D2.1 – Use Cases and Requirements

WP2 – Use cases, Requirements & Architecture

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## Acronyms

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<th>Meaning</th>
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<tr>
<td>AAA</td>
<td>Authentication, Authorization and Accounting</td>
</tr>
<tr>
<td>ADAS</td>
<td>Advanced Driver Assistance System</td>
</tr>
<tr>
<td>AN</td>
<td>Access Node</td>
</tr>
<tr>
<td>AP</td>
<td>Access Point</td>
</tr>
<tr>
<td>CPE</td>
<td>Customer Premises Equipment</td>
</tr>
<tr>
<td>EN</td>
<td>Edge Node</td>
</tr>
<tr>
<td>ER</td>
<td>Edge Router</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology.</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>ISP</td>
<td>Internet Service Provider</td>
</tr>
<tr>
<td>LTE</td>
<td>Long Term Evolution</td>
</tr>
<tr>
<td>NSP</td>
<td>Network Service Provider</td>
</tr>
<tr>
<td>QoE</td>
<td>Quality of Experience</td>
</tr>
<tr>
<td>QoS</td>
<td>Quality of Service</td>
</tr>
<tr>
<td>UE</td>
<td>User Equipment</td>
</tr>
<tr>
<td>UGC</td>
<td>User Generated Content</td>
</tr>
<tr>
<td>V2I</td>
<td>Vehicle to Infrastructure</td>
</tr>
<tr>
<td>V2V</td>
<td>Vehicle to Vehicle</td>
</tr>
<tr>
<td>WAN</td>
<td>Wireless Access Network</td>
</tr>
<tr>
<td>WAVE</td>
<td>Wireless Access in Vehicular Environment</td>
</tr>
</tbody>
</table>
1 Executive summary

This document corresponds to deliverable D2.1, “Use cases and requirements”, in FP7-MOTO. It is dedicated to the description of specific use-cases, which will be the basis for the remaining work in MOTO.

The document is organized as follows. It starts with a set of definitions and additional terminology to assist the reader in the understanding of the document. Section 2 covers the MOTO use-cases. In the first subsection, the “scenario space” is exposed. This space is spanned by 5 dimensions and has been defined to identify a relevant and meaningful group of MOTO scenarios. These scenarios have been grouped in three different use cases, providing for each of them the sets of actors, pre-conditions, and offloading benefits. Finally, a list of requirements derived from the use cases are presented in Section 3.
2 Terminology and definitions

The definitions provided in this document have limited scope to D2.1 and are provided for the sake of clarity and to assist the reader in the document understanding.

**Table 2: Terminology and definitions**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed Client</td>
<td>Users or machines that have requested content, which are shared by other users, directly from the WAN. It also applies to vehicles that generate content (e.g., sensor information), which is shared with other users or machines.</td>
</tr>
<tr>
<td>Opportunistic Client</td>
<td>Users or machines that have requested content through seed clients or other opportunistic clients.</td>
</tr>
<tr>
<td>MOTO Platform</td>
<td>A system that provides opportunistic MOTO Services for MOTO clients.</td>
</tr>
<tr>
<td>MOTO Service</td>
<td>A service handled by MOTO platform which provides offloading functionalities to MOTO clients.</td>
</tr>
<tr>
<td>Content</td>
<td>Information elements requested or generated by clients. For example web pages, information related to an application, information related to vehicles sensors, etc.</td>
</tr>
<tr>
<td>MOTO Application</td>
<td>A tool installed in the client to provide a MOTO Service.</td>
</tr>
<tr>
<td>MOTO Network Service</td>
<td>A system that is required to support, from a network perspective, connectivity among MOTO clients.</td>
</tr>
<tr>
<td>MOTO Service Provider</td>
<td>An ISP running the MOTO platform to provide offloading facilities/MOTO Services to its users.</td>
</tr>
<tr>
<td>MOTO Client Reputation</td>
<td>A client assigned trust value based on the trust reports recollected from all the other MOTO users he has connected historically.</td>
</tr>
<tr>
<td>Trust</td>
<td>A numeric value given to a certain communication with a particular MOTO client by other MOTO client applications based on the behaviour of the first in the communication with the others.</td>
</tr>
<tr>
<td>Offloading</td>
<td>Action of using alternative communication channel(s) to redirect traffic that was originally sent through a main communication channel.</td>
</tr>
</tbody>
</table>
3 MOTO Use Cases

Use cases in MOTO serve the purpose of establishing realistic boundaries and requirements for the functionality to be developed in the project. For each use case, a detailed description is provided including technology and functionality that are available and will be applied, as well as the innovative aspects that MOTO will pursue. Then, a set of requirements for each use case are derived.

These use cases are the basis for all the specification and development to be performed in WP4 and also the basis for the set of scenarios to be implemented in WP5 for the purpose of MOTO validation and demonstration.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119.

3.1 Scenario classification criteria

The set of scenarios that can be studied in the MOTO project constitutes, in principle, a very large one. This deliverable presents a set of coherent scenarios that captures the major dynamics that are of interest in deploying MOTO systems. In such an approach, it is also very important to understand the nature of scenarios that are not being addressed, being fully aware of the scope of the study.

Towards this end, as the initial step in WP2, the MOTO consortium has identified a “scenario space” that is spanned by 5 dimensions that will – in principle – locate any scenario considered. The five selected dimensions are (i) Network Benefit, (ii) Mobility, (iii) QoS, (iv) End Actors, and (v) Push/Pull implications. The network benefit characterizes the system in terms of its contribution to resource efficiency, whether the system is coverage limited, capacity limited (or both). The mobility of a scenario determines whether it involves clients on the go, clients that occasionally move, or clients that do not move at all. The QoS dimension denotes the delay tolerance of the application to be run on the MOTO platform, and the “End Actor” dimension determines whether the recipient of the service is an end user or a machine. Finally, the “Push/Pull” dimension determines whether user or the network drive the content delivery.

Network Benefit
   a) Capacity (i.e., use case shows MOTO as an enabler to increase capacity in the network).
   b) Coverage (i.e., use case shows MOTO as an enabler to increase coverage in the network).
   c) Both (capacity and coverage).

Mobility
   a) Nomadic (i.e., use case mainly involves nomadic / low mobility users).
   b) Mobile (i.e., use case mainly involves mobile / medium - high mobility users).

QoS
   a) Low delay tolerance or delay intolerant (i.e., use case mainly involves services that are delay intolerant or shows low delay tolerances, like on-line gaming, video streaming etc.).
   b) Medium delay tolerance (i.e., use case mainly involves services that are medium delay intolerance like augmented reality).
   c) High delay tolerance (i.e., use case mainly involves services that are high delay tolerance like advertising).

End Actors
   a) End user (i.e., use case involves end users as consumers of the information).
   b) Machines (i.e., use case involves machines, like vehicles, as consumers of the information).

1 Bradner, Key words for use in RFCs to Indicate Requirement Levels. IETF RFC 2119 (Best Current Practice Category), March 1997
Push / Pull

a) Push (i.e., use case involves information pushed to the end actor).

b) Pull (i.e., use case involves information pulled by the end actor).

c) Both (i.e., push + pull information).

Apparently, one can produce a large number of scenarios corresponding to different combinations of “dimension” values. As for the MOTO consortium, we have converged on the below set of 3 use cases which are of interest considering the business visions of the participants. The considered scenarios are outlined in the table below.

### Table 3: Scenario classification.

<table>
<thead>
<tr>
<th>Scenario Title</th>
<th>Network Benefit</th>
<th>Mobility</th>
<th>QoS</th>
<th>End actors</th>
<th>Push / Pull</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Use Case 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile customers accessing the web page of a shopping centre</td>
<td>Both</td>
<td>Nomadic</td>
<td>Medium-High delay tolerance</td>
<td>End user</td>
<td>Both</td>
</tr>
<tr>
<td>Internet access proxing in a congested/no coverage mobile network</td>
<td>Both</td>
<td>Nomadic</td>
<td>Medium delay tolerance</td>
<td>End user</td>
<td>Pull</td>
</tr>
<tr>
<td>Energy-saving Data dissemination with Offloading in Crowds for day-by-day uses (Augmented reality application in a crowded museum)</td>
<td>Capacity</td>
<td>Nomadic</td>
<td>Medium-High delay tolerance</td>
<td>End user</td>
<td>Push</td>
</tr>
<tr>
<td>Energy-saving Data dissemination with Offloading in Crowds to handle peak of data traffic demands</td>
<td>Capacity</td>
<td>Nomadic</td>
<td>Medium-High delay tolerance</td>
<td>End user</td>
<td>Both</td>
</tr>
<tr>
<td><strong>Use Case 2</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expanded Coverage and 3G Offloading</td>
<td>Both</td>
<td>Nomadic</td>
<td>Medium delay tolerance</td>
<td>End user</td>
<td>Pull</td>
</tr>
<tr>
<td>Content dissemination based on payment system</td>
<td>Capacity</td>
<td>Mobile</td>
<td>Low-Medium delay tolerance</td>
<td>End user</td>
<td>Pull</td>
</tr>
<tr>
<td><strong>Use Case 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Fleet Management</td>
<td>Capacity</td>
<td>Mobile</td>
<td>High delay tolerance</td>
<td>Machines</td>
<td>Both</td>
</tr>
<tr>
<td>Map-Based Advanced Driver Assistance Systems (ADAS)</td>
<td>Capacity</td>
<td>Mobile</td>
<td>Low-Medium delay tolerance</td>
<td>Machines</td>
<td>Pull</td>
</tr>
<tr>
<td>Enhancing Traffic Efficiency through Cooperative V2X Communication Systems</td>
<td>Both</td>
<td>Mobile</td>
<td>Low-Medium delay tolerance</td>
<td>Machines</td>
<td>Both</td>
</tr>
</tbody>
</table>
3.2 Use Case 1: Medium – Big crowds scenario

Wireless operators have always considered offering access to a large number (a “crowd”) of users during the same time period and in a relatively limited space as a tough challenge. In fact, such an objective can consist of simple scenarios where users will request to download popular contents on their mobile devices. Scenarios where users not only download content from designated providers, but also share content according to UGC models, also fall within this category. In most common scenarios, users’ requests will not be strictly synchronized (i.e., multicast solutions will not be applicable); in addition, real-time delivery will not be necessary. Therefore, in this use case we focus on stored content, which shows medium – high delay tolerance as for instance pre-recorded audio/video clips. In this context, it is quite reasonable to assume that users request content with loose QoS, and consume it once available on their devices, i.e., few-minute delays can be tolerated.

This use case covers medium-big crowds scenarios such as museums, concerts, and shopping malls, where the MOTO Service aim is not only to share content to reduce the load on the network, but also to provide Internet access to devices that are outside the range of coverage of LTE or Wi-Fi networks.

<table>
<thead>
<tr>
<th>Use Case Name</th>
<th>Medium – Big scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Case ID</td>
<td>MOTO – 1</td>
</tr>
<tr>
<td>Goal</td>
<td>Enhance network capacity and coverage</td>
</tr>
</tbody>
</table>

3.2.1 Scenarios

3.2.1.1 Scenario 1: Mobile customers accessing the web page of a shopping centre

3.2.1.1.1 SUMMARY

Customers in a shopping mall are provided access to the Shopping Mall web site pages on their mobile phones. The MOTO system allows the customers’ terminals caching the web pages. These terminals may also serve as proxies to access the web site to other customers.

3.2.1.1.2 DESCRIPTION

Maria is a MOTO Service user carrying her Android smart-phone (UE) and she is with her friends in a shopping mall. When Maria turns on her UE, it associates / registers to the net (Wi-Fi or LTE) and authenticates into MOTO platform. Maria’s UE was provided with MOTO credentials when she first registered into the MOTO Service. In order to assume a particular MOTO role (i.e., seed or opportunistic), Maria trust level should be above a threshold (i.e., good reputation). The trust level as seed or opportunistic clients is constructed from previous information obtained by the network operator and from users engaged with Maria in previous opportunistic interactions. Maria trust level is set.

Maria decides to search whether the shops and restaurants of the shopping mall have interesting offers. For that purpose Maria, with her smart-phone, tries to access to the mall’s web page. In that moment her UE exchanges information with the MOTO platform in order to receive the role that is going to take into the MOTO Service. The MOTO platform looks for other trusted UEs that have already downloaded this information from the Internet and as none has previously downloaded it, the role that Maria’s UE receives is “seed client”. Once the UE has the “seed client” role defined, it accesses the net to obtain the mall’s web page. From that moment onwards, Maria’s UE periodically sends to the MOTO platform the information about what content has already downloaded and other information in order to, among others, coordinate the communications.
Tom, another user of MOTO Service, is in the same shopping mall. As Maria has previously done, he wants to know whether shops and restaurants of the shopping mall have interesting offers. Thus, his UE follows the same process Maria’s one has followed, but this time, his UE receives the “opportunistic client” role since the MOTO Platform has looked for other trusted UEs that have already downloaded this content and has found Maria’s one. Straight afterwards, the MOTO Platform informs Tom’s UE about the nearest approved “seed client” from which the requested content can be downloaded (in this case Maria’s one), and therefore Tom’s device triggers a request for Maria’s device to connect. Maria allows other approved users (Tom), with whom her device does not yet have a trust association established, to interconnect by providing them a small amount of resources based on specific QoE requirements (e.g., only if her UE has enough battery level and up to 20%). Maria’s and Tom’s UE exchange their MOTO credentials and MOTO Platform assists Maria and Tom on validating such credentials. Afterwards, Maria’s UE connects to the MOTO Platform and applies for Tom’s reputation, once confirmed to be approved, Maria and Tom’s UE automatically negotiate connectivity (including terminal and content access rights) and Tom obtains the restaurant’s content through Maria’s device. Once Tom’s UE has received the requested content, it periodically sends information to the MOTO Platform about his connection and what it has downloaded. Both UEs start data collection for MOTO reputation creation.

The shopping mall’s owner realizes that many people access to his venue’s web page to consult the offers. Additionally, he has new offers and he wants this information to reach as many people as possible. Thus, he decides to automatically send the offers to all MOTO users in the shopping mall. Bob is shopping in a cloth shop in the shopping mall. He is also a MOTO Service approved user and the MOTO Platform has detected that Bob is close to the mall. Thus the MOTO Platform assigns Bob’s UE the “opportunistic client” role and indicates it to download the shopping mall’s offers (content) from an approved client (Tom). In this moment, Tom’s UE establishes a trust association (trust and identity confirmation through MOTO credential exchange) with Bob’s one in order to send it the restaurant’s offer information.

3.2.1.1.3 ACTORS
- End users with smart-phones with a MOTO Application for compliance with MOTO Services preinstalled.
- Network access providers (Wi-Fi, LTE) that constitutes the MOTO Network Service infrastructure.
- Service Providers
- Content for download.

3.2.1.1.4 PRE-CONDITIONS
- End users smart-phones need to have LTE and Wi-Fi functionalities.
- End users smart-phones need to have MOTO Application installed.
- End users smart-phones need to be subscribers of the MOTO Service, with their corresponding credentials issued by the MOTO Platform.

3.2.1.1.5 BASIC SEQUENCE
- A user arrives a shopping mall.
- The MOTO Application installed in her/his smart-phone exchanges information with the MOTO Platform and after authentication and approval, assigns the UE a seed client role.
- The smart-phone connects to the network through Wi-Fi or LTE and downloads the requested content.
- A new user arrives to the shopping mall.
- The new user requests the same content the first user requested.
- The MOTO Application installed in his smart-phone exchanges information with the MOTO Platform and detects the content has already been downloaded from another approved MOTO user.
- The MOTO Platform assigns the UE an opportunistic client role.
- The MOTO Platform coordinates the establishment of a connection between the two UE, ensuring both users are identified and “well intentioned”, under the “approval” condition.
Both MOTO clients exchange their MOTO credentials in order to identify each other.

The opportunistic client’s smart-phone downloads the content from the seed client’s smart-phone.

3.2.1.1.6 Offloading benefit
Localized web traffic is offloaded from the hotspot infrastructure to the Wi-Fi direct links between terminals. So there is less traffic on the web server and there is less usage of the Wi-Fi access infrastructure (these are the savings provided by offloading). This is offloaded to terminal memory and Wi-Fi ad-hoc (terminal-to-terminal) links. For users this implementation will be transparent, giving them the feeling of a robust and seamless service.

3.2.1.2 Scenario 2: Internet access proxing in a congested/no coverage mobile network

3.2.1.2.1 Summary
MOTO users benefit from this service in situations where network is congested or lacks coverage. The MOTO Service allows users to access the Internet through other users’ terminals when the radio link is congested or even when no coverage around the user is available. In this case, the user herself/himself has no access to the network but another user, in her/his vicinity does. This latter user acts as a relay for the first one and provides, thus, coverage extension.

3.2.1.2.2 Description
Mobile network dimensioning is planned before the actual deployment. However, in some cases a crowd requires services from the network that the net cannot handle. In such a case, almost all users obtain a deficient service (or even experience service unavailability issues). MOTO Service could manage the UEs to provide service (at least, a minimum bundle of services) for all users with the available mobile network infrastructure.

Maria is a MOTO Service user carrying her Android smart-phone (UE). She has gone with her friends to a carnival parade. They have arrived soon. There is almost nobody there when Maria takes his UE to retrieve some information (content) about the event. The UE, after authenticating into the MOTO Platform, exchanges information with the platform, in order to receive approval to use the service and the role that is going to take into the MOTO Service. The MOTO Platform checks Maria’s trust based on her reputation saved on the system. It also checks if network access capacity is full and confirms that it is not. Thus, Maria is approved because she has a reputation above threshold and the role that Maria’s UE receives is “seed client”. Once the UE has the “seed client” role defined, it accesses the net to obtain the content requested by Maria. From that moment onwards, Maria’s UE periodically sends to the MOTO Platform information about what it has already downloaded and other information in order to, among others, coordinate the communications.

Tom comes later. He, as Maria, is a MOTO Service user. After turning on his UE, authenticating and getting approval for service by the MOTO Platform, the MOTO Platform determines that he should connect to the net through Wi-Fi if possible and if not through LTE since the network’s access capacity is not full yet. Tom’s UE receives the role of “seed client” too and once connected, Tom’s UE periodically sends information to the MOTO Platform about his connection and the content it has downloaded, as well as any information related to his interaction with other users.

Gradually people begin to arrive the parade. When the parade has started, Bob arrives. He is also a MOTO Service user and when his UE authenticates into the MOTO Platform and gets approval, this last one detects that both LTE and Wi-Fi networks’ access capacity is full. Thus, his UE follows the same process Maria’s one has followed, but this time, his UE receives the “opportunistic client” role. Straight afterwards, the MOTO Platform informs Bob’s UE about the nearest “seed client” to connect through to the Internet (in this case Maria’s one). Therefore Bob’s device triggers a request for Maria’s device to connect. Maria allows other users (Bob) with whom her device does not yet have a trust association established based on previous connections but which are trusted by the MOTO Platform, to interconnect by providing them a small amount of resources based on specific QoE requirements (e.g., only if her UE has enough battery level.
and up to 20% and establishing some type of policies such as allowing only emergency call traffic or instant messaging services, etc.). Both users exchange their MOTO credentials and afterwards, Maria’s and Bob’s UE automatically negotiate connectivity (including access rights). Bob obtains Internet access through Maria’s device. Once Bob’s UE has received the requested content, periodically sends information to the MOTO Service about his connection (including information for trust profile build-up (reputation) and the content it has downloaded.

When there are a lot of people in the parade John arrives. In the place where he is, there is neither LTE nor Wi-Fi coverage. However, John is a MOTO Service user and he is near Bob. Thanks to MOTO Service, John’s UE establishes a secure connection with Bob’s UE and accesses to the Internet through his device.

3.2.1.2.3 ACTORS
- End users with smart-phones with a MOTO Application for compliance with MOTO Services preinstalled.
- Network access providers (Wi-Fi, LTE) that form the MOTO Network Service infrastructure.
- Service Providers
- Content for download.

3.2.1.2.4 PRE-CONDITIONS
- End users smart-phones need to have LTE and Wi-Fi functionalities.
- End users smart-phones need to have MOTO Application installed.
- End users smart-phones need to be subscribers of the MOTO Service, a reputation above threshold and a valid MOTO credentials.

3.2.1.2.5 BASIC SEQUENCE
- A user arrives a carnival parade.
- The MOTO Application installed in his smart-phone exchanges information with the MOTO Platform in order to get access, once authenticated and approved by the MOTO Platform, and after verifying that the network access capacity is not full, assigns to the UE the seed client role.
- The smart-phone connects to the network through Wi-Fi or LTE and downloads the requested content.
- A new user arrives to the parade.
- The new user tries to access to the Internet.
- The MOTO Application installed in his smart-phone exchanges information with the MOTO Platform. Once authenticated and approved, the MOTO Platform detects that the network access capacity is full.
- The MOTO Platform assigns to the UE the opportunistic client role.
- The MOTO Platform informs to the last user MOTO Application that it must be connected to the Internet through other MOTO user’s device.
- The MOTO Platform coordinates the establishment of a connection between the two UE. The MOTO user’s applications exchange their MOTO credentials.
- The opportunistic client’s smart-phone accesses to the Internet through the seed client’s smart-phone.

3.2.1.2.6 OFFLOADING BENEFIT
All the Internet traffic is offloaded from the hotspot or LTE infrastructure to the Wi-Fi direct links between terminals. This decreases congestion of the WAN interface, as some users connect to the Internet through other users’ devices. If the seed user has previously downloaded the content required by the opportunistic user, she/he may serve as a proxy server to provide the content to the opportunistic user. Users’ will be satisfied since they will not be affected by congestion or lack of coverage in the network, giving them the feeling of a robust and seamless service.
3.2.1.3 Scenario 3: Data dissemination with Offloading in Crowds for day-by-day uses (Augmented reality application in a crowded museum)

3.2.1.3.1 SUMMARY

Visitors in a museum are provided with a mobile guide application, which supports an augmented-reality museum visit. The MOTO system allows the users’ terminals to receive the additional multimedia content from nearby visitors rather than remote servers. This scenario exemplifies the use of MOTO for offloading data dissemination tasks to users’ terminal (while preserving energy efficiency) in crowded scenarios that occur almost constantly, i.e., on a day-by-day basis.

3.2.1.3.2 DESCRIPTION

In this scenario the critical issue is that the network infrastructure might need to be drastically over-provisioned in certain physical areas to handle large demands of traffic generated by a regular crowds of users, who want to download and/or share similar content mostly at the same time, though without precise synchronization points (i.e., multicast solutions are not applicable). In the specific case addressed in this scenario the crowd event happens frequently and almost on a daily basis, although the profile of the crowd traffic may be variable. A concrete example of such day-by-day scenario is the “Augmented Reality Tourism”, which allows guided multimedia visits in touristic sites. In this use case user Alice runs an Augmented Reality application at the Vatican Museums. As it is typical for this type of applications, Alice shots a picture of an artwork on display, and wishes to get back a multimedia content related to the artwork. In the following we provide a more detailed description of such scenario.

Alice is supposed to be subscribed to an LTE service, which provides coverage in the area of the Vatican Museums. In this case, MOTO Service is used to offload repetitive downloads of the same content through the LTE network, by exploiting opportunistic terminal-to-terminal protocols running between the users.

The operator of Alice’s smart-phone is supposed to have enabled MOTO on an appropriate subset of its terminals in the area of the Vatican Museums. The fraction of customers’ devices on which MOTO is operating is determined based on the current congestion of the LTE network, the expected number of customers in the area of the Museums and the expected traffic they generate. The operator can easily estimate the latter two elements by monitoring of the traffic generated by the users in the past. MOTO devices are identified and their connectivity behaviour profile is well known by the MOTO Platform of the operator, those users reported as having a profile of misbehaviour will be penalized, ideally by denying them access to the MOTO Platform/service, even removing their service access rights. Misbehaviour that can result in a low value of trust sent by UE’s MOTO Applications and which can affect MOTO client reputation stored in the MOTO Platform may encompass for instance, MOTO client-made modifications of the MOTO Application addressed to reduce offloading bandwidth, modifications to gain unauthorized access rights to other MOTO client’s UEs, modification of distribution constrains and rules stated by the MOTO Network Service, etc.

The other customers of Alice’s operator monitor the condition of the opportunistic network around them, e.g., in terms of average number of active users at any given point in time, congestion level experienced in terminal-to-terminal communication, etc. In addition, the smart-phones of such customers also monitor the energy consumption incurred by the current data traffic profile generated by the users. Based on the current energy level, and an estimate of the traffic generated by the Augmented Reality application, the MOTO Application running on each smart-phone determines an available energy budget. Based on this, the operator instructs each smart-phone on the duty cycling profile it should keep in order to match the user’s expected QoE without causing excessive battery drain.

When the MOTO Platform is enabled, Alice shots a picture of the artwork for which she wants to receive multimedia content. Instead of sending it on a dedicated server through the LTE network, the picture (or relevant features of it) is sent to other identified and approved MOTO smart-phones around through the opportunistic network. The data dissemination protocol guarantees that this information is not flooded throughout the network, but sent mostly to relevant users. The picture is received by users that already obtained multimedia content of the specific artwork either through LTE or through the opportunistic
network. This multimedia content is possibly augmented with own users’ annotations and comments. This content is sent back to Alice again by exploiting data dissemination protocols in the opportunistic network. If the content is not available on any user yet, the MOTO Application on Alice’s smart-phones times out, and it reverts to downloading the content from a dedicated server through its LTE connection.

3.2.1.3.3 ACTORS
- Users with a smart-phone, on which the operator has installed and activated the MOTO Platform. MOTO users with currently valid MOTO credentials and approval condition based on reputation.
- A large group of users visiting a common area, thus forming a crowd.
- MOTO Application implementing the offloaded data dissemination process controlled by the operator.

3.2.1.3.4 PRE-CCONDITIONS
- A sufficiently large crowd of people gather at popular locations such that serving their total demand through LTE is inefficient from a throughput standpoint.
- A minimal density of customers subscribed the same MOTO Service provider are available in the area.
- Alternatively, providers share their customers (sort of “MOTO roaming”) to jointly gain sufficient density for MOTO terminal-to-terminal protocols being effective.

3.2.1.3.5 BASIC SEQUENCE
- Users run the Augmented Reality application when entering the Vatican Museums.
- The operator detects a potentially critical condition in terms of available capacity and announces the need to activate the MOTO Platform to assure the QoS within its customers. MOTO Platform will be responsible specifically of:
  - Deciding the fraction of devices on which MOTO offloading will be active
  - Deciding the duty cycling scheme of users smart-phones based on available energy and expected demands
- Alice starts taking pictures of interesting artworks.
  - The picture is locally elaborated to extract features that uniquely identify the artwork.
  - The features are disseminated in a query in the opportunistic network. This query is identified with Alice’s credentials to ensure trusted query propagation.
- Other users that already store the corresponding multimedia content on their devices receive Alice’s query.
  - Multimedia content is sent back to Alice through an appropriate data dissemination protocol running on the opportunistic network. Alice will receive connection requests from MOTO users holding the content. These connections will contain the MOTO credentials of the emitter. Alice’s smart-phone will check the credentials and afterwards assess for contextual information e.g., reputation reports, to the MOTO Platform. After confirmation of trust approval, communication will take place.
  - If Alice does not receive a confirmation of the availability of the content by a given deadline (derived from her QoE profile), her smart-phone contacts an application server and downloads the multimedia content through a conventional LTE connection.

3.2.1.3.6 OFFLOADING BENEFIT
In this scenario traffic is offloaded from an LTE network to the opportunistic network formed by the users’ devices. The LTE network is used to seed the data dissemination task, and as a fallback channel, to guarantee that Alice receives the requested content in any case. LTE operators exploit local resources of their customers’ devices to improve the capacity of their services, with respect to the case where all the traffic is carried by the LTE network alone. The LTE network does not need to be over-provisioned to serve extremely large data traffic demands in specific physical areas. On the other end, the user will benefit from the offloading process in several ways. First of all, they will experience higher throughputs and...
downloading the demanded context will take less time. Furthermore, the performance in terms of energy-per-useful-bit will increase, despite the need to activate an additional wireless interface on mobile terminals.

3.2.1.4 Scenario 4: Data dissemination with Offloading in Crowds to handle peak of data traffic demands

3.2.1.4.1 SUMMARY
Spectators watching a football match in a stadium are provided with an application that allows them to get picture or video clips taken from other spectators in the same stadium. The MOTO system avoids that this locally generated content is delivered through the LTE network. This scenario exemplifies the use of MOTO for offloading data dissemination tasks to users' terminal (while preserving energy efficiency) in crowded scenarios that occur infrequently and on special occasions, i.e., “big events”.

3.2.1.4.2 DESCRIPTION
In this scenario we address the case of localized peak traffic conditions generated by occasional crowds. Differently from the scenario described in the previous section we target “big events” in which the crowd condition occurs infrequently and on special occasions, which makes quite difficult to predict the profile of the traffic generated by the users. A concrete example of big events scenarios is a very large crowd of spectators watching live sporting events at a stadium. In this use case user Bob is in at St. Denis stadium in Paris watching the Champions League final, and runs a content sharing application to get pictures or video clips taken by other spectators in the same stadium (e.g., because they have a better viewpoint). In the following we provide a more detailed description of such scenario.

Bob is supposed to be subscribed to an LTE service, which provides coverage in the stadium. In this case, MOTO is used to avoid that multimedia content locally generated by other users in the same place gets delivered through the LTE network. Instead it gets diffused to interested users by exploiting opportunistic terminal-to-terminal protocols running between the users.

The operator of Bob’s smart-phone is supposed to have enabled MOTO on an appropriate subset of its terminals in the area of the St. Denis stadium, although MOTO Service can be dynamically activated/deactivated during the event if traffic patterns and users’ interests change. The fraction of customers' devices on which MOTO is operating is determined based on the number of customers that are interested in receiving live videos and clips taken by other spectators, on the popularity of the content that individual users generate, and on the current congestion of the LTE network. The operator can obtain estimates of the first two elements by monitoring the traffic generated by the users, and the actions performed by the users in the content sharing applications.

When the MOTO Platform is enabled multiple identified and approved MOTO users can capture a scene from different viewpoints. During the half-time break (or any other interruption of the game) Bob can interactively choose the viewpoint he prefers or he can generate a personalized view by mixing pieces of content from multiple sources. However, the users that generated the original clips instead of sending them to a dedicated remote server through the LTE network, from which Bob should download the pieces of content he is interested in, sends them directly to Bob through the opportunistic network. The data dissemination protocol guarantees that this information is not flooded throughout the network, but sent mostly to Bob and other relevant users. Note that the smart-phones on which the MOTO Service is active monitor the condition of the opportunistic network around them, e.g., in terms of delay experienced in terminal-to-terminal communications, average number of active users, etc. In addition, the smart-phones of such customers also monitor the energy consumption incurred by the current data traffic profile generated by the users. Based on this, the operator instructs each smart-phone on the duty cycling profile it should keep in order to match the Bob’s expected QoE without causing excessive battery drain in other users’ devices.

In order to create a trust relationship among the users, MOTO will also support exchange credentials and reputation (trust) reports. MOTO users must be able to deny connection whenever they do not trust other peers. Each user device must define access and connection must be agreed between them. It is assumed
that disseminated content are considered public by the users that generated them, so that anyone else can receive them. Therefore, initially no encryption is considered.

3.2.1.4.3 **ACTORS**

- Users with a smart-phone, on which the operator has installed and activated the MOTO Application. MOTO users with currently valid MOTO credentials and approval condition based on reputation.
- A Large Group of users visiting a common area, thus forming a crowd.
- MOTO software implementing the offloaded data dissemination process controlled by the operator (this control will need to be limited; operator cannot impose but only steer connection between users, or force communications).

3.2.1.4.4 **PRE-CONDITIONS**

- A sufficiently large crowd of people gather at popular locations such that serving their total demand through LTE is inefficient from a throughput standpoint.
- A minimal density of customers subscribed the same MOTO Service provider are available in the area.
- Alternatively, providers share their customers (sort of “MOTO roaming”) to jointly gain sufficient density for MOTO terminal-to-terminal protocols being effective.

3.2.1.4.5 **BASIC SEQUENCE**

- Users run the content sharing application when entering the stadium
- The operator detects a potentially critical condition in terms of available capacity and announces the need to activate the MOTO Platform to assure the QoS within its customers. MOTO Platform will be responsible specifically of:
  - Deciding the fraction of devices on which MOTO offloading will be active
  - Deciding the duty cycling scheme of user’s smart-phones based on available energy and expected demands.
- Users with different viewpoints start taking pictures and clips of the sports events
- Bob asks the content sharing platform for a subset of possible viewpoints.
- Bob’s request is disseminated in the opportunistic network. This query is identified with Bob’s credentials to ensure trusted query propagation.
- Matching content is sent back to Bob through an appropriate data dissemination protocol running on the opportunistic network. Communicating opportunistic users will exchange credentials to be authenticated. When receiving a connection request, Bob’s MOTO Application will send back Bob’s MOTO credentials, check the MOTO credentials received, gather a reputation value of the user from the MOTO Platform and after confirmation of approval, establish a connection with the MOTO user.
- If Bob does not receive an acceptable connection request by a given deadline (derived from his QoE profile), MOTO client contacts the operator, which may activate MOTO Service in additional users or change the duty cycling in already active users. In the very worst case, the operator may activate transfer of content through the LTE network (in both upload and download directions) to guarantee a fallback solution to satisfy Bob’s requests.

3.2.1.4.6 **OFFLOADING BENEFIT**

In this scenario content is exchanged directly between the users watching the match, instead of being uploaded, stored at some centralized server, and downloaded again through the LTE network. The LTE network is used only as a fallback solution in extreme cases. The benefit for the operator is the possibility of supporting multi-media content intensive applications for its users without provisioning the network for sudden and infrequent peaks of traffic. For the users the benefits are twofold. First, they can have access to locally generated content without going through the LTE infrastructure but using opportunistic
communications, thus saving money. Second, duty cycling improves the energy consumption of users’ terminal during the data dissemination process.

### 3.3 Use Case 2: Small crowds scenario

This use case is focused on smaller crowds such as buses, trains, airports, etc. Related scenarios show specific aspects and requirements, as mobility of those devices connected directly to the WAN, devices location, etc.

#### Table 5: Small crowds scenario

<table>
<thead>
<tr>
<th>Use Case Name</th>
<th>Small crowds scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Case ID</td>
<td>MOTO – 2</td>
</tr>
<tr>
<td>Goal</td>
<td>Enhance network capacity and coverage on mobility scenarios</td>
</tr>
</tbody>
</table>

#### 3.3.1 Scenarios

**3.3.1.1 Scenario 5: Expanded Coverage and Cellular Network Offloading**

**SUMMARY**

MOTO users in a given locality share a single playlist. The local playlist is specific to the given neighbourhood and thus reflects the cultural heritage of the district. The MOTO users can upload (resp. download) songs to (resp. from) the list. The transactions are coordinated by MOTO Application server, which favours either direct connections to infrastructures or opportunistic networking depending on requesting users’ conditions. The offloading is a major enhances the total capacity of the system, as well as possibly reduce the transfer latencies.

**DESCRIPTION**

“Local Music Jukebox” is a mobile MOTO Application that enables users present in the same location to share a single playlist. By this way, users develop a local community experience. Localities in different parts of a city are anticipated to have different moods or cultures in terms of the music lists, thus creating a sense of locality and dynamicity.

The implementation of the MOTO Application involves the location information of mobile devices being fed to a server. The server than makes the local song list available to the subscribed users in the locality. The list is dynamic; and the users at a given location can also upload their own songs to the list.

The opportunistic networking approaches inherent in the MOTO project can be instrumental in establishing an implementation of “Local Music Jukebox” application along the lines outlined below:

- The opportunistic users in a given location could directly communicate with each other through opportunistic networking. This approach would enable capacity gains for the service provider. Additionally, it is deemed to be technically feasible as the considered MOTO Service is asynchronous in nature.
- In this scenario, the server would be instrumental in keeping track of the music files present in the location. In case a music file is not present on the server itself, the server can be instrumental in establishing a direct radio link between the requester (opportunistic client), and the user who has the file on his/her own device (i.e., the seed user).
- The opportunistic client can also update the song list, and upload a music file of his/her own to the server.
- Such a MOTO approach would also require a new business model and transaction structure.
StoryLine:
Burak has arrived on Kandilli Square, and has taken a seat facing the Bosporus. He enjoys his tea, and glances over the canal towards the European side. He then feels like listening to music, and turns on his juke box MOTO Application. Being mostly crowded with local people, the square seems to favour traditional folk music: the juke box list is full of such songs. Burak picks a song name, and waits for streaming to start. At this phase, the client MOTO Application on Burak’s phone inquires about the preferred file at the server, and finds out that the servers does not hold the document. The server instead identifies another user (seed client) – Nazlı – at the same location who seems to have the file. The server coordinates the establishment of a Wi-Fi link between Burak’s phone and Nazlı’s tablet. The coordination takes care of all link layer association and authentication procedures, as well as accounting functions. The transfer of files from Nazlı to Burak transfers part of Burak’s virtual currencies to Nazlı. After the streaming is over, Burak sends a smiley to express his gratitude to Nazlı. He has to leave now, and starts walking towards the bus stop.

3.3.1.1.3 ACTORS
- Users with GPS enabled smart-phone or tablet, with preinstalled local music jukebox MOTO Application.
- MOTO Application server located at the technology centre (part of MOTO Network Service).
- Service Provider’s Radio Access and Core Network infrastructure, part of MOTO Network Service
- Service Provider’s authorization and accounting servers, part of MOTO Network Service

3.3.1.1.4 PRE – CONDITIONS
- Devices involved need to have GPS and Wi-Fi functionalities.
- Devices involved need to have client app installed.
- Devices involved need to be approved subscribers of the local content sharing MOTO Service, with their corresponding identity MOTO credentials.

3.3.1.1.5 BASIC SEQUENCE
- Opportunistic approved client arrives at a given location, authenticates in the MOTO system and sends location info to the app server utilizing its GPS module and cellular connectivity.
- The app displays the local playlist to the opportunistic client.
- The opportunistic client makes a pick from the list.
- If opportunistic client’s pick is on the server, streaming starts right away through cellular network connectivity,
- If the pick is not present on the server, the server informs the opportunistic client, and conveys the identity of the closest approved user (seed client) who has the file.
- MOTO users exchange their MOTO credentials, and request for reputation information to the MOTO system. Once both are confirmed, identity and trust profiles, they agree to connect.
- The server coordinates the establishment of a connection between the two.
- During the establishment phase, care must be taken to allocate orthogonal 802.11 channels to pairs coexisting on the same locality, to the extent possible.
- During the establishment phase, authentication procedures should be followed.
- Once the streaming is over, the link should be teared down and user client applications will send trust reports to the MOTO Platform.
- The servers initiate the monetary procedure through which the users exchange virtual currencies.

3.3.1.1.6 OFFLOADING BENEFIT
In this scenario, the music content is shared directly among opportunistic users as appropriate. This reduces the bandwidth utilization of the cellular structure in its entirety, thus practically increasing the total radio access capacity. The approach also reduces the burden on the core network of the service provider and possibly reduces latency of the service.
From a user perspective, the proposed mechanism corresponds to increased availability of service, avoiding the hassles of network congestion. The users would also potentially benefit from reduced charges, as instead of utilizing the precious bandwidth resources, they instead make use of the readily and freely available ISM bands.

3.3.1.2 Scenario 6: Content dissemination based on payment system

3.3.1.2.1 SUMMARY

Travellers or customers, using regularly public means of transportation, would like to use services or facilities to make their moving pleasant, such as music or instantaneous download. The MOTO system offers an interesting way of using desired entertainment services through a payment system.

3.3.1.2.2 DESCRIPTION

Public means of transportation, e.g., buses as well as long-distance and light trains, are inherent “hot spots”, because they attract high numbers of mobile network users in a very limited space. Furthermore, it is reasonable to assume that many of the users regularly use the transportation services, e.g., travellers commuting between residence and the place of work, and, hence, they are very thoughtful of any service or facility which may relieve the burden of travelling and improve their quality of life.

Likely, a high bit-rate wireless connection to the Internet in public means of transportation would create satisfaction of a large fraction of the users, since this would enable entertainment applications (e.g., music and video streaming or instantaneous download), e.g., as enabled by smart phones or tablets.

However, because of its “hot spot” nature, the described environment also creates a technical challenge for the mobile operator, in terms of capacity. With “regular” hot spots, e.g., squares, stations, or airports, the typical approach is to deploy more resources in the area of interest until the capacity meets the expected peak demands. Clearly, such a method is not applicable to this scenario, since the area of interest moves together with the hot spot, sometimes spanning distances of hundreds of kilometres, e.g., with long distance trains.

An economically viable solution to this problem for a MOTO Service Provider would be to use a MOTO Service, where passengers belong to one of the two categories:

- **Opportunistic clients**, with only a Wi-Fi interface enabled, request content from seed clients, possibly through multi-hop relaying with other intermediate opportunistic clients in between. The opportunistic clients pay a virtual credit to use this service which, when exceeding a given negative threshold, must be converted into an actual fee paid to the MOTO Service Provider.

- **Seed clients**, who have both a Wi-Fi and a LTE wireless card enabled. The seed clients retrieve content using the LTE interface on behalf of identified and approved opportunistic clients, with which they communicate via the Wi-Fi interface. Seed clients have an additional CPU, memory, and energy consumption burden compared to opportunistic clients, but they receive a virtual credit which can be both spent when the same device acts as an opportunistic client and converted into real credit for phone calls and text messages.

Both types of clients need to have a MOTO Application installed, which is provided by the MOTO Service provider when the user subscribes to the MOTO Service, and it is used to: i) keep track of the virtual credit; ii) to authenticate the use of opportunistic communications; and, iii) to provide the MOTO Service provider with feedback on the position of the device and current usage of the network resource, for configuration optimization, a MOTO credential will be provided when registering for the first time to the MOTO Service, this credential will enable the MOTO user to assure that self-earned credits due to “seeding” behaviour, are assured to be linked to their own personal MOTO account.

Maria’s storyline:

Maria commutes from Pisa to Florence every working day using public transportation. Her journey starts from Pisa, where she takes a regional train towards the central station of Florence. During the morning trip she likes to get updates on local news via the Web while she listens to an Internet streaming radio station.
Upon suggestion from friends, Maria subscribed to the Public Transportation MOTO Service provided by her mobile operator. Therefore, when she arrives at the station she switches on the Wi-Fi interface of her smart phone while taking a seat and plugging her earphones. Since today she guesses she will not be able to recharge the battery of her smart phone due to a busy agenda, she enables the checkbox “Low energy mode” on the MOTO Application running on her smart phone, understanding that today she will not get any virtual credit in the journey. The application authenticates at the Public Transportation MOTO Service with Maria’s username and password that it has stored. The train is crowded. Nonetheless, she obtains access to all the pages faster than usual, which she guess must be because many of her fellow passengers are also looking to the same content because of the hot local news in these days.

**Federico’s storyline:**

Federico travels frequently using metropolitan public transportation means in Florence because of his job of freelance journalist and photographer. He uses a laptop with an LTE USB dongle, and, while travelling in the trams and buses, he connects to the Internet to store in the cloud his recent shots and update his many blogs in the Web. Federico subscribed to the Public Transportation MOTO Service provided by his mobile operator because it allows him to get virtual credit, which he can then redeem as real credit for phone calls and text messages, thus cutting down his smart phone monthly costs. For this reason, Federico always remembers to make sure the MOTO Application is running on his laptop before leaving in the morning, with the “Low energy mode” option off. He understands this will consume some more energy than necessary for his own personal use, but this issue does not worry him since he usually connects his laptop to an electricity socket while he is home or at restaurants while having lunch.

### 3.3.1.2.3 **ACTORS**

- Public transportation passengers.
- The MOTO Service provider.
- MOTO identified and approved users

### 3.3.1.2.4 **PRE – CONDITIONS**

- The terminals of users with opportunistic clients have Wi-Fi enabled.
- The terminals of users with seed clients have both Wi-Fi and LTE enabled.
- A MOTO Application is installed in the devices of passengers wishing to use this MOTO Service.
- A dedicated MOTO Service is deployed and run by the MOTO Service Provider.

### 3.3.1.2.5 **BASIC SEQUENCE**

- A user, during his/her morning trip towards work office, by train, likes to get updates on local news via Web or listening music on streaming radio station.
- Due to the battery low of his/her smart-phone and incapability of recharge it, the user enables “Low energy mode” on MOTO Application running on his/her mobile device and switches on the Wi-Fi interface.
- The user subscribes to the Public Transportation MOTO Service.
- The MOTO Application installed on his/her smart-phone exchanges successfully authentication information with Public Transportation MOTO Service, which assigns to the UE the role of opportunistic client.
- The user (opportunistic user) can enjoy the entertainment services, that makes pleasant his/her working day travel, because the opportunistic network formed by the other passengers which are accessing at the same Web content.
- Another user travels frequently by metropolitan and, due to his/her job, he/she connects to the Internet to upload photos and update his/her blogs in the Web.
- He/she connects to the Internet via his/her laptop and, because he/she is able to recharge the laptop battery during the day, he/she disables “Low energy mode” on MOTO Application running on his/her mobile device.
- The user subscribes to the Public Transportation MOTO Service.
- The MOTO Application installed on his/her smart-phone exchanges successfully authentication information with Public Transportation MOTO Service which assigns to the UE the role of seed client with the knowledge that he/she can get a virtual credit that can be redeemed for phone calls and text messages.
- The user can store in the internet cloud his/her recent shots and update his/her blogs through MOTO Service.

### 3.3.1.2.6 Offloading Benefit

In this scenario, MOTO Service assures that customers can enjoy entertainment services and applications, during their moving, sometimes spanning long distances.

The MOTO Service allows a few users (seed clients) to retrieve the requested content using LTE network; these seed users in turn will disseminate the information to the other users (called opportunistic users, with only Wi-Fi interface enabled) through Wi-Fi infrastructure, without overprovisioning the LTE network.

Moreover, the dissemination of data to interested users is regulated by a payment system: the opportunistic users have to pay a virtual credit to network operator through MOTO Platform to use the offered services while the seed users receive a virtual credit from network operator through MOTO Platform.

### 3.4 Use Case 3: Vehicular scenario

The car industry is witnessing a major business shift by which its commodity model is increasingly moving towards a service model. Offering new services to car users (driver and passengers) is a key requirement, which relies heavily on innovative ICT and especially communications systems.

With MOTO different services can be offered regarding the vehicular environment. This use case tries to cover some of the possible scenarios that can be benefited from the MOTO Service.

<table>
<thead>
<tr>
<th>Table 6: Vehicular scenario</th>
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<tbody>
<tr>
<td><strong>Use Case Name</strong></td>
</tr>
<tr>
<td><strong>Use Case ID</strong></td>
</tr>
<tr>
<td><strong>Goal</strong></td>
</tr>
</tbody>
</table>

#### 3.4.1 Scenarios

### 3.4.1.1 Scenario 7: Vehicle Fleet Management

#### 3.4.1.1.1 SUMMARY

Taxi, bus or car rental companies manage fleets of vehicles. A vehicle fleet management system allows gathering information on vehicles (location, state of mechanical parts, level of liquids) to anticipate and plan maintenance operations. Information monitored by sensors embedded on vehicles is sent to the vehicle fleet management system using several communication channels so that available resources are efficiently used for this frequent reporting.

#### 3.4.1.1.2 DESCRIPTION

In the use case presented here, named Fleet Maintenance of Vehicles, we plan to provide a platform, which takes advantage of the growth of mobile devices to provide applications in the vehicular field.

The proliferation of electronics in automobiles during these last decades has introduced a large volume of sensor data within the vehicles. The in-vehicle computing capabilities increase in storage and processing can be exploited to offer multiple types of services and capabilities for drivers and passengers. In the same
trend of innovation, the combination of vehicle sensing and computing resources with wireless communications enables telematics services also for remote diagnostics, fleet management, and traffic monitoring. Such services can provide benefits to drivers, fleet managers and public organizations to improve their maintenance operation, support services, and mission critical assignments.

The scenario we consider has three main objectives:

- Get (real-time) information of vehicles in use. This information is gathered by a sensor on the vehicle and can be of any type such as GPS location, degree of wear of mechanical parts, remaining level of fuel/water/oil in cars, number of passengers, speed of vehicles, etc.
- Compute and analyze gathered data in order to proactively plan vehicle repair and provisioning. In the case of a car rental company for instance, the manager can know in almost real-time, the number of vehicles that will not be available immediately because of their need for repair. Also, it may help ordering the right components to be replaced before the arrival is back at the store.
- With all these features, provide a way to better manage a large fleet of vehicles, anticipate provisioning of mechanics and vehicles, and optimize the supply.

In order to reach this goal, sensors on the vehicles will collect data from on-board sensors, which can provide, thus, vehicle hardware status, vehicle usage, and vehicle location. All this information, or content, is aggregated on the vehicle(s) according to some aggregation algorithm, and then sent back to the central server to be analyzed. The MOTO Service provides content dissemination functionalities to better exploit network resources while taking advantage of intermittent connectivity among vehicles (seed clients).

Security Issues: A malicious node could modify the content in order to immobilize a vehicle, sending malicious content about the need to repair it when unnecessary or even worst, sending information that dismisses the need for reparation when needed, and getting passenger of the vehicle at risk (integrity). This means this offloading encompasses sensible content. Understanding therefore that MOTO clients (in this case, companies and drivers) demand integrity of the content and privacy in the communication, it will be very important that MOTO Services, provided by the MOTO Application, allows encryption (confidentiality/integrity). Other security issue to be considered is the identification of the source of the information; all these information gathered by the MOTO client’s central server will be useless if the source of the information (Other MOTO clients) cannot be verified (authentication). Therefore, it is important that MOTO assures three aspects when offloading content to MOTO clients (both seeds and opportunistic): confidentiality, the source (MOTO client) from which it comes from, and the integrity of the content delivered, when required.

This scenario description can be applied to many applications such as:

- Taxi/Bus companies,
- Car renting companies,
- Individual car owners subscribing to a monitoring services,
- Public safety vehicle maintenance.

### 3.4.1.1.3 ACTORS

- Vehicles equipped with sensors to generate content, communication systems, including LTE and 802.11p, to transmit data, and a MOTO Application for compliance with MOTO Services, including MOTO identity credentials
- Central server, responsible for credential management.
- Network access providers (Wi-Fi, LTE) that form the MOTO Network Service infrastructure,
  - A connected environment, such as intelligent road or smart city, including dropboxes (e.g., at the road lights) can also be part of the MOTO Network Service infrastructure,
- Service Providers (e.g., vehicle fleet management service).

### 3.4.1.1.4 PRE–CONDITIONS

- All embedded elements are MOTO capable.
- Connection between vehicles and with Internet can be intermittent and disrupted.
3.4.1.1.5 **Basic Sequence**

- Embedded sensors generate different types of data. This content is first stored at the sensors level.
- All content that needs to be sent to the centralized server is gathered at a unique location on the vehicle.
- Content is encrypted and transmitted on regular basis to the centralized server. For this matter, content can be sent to:
  - Another vehicle using direct connection between vehicles,
  - The connected environment, either a road light station or any dedicated equipment disseminated in the area, using direct communication between vehicle and the environment,
    - Data sent to another vehicle or to a dropbox in the environment will be transferred to the central server by infrastructure connection.
  - Directly to the server via a MOTO Network Service infrastructure link (e.g., LTE)
- Content is gathered decrypted and analyzed, Source and integrity of the information are checked.
- Management and organization of the preparation, maintenance, repair, and provisioning of the vehicles according to data analysis.

3.4.1.1.6 **Offloading Benefit**

Instead of systematically sending gathered information through the cellular network, some transmissions are delayed to take benefit of opportunistic communications on alternate channels (vehicle-to-vehicle communications, vehicle-to-infrastructure communications). This makes the reporting mechanism more efficient in terms of resource usage on the cellular network, while maintaining a relevant level of information accuracy to plan maintenance of the vehicles.

3.4.1.2 **Scenario 8: Map-Based Advanced Driver Assistance Systems (ADAS)**

3.4.1.2.1 **Summary**

Modern and future cars will be always more equipped with map-based systems. These detailed maps will occupy a lot of space and will be characterized by high updating rate. The MOTO Platform gives the possibility to each vehicle to obtain the required updated map in a timely and effective manner.

3.4.1.2.2 **Description**

Advanced Driver Assistance Systems (ADAS) have gained a lot of interest among car manufacturers and suppliers since their introduction in 1970s. The first applications of ADAS technologies were mainly aimed at improving safety of road users and were characterized by a limited market penetration (i.e., only for luxury vehicles). Their introduction into other market segments has been pushed not only by technologies enhancement and cost reduction, but also by policy and regulatory actions (like, e.g., the mandatory installation of airbags since 1998). In such a way, ADAS technologies can be seen as a fundamental component of any modern car. Nowadays, these systems are not only “limited” to safety purposes, but they give a wider support to the driver, helping him while driving in order to improve also efficiency, comfort, and ecology.

In such a context, modern ADAS require high sensing capabilities both for the vehicle environment and its surroundings. This target has been firstly reached by using different kinds of sensors (e.g., radar, lidar, and camera systems). In general, the resulting systems are able to provide very good performances but they also suffer for some intrinsic limitations (due to, e.g., occlusions and weather effects).

In order to overcome such a situation, the use of maps has been recently considered for improving the performances of certain ADAS applications but also to enable new ones. Following these considerations, the so-called map-based ADAS can be classified into three categories according to the use of the maps they do:

1) Non-map ADAS: do not use any map and wouldn’t have any improvement by using it (e.g., ultrasonic parking distance control and alcohol ignition locks)
2) Map-enhanced ADAS: can work also without maps, but their performances can be improved by using them (e.g., adaptive cruise control, speed limit info, and predictive front lighting)

3) Map-enabled ADAS: exist only thanks to the maps (e.g., curve speed warning, passing/overtaking assistant, eco-routing/eco-driving)

All the systems belonging to category 2) and 3) are usually referred to as map-based ADAS. In the context of the MOTO project, this kind of systems will be considered.

In fact, it is worth to be noted that the required maps are usually very different with respect to those used for navigation. They are much more accurate and contain very high-definition details, such as enhanced geometry, road curvature, height, slope, speed limits, lane information, and more.

This particular type of maps will therefore occupy much more space with respect to traditional ones. Moreover, considering the high level of details, their updating rate will be very fast (due to, e.g., changes in speed limits, different lane configuration deriving from permanent or temporary road works...).

Based on these assumptions, the traditional approach used for in-vehicle navigators (i.e., storing all the maps on a static support (CD, DVD, hard disk, etc.) and updating them every few months or years) doesn’t seem to be the more adequate one for this technology. This is particularly true for safety applications, where it is necessarily required to always have updated maps in order to improve reliability and robustness of the systems.

In order to avoid such a problem, the possibility to download the needed map in almost real-time is being considered by automotive manufacturers as a viable solution. In this case, all the maps would be stored on a central server with the possibility to update them on a daily or weekly basis. Cars, thanks to the real-time connectivity capabilities based on 4G/LTE, would then download the needed map.

In such a scenario, each car would be able to always use the correct and updated map. However, this functioning logic would easily generate heavy network load, mainly due to the high quantity of data to be received by each vehicle. Therefore, the network capacity could be often saturated when several cars are located on a certain area (e.g., traffic jam, highway and urban scenarios).

The MOTO approach can be seen as an effective solution to overcome and avoid such a situation. In fact, when many cars are located in the same zone or are driving in the same direction, it is very likely they will need the same maps. Moreover, this kind of content can be downloaded well in advance with a certain tolerance to delay.

Given that, the traffic generated on the cellular infrastructure in order to distribute the same map to different cars can be partially or completely offloaded to the vehicular network, thanks to the direct communication between vehicles enabled by IEEE 802.11p standard.

**Storyline:**

Bob is driving towards Milan on the highway. He has a modern car equipped with the most advanced safety systems (like, among the others, several map-based ADAS). It also has several connectivity capabilities, both with the rest of the world (through a 4G/LTE modem) and with the surrounding vehicles (thanks to the IEEE 802.11p-based device), implementing also the MOTO Application for taking advantage of MOTO Services. Bob’s car starts acquiring from the LTE network the maps it will need in Milan in order to have all its map-based ADAS well functioning. The download from the MOTO Service provider starts few tens of kilometres before the destination. Bob is driving in dense traffic conditions. The surrounding vehicles are equipped with similar safety systems. They also need to download the map data of the same area and are provided with MOTO Application. The network infrastructure covering the highway towards Milan starts quickly being saturated by all these requests of similar contents. Thanks to the available MOTO Platform, this traffic directly coming from the cellular infrastructure is easily reduced. In fact, only Bob’s car and few other vehicles are selected as seed clients and receive the required map from the 4G/LTE network. The other cars (i.e., opportunistic clients) receive the same content thanks to the opportunistic network created...
by direct communication between vehicles enabled by IEEE 802.11p-based devices. In this way, all the vehicles driving towards Milan are able to acquire the needed maps in a timely and effective manner.

Security Issues: In order to avoid a misuse of the MOTO functionalities of this use case, the connection path of the vehicles should be limited to the server which allocates the updated maps, and the communication should limited to the request and download of such a maps. Vehicles will be identified as authorized to download the requested content, and downloaded content will be encrypted. This way, all vehicles that receive the updates of map, will be able to confirm the source and therefore trust the content. It is vital that map information disseminated through the opportunistic network remains unmodified by malicious third parties.

3.4.1.2.3 ACTORS
- Vehicles equipped with map-based ADAS, 4G/LTE modem, and IEEE 802.11p device
- Network operator (providing and managing communication infrastructures)
- MOTO Service provider (for map data)

3.4.1.2.4 PRE-CONDITIONS
- A large number of vehicles located in the same area or driving towards the same direction or destination (so that they will likely require the same map data) have set on the ADAS the destination and it is sent to the MOTO service provider.
- A sufficiently large portion of them is equipped with the MOTO Application.

3.4.1.2.5 BASIC SEQUENCE
- Several vehicles equipped with map-based ADAS need the same maps.
- They start downloading them through the LTE network.
- The LTE network is easily overloaded.
- The offloading procedures enabled by the MOTO Platform are initiated.
- The opportunistic clients are able to receive the required content through the selected seed clients. Before sending the required content to other users, MOTO user applications exchange and check each other’s MOTO credentials.

3.4.1.2.6 OFFLOADING BENEFIT
Map data traffic is offloaded from the cellular infrastructure to the IEEE 802.11p-based direct communication between vehicles. In this way, the network load can be easily and heavily reduced (i.e., only few seed clients will directly download the maps from the LTE network, the other users will receive them through the opportunistic network). On the other side, the vehicle will be always equipped with the right and updated map. The driver will therefore gain much more confidence in the advanced safety applications implemented on its vehicle.

3.4.1.3 Scenario 9: Enhancing Traffic Efficiency through Cooperative V2X Communication Systems

3.4.1.3.1 SUMMARY
Several applications based on cooperative V2X communication systems require data transmission from the infrastructure to the vehicles, delivering information related to, e.g., road works, traffic jam, speed limits, and traffic signs. The MOTO system gives the possibility to spread this information through direct communication between vehicles.

3.4.1.3.2 DESCRIPTION
A significant body of knowledge is undergoing in the telecommunications and automotive research community related to information exchange among vehicles (i.e., vehicle-to-vehicle, V2V) and between vehicles and infrastructure (vehicle-to-infrastructure, V2I), more in general referred to as V2X cooperative communication systems. This kind of systems is mainly aimed at increasing the road safety, giving the possibility to implement a lot of different services (like, e.g., safe distance warning, traffic jam warning, accident warning). Besides active road safety, the same technology gives also the possibility to develop
several applications related to cooperative traffic efficiency, cooperative local services, and global internet services (as stated in the ETSI technical report ETSI TR 102 638 v1.1.1 (2009-06)).

A dedicated standard (namely IEEE 802.11p) has been developed to assure wireless access in vehicular environments (WAVE) and higher layers have been developed on its top (like, e.g., IEEE 1609, known as WAVE). Their development has been driven by the needs to have a dedicated communication medium able to offer very high performances in terms of latency and reliability.

However, the upcoming 4G/LTE standard is able to offer similar or even better performances. For this reason, car manufacturers are investigating the possibility to implement the information exchange among vehicles and between vehicles and infrastructure through a 4G/LTE-based communication system (possibly the same used in the e-Call platform to offer additional services). In this way, their applications would benefit from the higher penetration rate assured by the Telco operators for the new standard. On the other side, different issues could arise in using a public cellular network for safety applications, mainly due to the heavy load already required by traditional usages of the network capacity.

In such a context, the MOTO project will take into account some specific applications aimed at transferring useful information from the infrastructure to the drivers. Safety applications will be not taken into account for offloading purposes, given that they are absolutely not delay tolerant and would require very strict requirements in terms of latency time (i.e., less than 100 ms).

The information of interest is aimed at improving both traffic efficiency and ecological aspects of the driving experience. Such a target can be obtained by distributing to each vehicle messages related to road works, traffic jam, speed limits, and traffic signs.

This content can be transmitted on the cellular network through small packets. The required throughput is therefore very low for each vehicle (few kbps). However, when several cars are located in the same area (e.g., urban traffic jam), the network could be excessively loaded (i.e., mainly on the control plane since the large numbers of connection the cellular network would have to handle).

In such a case, the MOTO Platform could be used in order to offload part of the traffic to the IEEE 802.11p-based vehicular network, in order to mitigate localized peak situations. Moreover, the same opportunistic network created among vehicles could be also used to improve the coverage of the information dissemination of a single road side unit, reaching also vehicles located in other zone of the city giving them the possibility to, e.g., avoid passing through congested areas.

**Storyline:**

Alice is driving her car in the city centre. The car is able to receive useful information from the MOTO Service provider (e.g., traffic signs, speed limits, and traffic jam). The car navigator uses this content in order to suggest the most efficient route. However, an accident has just happened in the centre of the city, causing a long queue of vehicles on the same road Alice should take to reach her destination. This content is locally distributed in the zone near the accident by the MOTO Service provider through a 4G/LTE-based road side unit. However, the only cars able to directly receive it are already stuck in the queue. The MOTO Platform gives the possibility to use the opportunistic communication between vehicles (based on IEEE 802.11p) in order to disseminate the same content also to other cars located far away from the zone where it has been created. In this way, Alice’s car receives this information well in advance and has the possibility to choose an alternative route in order to reach the destination. Additionally, the 4G network can be offloaded and it is not necessary to broadcast the same information to every car located in the city.

**3.4.1.3.3 ACTORS**

- Vehicles able to use information coming from an external MOTO Service provider and also equipped with 4G/LTE modem and IEEE 802.11p device.
- Network operator (providing and managing communication infrastructures)
- MOTO Service provider (able to gather and disseminate information related to traffic and road infrastructure)
3.4.1.3.4 **PRE–CONDITIONS**
- The information dissemination is limited to a specific geographic area.
- A certain number of vehicles are able to directly receive this information from the infrastructure.
- The same information is also required and useful for other vehicles not directly located in that area.
- The involved vehicles are equipped with the MOTO Application.

3.4.1.3.5 **BASIC SEQUENCE**
- Certain information is transmitted to some vehicles located in the same area.
- The same information could be useful also for other vehicles not directly located in that area.
- The offloading procedures enabled by the MOTO Platform are initiated in order to improve the coverage of the network.
- The opportunistic clients are able to receive and trust the content through the seed clients.

3.4.1.3.6 **OFFLOADING BENEFIT**
Information related to traffic efficiency and management is offloaded from the 4G/LTE cellular infrastructure and directly disseminated among interested vehicles through the IEEE 802.11p-based opportunistic network. The amount of data to be distributed is not so high but the MOTO system gives the possibility to increase the coverage of the vehicular cooperative applications. In this way, users’ perception and satisfaction will be not negatively affected by poor coverage of the network, giving them the feeling of a robust and seamless service.
4 Requirements

This section provides a list of MOTO requirements, which have been collected based on the MOTO use-cases provided in Section 2. This is a relatively limited list of requirements, which however provides clear boundaries on what the MOTO Platform, the MOTO clients and the MOTO Services are required to do to cover the scenarios described before. Note that we decided not to break down these requirements in too many detailed requirements at the technical level at this stage, as this may result in limiting the possibilities to propose innovative technical solutions in the next stages of the project. We prefer to provide a limited set of very clear and binding requirements in terms of functionality and behaviour, while we defer a more precise definition of the technical features to the phase where we design the actual algorithms and technical solutions.

Table 7: Requirements.

<table>
<thead>
<tr>
<th>Requirement ID</th>
<th>Description</th>
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<tbody>
<tr>
<td>R-1</td>
<td>The MOTO Platform MUST be able to monitor and determine what clients are participating and can consume MOTO Services in a certain location and time.</td>
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<tr>
<td>R-2</td>
<td>The MOTO Platform MUST be able to monitor and determine the fraction of time opportunistic clients are active in the offloaded opportunistic network basing on evolving network conditions, client location, client stored content, etc.</td>
</tr>
<tr>
<td>R-3</td>
<td>The MOTO Platform MUST be able to monitor the performance of provided MOTO Services (e.g., latency, energy consumption, capacity gained through offloading, alarms, etc.), and automatically re-configure the MOTO Services (e.g., the data dissemination protocols) accordingly.</td>
</tr>
<tr>
<td>R-4</td>
<td>The MOTO Platform MUST make available performance information for the MOTO Service provider.</td>
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<tr>
<td>R-5</td>
<td>The MOTO Platform MUST allow direct communication among MOTO opportunistic clients for MOTO Services provision. The operator MUST NOT force specific opportunistic clients to communicate directly, but opportunistic clients MUST be able to self-organize direct communications.</td>
</tr>
<tr>
<td>R-6</td>
<td>The MOTO Platform MUST allow MOTO Service provider to (re-)allocate the available radio resources when the opportunistic communication is not feasible.</td>
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<tr>
<td>R-7</td>
<td>The MOTO Platform MUST verify the reputation (acceptable historic trust profile) of users before providing them access to the MOTO Services</td>
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<tr>
<td>R-8</td>
<td>The MOTO Platform SHOULD be able to implement relevant accounting procedures on seed clients, for what concerns the communications occurring over the cellular infrastructure.</td>
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<td>R-9</td>
<td>The MOTO Platform / MOTO network service SHOULD be able to verify the termination of the link.</td>
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<td>R-10</td>
<td>The MOTO Applications MUST allow MOTO clients to decide whether to participate or not in a MOTO offloading service at a certain point or location.</td>
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<tr>
<td>R-11</td>
<td>The MOTO Application MUST allow MOTO clients setting their QoE expectations.</td>
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<tr>
<td>R-12</td>
<td>The MOTO Application MUST allow opportunistic clients to resume content downloading from the WAN (i.e. when the MOTO Service is not anymore available).</td>
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<tr>
<td>R-13</td>
<td>Even when the MOTO Service is available and correctly functioning, the MOTO Platform MUST implement a control mechanism which provides an upper bound for the content delivery time (i.e., when the opportunistic network is not able to deliver the required content within a certain delay, a backup solution based on the WAN network MUST be available).</td>
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<tr>
<td>R-14</td>
<td>MOTO Application MUST guarantee privacy of user’s data stored in the UE.</td>
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<td>R-15</td>
<td>The MOTO Application MUST request MOTO clients to authenticate before start using MOTO Services.</td>
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<td>R-16</td>
<td>MOTO Application SHOULD enable users to define connection features such as access rights, encryption and signature.</td>
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<td>R-17</td>
<td>The client-pair association MUST be secure, including authentication, encryption and signature when necessary.</td>
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<td>R-18</td>
<td>Clients MUST interchange their credentials so that they can validate each one’s real identity in order to establish a connection.</td>
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<td>R-19</td>
<td>Clients MUST be able to send trust feedback about the other clients to the MOTO Platform.</td>
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<td>R-20</td>
<td>The system MUST gather historical trust profiles from all clients that have already used MOTO Services.</td>
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<tr>
<td>R-21</td>
<td>MOTO Application SHOULD allow clients to share their resources.</td>
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<td>R-22</td>
<td>When opportunistic client reconnects to MOTO client from regular cellular transmission, opportunistic client’s session SHOULD continue seamlessly (IP address preservation).</td>
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<tr>
<td>R-23</td>
<td>A MOTO Platform SHOULD allow integration / interoperability with other MOTO Platforms managed by other service providers to enable MOTO Service roaming.</td>
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<tr>
<td>R-24</td>
<td>MOTO Platform SHOULD be able to collect the necessary information to allow billing processes.</td>
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