third parties must guarantee a certain level of quality in order to be of use. Data quality is determined by the following aspects:
    a. **Timeliness:** data is gathered in real-time, stored locally and transmitted opportunistically, but with reasonable maximum delays. Data elaboration and aggregation will be performed as frequently as possible, ensuring freshness of generated data visualizations. Real-time collection and aggregation will be studied and implemented if possible.
    b. **Validation:** in particular during test-bed deployments, the validity of the final data will be ensured through the definition of an, as formal as possible, definition of ground truth metric for road roughness and the examination of collected aggregated data.
    c. **Assessment:** consistency of raw, computed, and aggregated data must be pursued at each step of development. In detail:
        i. Multi-platform and multi-device development, already in place for the client-side part of SmartRoadSense, allows for comparative checking of data generated by different devices.
        ii. Data collection devices will be initially calibrated before being used. Calibration results will be gathered in order to design the needed calibration techniques and implement them.
        iii. The prospected multiplayer gamification modes will allow multiple devices to report the same data, also allowing for further

calibration and assessment of differences between devices and collected data.

C. **Usability:** the mobile clients design is intended to be as easy to be used as a possible. All the tasks the user has to perform utilizing one of the mobile apps will have to be intuitive and straightforward. As the apps will be mostly used right before to start driving or right after the drive, users need to be able to activate, or deactivate, the *SmartRoadSense* app tracking in a few clicks. For the same reason also all other activities such as sharing achievements or checking personal statistics will have to be kept as fast as possible.

D. **Scalability:** crowd sensing applications as *SmartRoadSense* heavily rely on robust software/hardware infrastructure. As timeliness, usability and an overall excellent user experience need to be ensured, both the mobile and the cloud components of the system will have to be designed in order to efficiently manage great amounts of data.

   a. **Mobile applications:** mobile clients are responsible of the preprocessing of the raw data directly gathered by device on-board sensors. The development of efficient data analysis algorithms will be regarded as a crucial part of the multi-platform mobile app design process.

   b. **Communication protocol:** each mobile device can possibly collect long burst of data depending on the length of recorded tracks. In order to optimize the size and the duration of client-server communications the sending process will include the splitting of long bursts of contiguous data into smaller chunks. The task of re-assembling each track on the server side will be complicated by the privacy-preserving structure of the current communication protocol as the scarcity of information would impede the re-construction. A suitable solution will be designed.

   c. **Remote server:** the remote server will leverage the power and flexibility of the *MCloud* infrastructure. Moreover, the entire structure of the remote platform will be encapsulated and divided in multiple atomic– and possibly replicable– modules. The most modern virtualization techniques will be employed to ensure scalability for both databases and parallel executions of remote procedures.

4. Operative Performance Indicators

Operative Performance Indicators (OPIs) are indicators used during all development phases as a metric of software maturity, performance, and adherence to the requirements of the project.

Indicators are thematically separated into 4 different sections.

They generally reference the Key Performance Indicators (KPIs) described in Deliverable 1.2, making reference to most of the same metrics and indicators. OPIs however do not provide specific numeric targets to reach, since they are intended as guidance during development.

4.1 Data Quality

The Open Data continuously released by *SmartRoadSense* includes a measure of data quality for each single dataset item[1]. This quality measure already takes into account most of the fundamental aspects of data quality such as the number of collected data, their coherence and age. The average of this measure (indicated with *ODQM*) and its trend will be regarded as overall numerical indicators of the entire process data quality.

OPIs	
OQ1	Average open data quality measure (ODQM)

4.2 Scalability

These OPIs help in checking whether the *SmartRoadSense* platform software and hardware resources are suitable or not to process the incoming data flux.

OPIs	
OS1	Raw database size per kms of mapped roads

[1] For further information about the process of calculating the data quality please see [DQT]

OS2	Aggregate database size per kms of mapped roads
OS3	Average duration of aggregation execution
OS4	Server bandwidth average usage for incoming data (from mobile clients)
OS5	Server bandwidth average usage for map views

4.3. Usage

These OPIs keep track of how much and how frequently the *SmartRoadSense* system is used by mobile app users to contribute to road quality measurement.

OPIs	
OU1	Total *SmartRoadSense* active users
OU2	*SmartRoadSense* new installations per day
OU3	Number of uploaded raw data points per day
OU4	Number of total monitored kms per day
OU5	Number of monitored kms per active user per day
OU6	Percentage of monitored roads whose roughness indicator is updated per year
OU7	Percentage of user sessions providing trip-sharing data
OU8	Percentage of user sessions making use of multi-user cooperation features and other gamification-related features

4.4. Social Appeal

These OPIs also reference the KPIs described in Deliverable 5.2 and are related to all publicly visible activities tied to the project.

OPIs	
OA1	Number of total reach and reactions on *SmartRoadSense* achievements

	shared on social networks (social network virality)
OA2	Number of total achievements shared in social networks by users
OA3	Traffic to *SmartRoadSense* or CROWD4ROADS website or social outlet (Facebook pages, Twitter, etc.) through achievements social sharing
OA4	Percentage of *SmartRoadSense* installations that have participated at least once in multi-user cooperative modes (in-person virality)

5. Referenced documents

[DQT] V. Freschi et al. “Bootstrap based Uncertainty Propagation for Data Quality Estimation in Crowdsensing Systems.” *in publication on IEEE Access.*

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