Ref. Ares(2015)590607 - 12/02/2015

Document Title	Document Version
D5.5 User Experience Report 2	0.9

Project Number	Project Acronym	Project Title
FP7-2011-7-287661	GAMBAS	Generic Adaptive Middleware for Behavior-driven Autonomous Services

Contract Delivery Date	Actual Delivery Date	Deliverable Type	Deliverable Access
M36	January 31st, 2015	R (Report)	PU (Public)

Document Author or Reviewer	Organization	Work Package
Marcus Handte	UDE	WP5
Gerd Kortuem	OU	WP5

Abstract

Deliverable 5.5 is the last deliverable of WP5: Deliverable 5.1 laid the groundwork by defining a design approach for intent-aware user interfaces; Deliverable 5.2 described the first version of the user interface software; D5.3 delivers first insights into usability aspect of the GAMBAS user interface. D5.4 extended the user interface developed in D5.2 with social aspects. In line with the overall project organisation this deliverable investigates usability aspects of these new social interfaces. This report is based on a usability study that focuses on a very specific aspect of the GAMBAS system, namely the visual representation of the location information as well as the associated security and privacy interfaces used to limit the access to this information. The study investigates user perception of the interfaces and discusses possible improvements proposed by the users. The results have been used to shape the final user interface of the GAMBAS application prototype 2.

Revision	Organization	Description
0.1	UDE	Structure added.
0.2	UDE	Introduction added.
0.3	UDE	Background added.
0.4	UDE	Methodology added.
0.5	UDE	Results added.
0.6	UDE	Conclusions added.
0.7	OU	Review.
0.8	UDE	Fixed issues reported by OU.
0.9	UDE	Prepared submission.

Table of Contents

1 Introduction 1
1.1 Purpose 1
1.2 Scope 1
1.3 Structure 1
2 Background 2
2.1 Configuring Users 2
2.2 Configuring Permissions 3
2.3 Visualizing Information 4
3 Methodology 5
3.1 Presentation Session 5
3.2 Hands-on Session 6
3.3 Questionnaire Design 7
4 Results 9
4.1 Experience Level 9
4.2 Sharing Attitude 10
4.3 Key Exchange 11
4.4 Access Control 14
4.5 Location Sharing 17
5 Conclusions 22
6 Bibliography 23

List of Figures

Figure 1 – GAMBAS Middleware Privacy Interfaces and Tools 3
Figure 2 – GAMBAS Locator Interfaces and Visualizations 4
Figure 3 – Presentation Session....6
Figure 4 – Questionnaire Excerpt 7
Figure 5 – Application Experiences....9
Figure 6 – Sharing Experiences....10
Figure 7 – Sharing Usefulness....10
Figure 8 – Sharing Security....11
Figure 9 – NFC Key Exchange....12
Figure 10 – Facebook Key Exchange 13
Figure 11 – Facebook Key Exchange vs. NFC Key Exchange....14
Figure 12 – Access Control Model 15
Figure 13 – Access Control Visualization....15
Figure 14 – Access Control Usability....16
Figure 15 – Policy Generator Usefulness 17
Figure 16 – Map-based Location Visualization....18
Figure 17 – Map-based Status Visualization 19
Figure 18 – List-based Location Visualization....19
Figure 19 – List-based Status Visualization 20

1 Introduction

The goal of the GAMAS project is the development of an adaptive middleware to support the development of behaviour driven autonomous services. This middleware encompasses data models and acquisition mechanisms as well as privacy and security protocols and tools. To make these mechanisms and tools useful for the end user, the visualizations developed in WP5 provide a graphical frontend for them. This document evaluates the graphical frontends and visualizations that have been developed specifically for the security and privacy mechanisms in the context of a mobile application that enables persons to share their location.

1.1 Purpose

This delivery presents results of an experimental user study of the GAMBAS user interface with a special focus on the visualisation of user locations as part of the mobility scenario of the second version of the GAMBAS prototype applications. The report highlights the study methodology and discusses quantitative and qualitative usability data.

1.2 Scope

Deliverable 5.5 is the last deliverable of WP5: Deliverable 5.1 laid the groundwork by defining a design approach for intent-aware user interfaces; Deliverable 5.2 described the first version of the user interface software; D5.3 delivers first insights into usability aspect of the GAMBAS user interface. D5.4 extended the user interface developed in D5.2 with social aspects. In line with the overall project organisation, this deliverable investigates usability aspects of these new social interfaces. This report is based on a usability study that focuses on a very specific aspect of the GAMBAS system, namely the visual representation of the location information as well as the associated security and privacy interfaces used to limit the access to this information. The study investigates user perception of the interfaces and discusses possible improvements proposed by the users. The results have been used to shape the final user interface of the GAMBAS middleware as well as the application prototype 2.

1.3 Structure

The remainder of this deliverable is organized as follows. First, we describe relevant background information on the parts of the GAMBAS middleware that are evaluated in this deliverable. Thereby, we split the functionality into three subcomponents. Thereafter, we introduce the methodological approach taken for the user interface evaluation and we discuss the main rationale behind it. Once the approach and methodology has been explained, we describe the results of the user study. Finally, we conclude the deliverable with a summary and discussion of our key findings.

2 Background

The purpose of this deliverable is the evaluation and validation of the social interfaces that have been conceptualized, designed and implemented as part of the GAMBAS project. From a functionality perspective, these interfaces can be grouped into three subcomponents. The first two interface components are application-independent and built into the GAMBAS middleware. They enable users to configure the set of other users (which we will refer to as “friends” in the following, since this is the common terminology used on popular social networking sites) with whom they may want to interact. In addition, they enable the definition of permissions either automatically via a policy generator or manually via a user interface built into the GAMBAS middleware. The third interface component is application specific and visualizes in this case the location information as well as the status information of the configured friends. In the following, we briefly outline the components.

2.1 Configuring Users

In order to configure users, the GAMBAS middleware provides three main mechanisms, which not only exchange the identities of the associated users but also cryptographic secrets in order to enable authenticated and encrypted communication. These mechanisms are:

- **Manual key exchange**: This key exchange mechanism enables users to setup “friends” by typing in the pseudonym and the shared secret of another user. Since this interaction can be cumbersome, it is primarily intended for development purposes. Consequently, the usability of this mechanism is not analysed in this document, as it is already clear that it is not suitable for the end user in general.
- **NFC-based key exchange**: This key exchange mechanism relies on the NFC capabilities of modern Android phones in order to transfer the pseudonym and shared secret from one device to another. Since NFC communication is unidirectional, in the background, the device’s network connectivity will be used to transfer the pseudonym in the other direction as well. From a user’s perspective, this key exchange entails “bumping” the devices into each other which seems comparatively easy. However, it requires both devices to be equipped with NFC capabilities and they need to be physically present at the same place and time which can limit the scalability of the approach.
- **Facebook-based key exchange**: This key exchange mechanism relies on Facebook as one of the most widely used social networking sites in order to exchange identities and keys. In order to use this mechanism, the user has to provide his login credentials to the GAMBAS middleware which in turn will start to exchange private messages (via Facebook) with other instances of the GAMBAS middleware. The contents of these messages will be used to perform a Diffie-Hellman key exchange which ensures that even though Facebook can read the messages, it will not be able to read the resulting key (unless it starts to alter the messages).

As indicated previously, the user study done in the following focuses on the NFC-based key exchange and the Facebook-based key exchange as the manual key exchange is primarily intended for development purposes.

2.2 Configuring Permissions

Once the set of friends is configured using one of the key exchange mechanisms, the next step is to setup the permissions. To do this, the GAMBAS middleware application for Android provides a number of user interfaces to configure the access control model detailed in [GPS13] . As shown below, these interfaces enable the user to select a friend and to view the permissions that are already assigned to the friend. In addition, it is possible to modify the permissions. To do this, the user can select one of the friends and select an item from the action bar to change the permissions. This will bring up a screen with the permissions that are currently assigned to the user. By selecting a permission and pressing the delete button, an existing permission can be deleted. By clicking an add button, a user can select the type of context information on which a permission should be added to the user. This list is generated from the list of context types defined in the GAMBAS ontology.

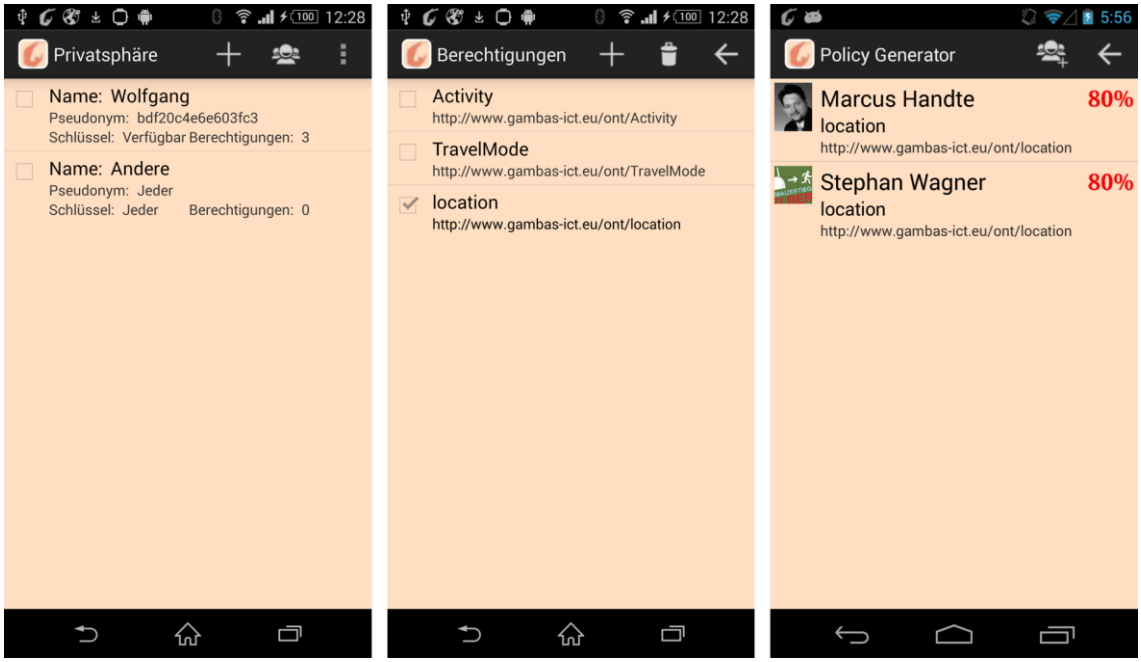

Figure 1 – GAMBAS Middleware Privacy Interfaces and Tools

In addition to the manual configuration, the user can also perform an automatic configuration using the policy generator. To do this, the user must log into Facebook in order to grant the policy generator the necessary access rights to the user's sharing behaviour on this social networking site. Once the user is logged in and the policy generator is executing, it will analyse the user's past sharing behaviour with the set of friends that is configured in the GAMBAS middleware. Based on the data that is shared with users, the policy generator will create a proposal for known context types. To do this, it analyses the status messages shared with other users and determines whether they expose the user's location. The result is a proposal for sharing permissions that reflects the user's past sharing behaviour on Facebook. Of course, a user can use the manual configuration to further fine-tune the proposal in case that it does not reflect his actual preferences.

2.3 Visualizing Information

Once the permissions are configured, the GAMBAS middleware can share information on behalf of any GAMBAS-enabled application. In the study detailed in this document, however, the focus lies on a particular application – namely the GAMBAS Locator. The GAMBAS Locator is a location tracking and prediction application that optionally captures audio data in order to create a noise map. In addition, it enables users to share their location in a peer-to-peer fashion through the GAMBAS middleware. To do that, the users configure their sharing permissions in GAMBAS and then they can view the locations of friends that are sharing their location information with them.

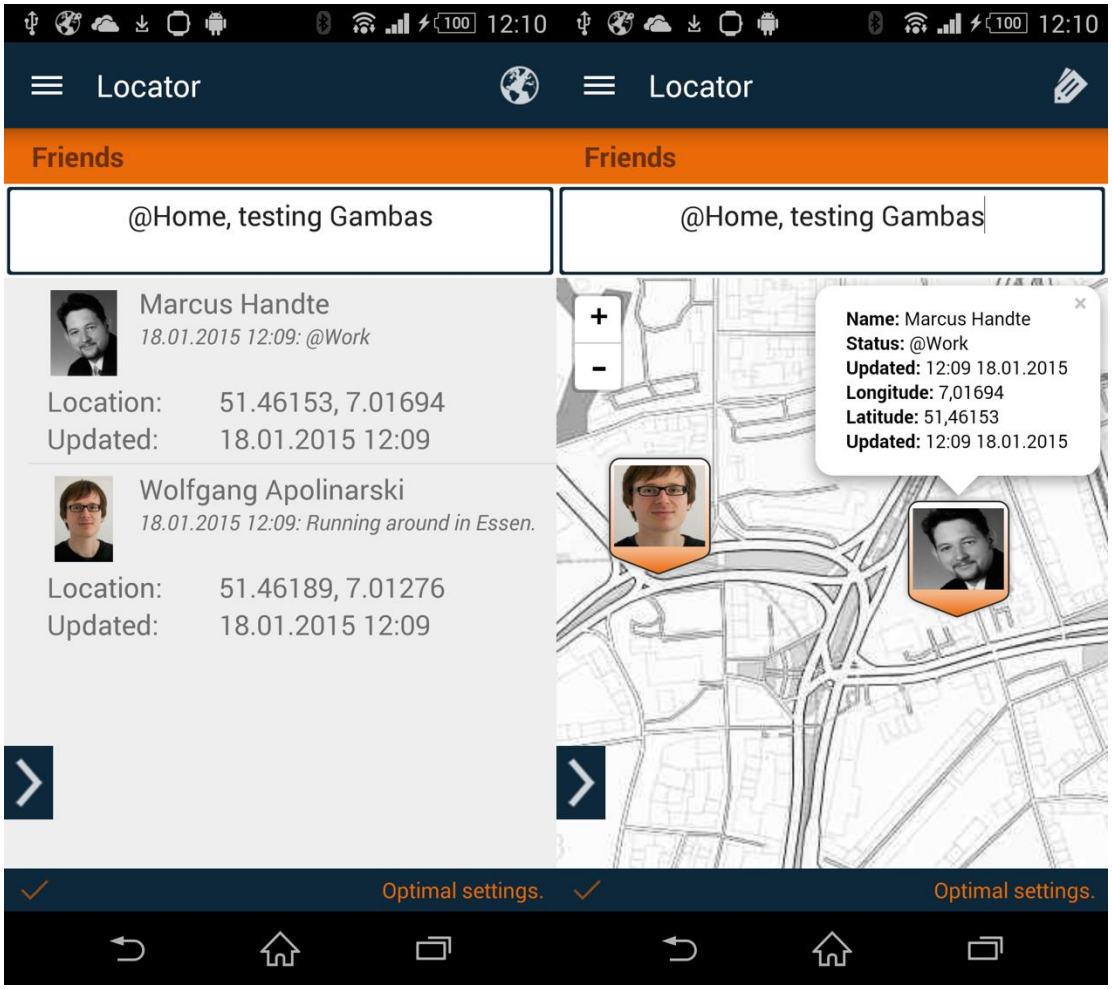

Figure 2 – GAMBAS Locator Interfaces and Visualizations

To visualize the location information, the GAMBAS Locator provides two interfaces – namely a list-based and a map-based visualization, which have been defined in D5.4 User Interface Software – Social Interfaces. In addition to the current user location, they enable friends to share short textual "status" messages that can be used to convey the current user activity. In addition, the application provides several other interfaces in order to view the past history of locations as well as the noise profile of the day, however, in the user study that is described in the following, we focus on the social part of the user interfaces, i.e. the sharing of location information and status messages.

3 Methodology

In order to evaluate the suitability and usability of the user interfaces and concepts introduced by the GAMBAS middleware and the GAMBAS Locator, we performed an end user study with a user group acquired from students and employees at the University of Duisburg-Essen.

The study evaluates three key functional aspects of social interfaces:

- Key Exchange
- Access Control
- Location Sharing

In order to contextualize these areas the study captures key user characteristics.

- Sharing Attitude
- Experience Level

The user study uses a qualitative method based on questionnaires with a combination of open and closed questions. Closed questions are in the form of multiple choice questions and Likert-scale questions.

The study encompassed three main components that focus on providing the users with the necessary background information on the GAMBAS project and the applications and user interfaces that ought to be evaluated. In the following, we describe the overall evaluation process that has been executed in two workshops with multiple users.

3.1 Presentation Session

The first part of the workshop included a presentation and demonstration session, which outlined the goal of the user interface evaluation workshop. To do this, the workshop started with a presentation on the GAMBAS project and objectives. This introduction to GAMBAS was followed by a demonstration of the GAMBAS Locator application with its location sharing capabilities. During the presentation, special attention was paid to the discussion of the user interface elements (see figure below).

Figure 3 – Presentation Session

Once the demonstration of the Locator was completed, the presentation continued with additional presentation and demonstrations of the key exchange mechanisms of the GAMBAS middleware application and the interfaces to assign and revoke permissions on context types to different friends. During the presentations and demonstrations, users were asking questions on the particular mechanisms and interfaces and the questions were answered by the GAMBAS members that were organizing the workhop.

3.2 Hands-on Session

After all features that ought to be evaluated where presented by means of presentations and demonstrations, a number of devices was given out to the participants and they were able to test the applications and user interfaces by themselves. During the complete time of this hands-on session, personal with GAMBAS experience was present in order to answer questions. The tasks executed by users included the exchange of a cryptographic key via NFC or the localization of friends using the map-based and the list-based visualization of the locator application. The hands-on session ended as soon as all users understood the use of the applications and in order to gather their feedback they were asked to fill out an online questionnaire detailed below.

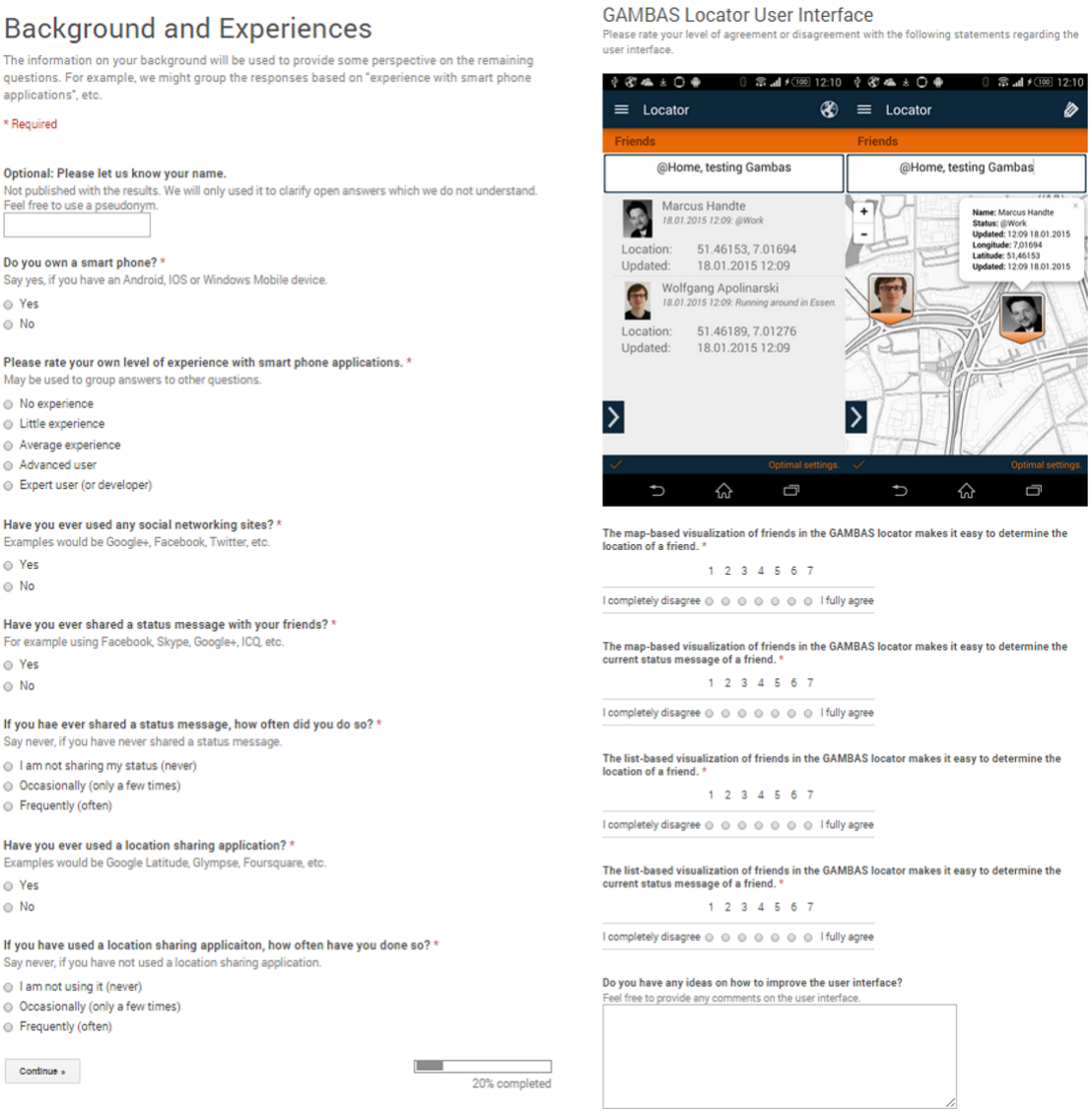

Figure 4 – Questionnaire Excerpt

3.3 Questionnaire Design

In order to gather the feedback of the users, we decided to use an online questionnaire in order to simplify the evaluation procedure. To create the questionnaire and to collect the responses of the users, we used Google Forms as it provided all the necessary functionality at no cost.

To capture all necessary information for the evaluation, the questionnaire was broken down into 5 different groups of questions which we briefly outline in the following. Two example groups of the questionnaire are depicted in the figure above.

- **Experience Level**: The first group of questions was focusing on the experience level of the users. In particular, the questions evolved around the users' experiences with smart phones and smart phone applications. The purpose of these questions was to provide some background information on the users in order to identify correlations with other questions based on their experiences – which can help to identify concepts that are, for example, hard to understand for novice users.

- **Sharing Attitude**: The second group of questions was focusing on their attitude towards location sharing. Due to the specific types of information shared through the GAMBAS Locator, the questions focused on location information and status messages. The purpose of this group was to determine the user's general attitude towards location sharing as well as their attitude towards privacy of information, which can provide a valuable indicator for the usefulness of the mechanisms introduced by the GAMBAS middleware.
- **Key Exchange:** The third group of questions was focusing on the key exchange mechanisms provided by the GAMBAS middleware in order to setup lists of friends that may receive information. The questions in this group focused on the key exchange via NFC and the key exchange via Facebook and the responses were contrasted with the sharing experience and attitude in order to determine which users may find which mechanism more useful.
- **Access Control**: The forth group of questions was focusing on the access control mechanisms introduced by the GAMBAS middleware. The focus was the manual configuration of permissions using the associated user interfaces embedded into the GAMBAS middleware application as well as the automated mechanisms that were tapping into Facebook in order to propose a user-specific sharing policy.
- **Location Sharing**: The fifth group of questions was focusing on the visualizations and interfaces provided by the GAMBAS Locator application, which realize the social interfaces conceptualized and implemented in D5.4 User Interface Software – Social Interfaces. The purpose of this section was to identify deficiencies and to evaluate the overall usability of the interfaces.

The questions in the first two groups provided context for the later questions, mostly consisted out of simple yes or no questions, and sometimes included additional choices to represent specific types of users or specific sharing frequencies. For the other three groups, which were the focus of the study we applied a Likert scale with an odd number of items in order to avoid forced choices. In particular we consistently used seven levels from 1 (complete disagreement) to 7 (complete agreement) with 4 being the default selection (neither agree nor disagree). Where possible we tried to determine correlations with the responses to the last three sections and responses to the first two sections in order to detect group-specific answer tendencies. In the following, we first discuss the results and then discuss the correlations where applicable.

4 Results

In the following, we describe the results of the structured user study that has been performed at the University of Duisburg-Essen with a heterogeneous user group consisting of 12 persons. These 12 person have been recruited from a broad spectrum of University members working and studying in Essen. They include administrative personnel, students and researchers.

4.1 Experience Level

As described previously, the purpose of the first set of questions was to determine the experience level of the users with respect to the functionalities that ought to be evaluated. Towards this end, we asked users about their experiences with smart phones and social networking. Interestingly, almost all users involved in the study (11 out of 12) owned a smart phone and half of them (6 out of 12) consider themselves to be a very experienced user. This can probably be attributed to the fact that the study was executed at a University using several computer science students which are developing mobile applications as part of their curriculum or PhD work. Similarly, when looking at the existing experiences with social networking sites, approximately half of the user group has used them already.

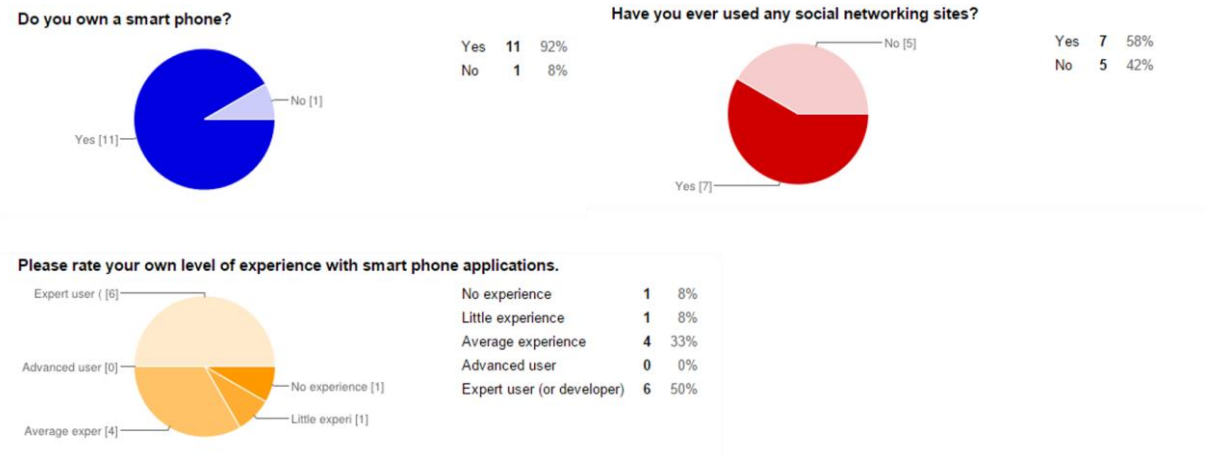

Figure 5 – Application Experiences

Looking at the specific experiences on data sharing, as depicted below, about the same number of users has also already shared a status message with someone else. From the 8 users that have ever shared a status message, only 3 are doing it frequently. The other 5 users do it on occasion. When looking at the experiences with location sharing, only 3 users have ever used an application to do it and if they do it they do it only from time to time but not frequently.

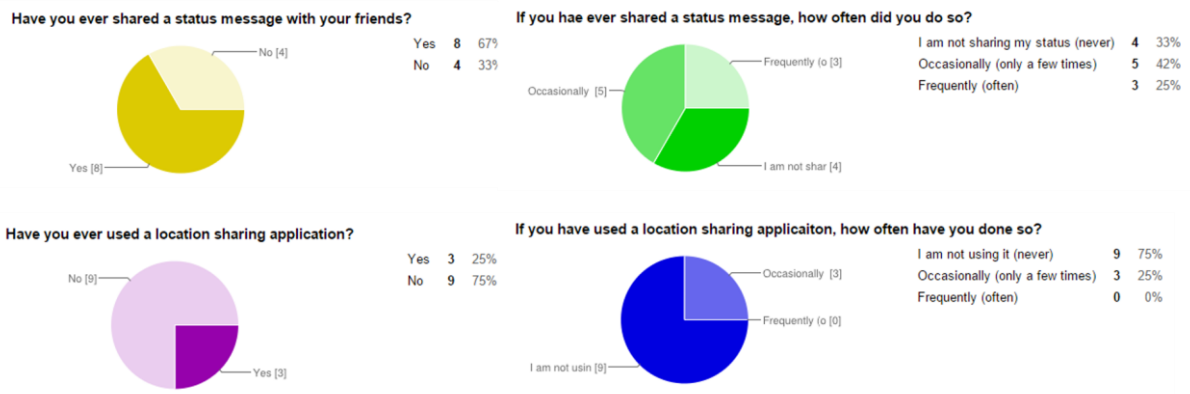

Figure 6 – Sharing Experiences

In summary, the user group seems to be well-mixed containing users with little smart phone experience as well as experienced users. Approximately, 50 percent of the users are sharing some data with their friends and about 25 percent even share location information already.

4.2 Sharing Attitude

The next section of the questionnaire focused on the user's attitude towards data sharing with a specific focus on location as the information that shall be shared. From the 12 users, the majority of users stated that location sharing could be useful for them (10 out of 12). While the remaining 2 do not see a use for themselves, they also believe that location sharing could be useful for others. This underlines the potential usefulness of sharing a location with others in an automated fashion as done by the 2nd version of the GAMBAS application prototypes.

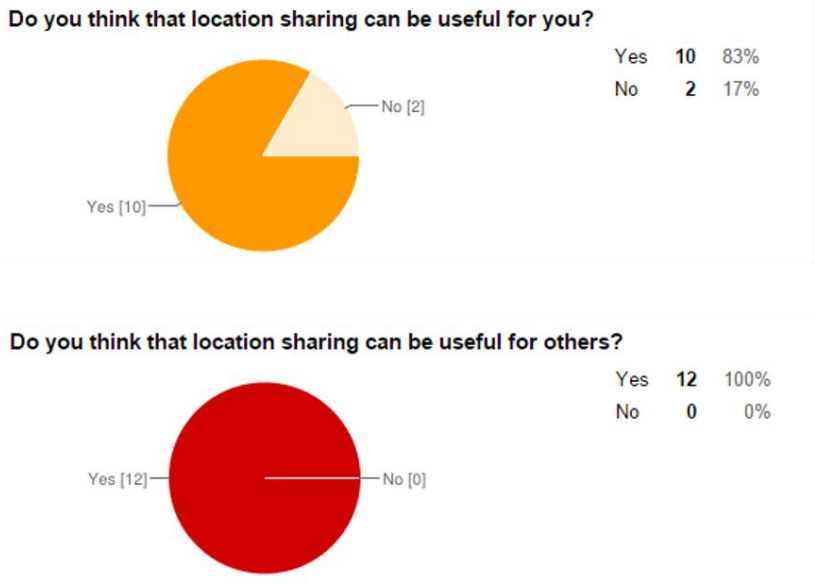

Figure 7 – Sharing Usefulness

Even more interesting than the pure potential usefulness of location sharing are is their attitude towards security and privacy. All members of the user group state that security is an important aspect of a location sharing application as depicted below. This provides a clear indicator for the necessity of the secure communication mechanisms integrated into the GAMBAS middleware.

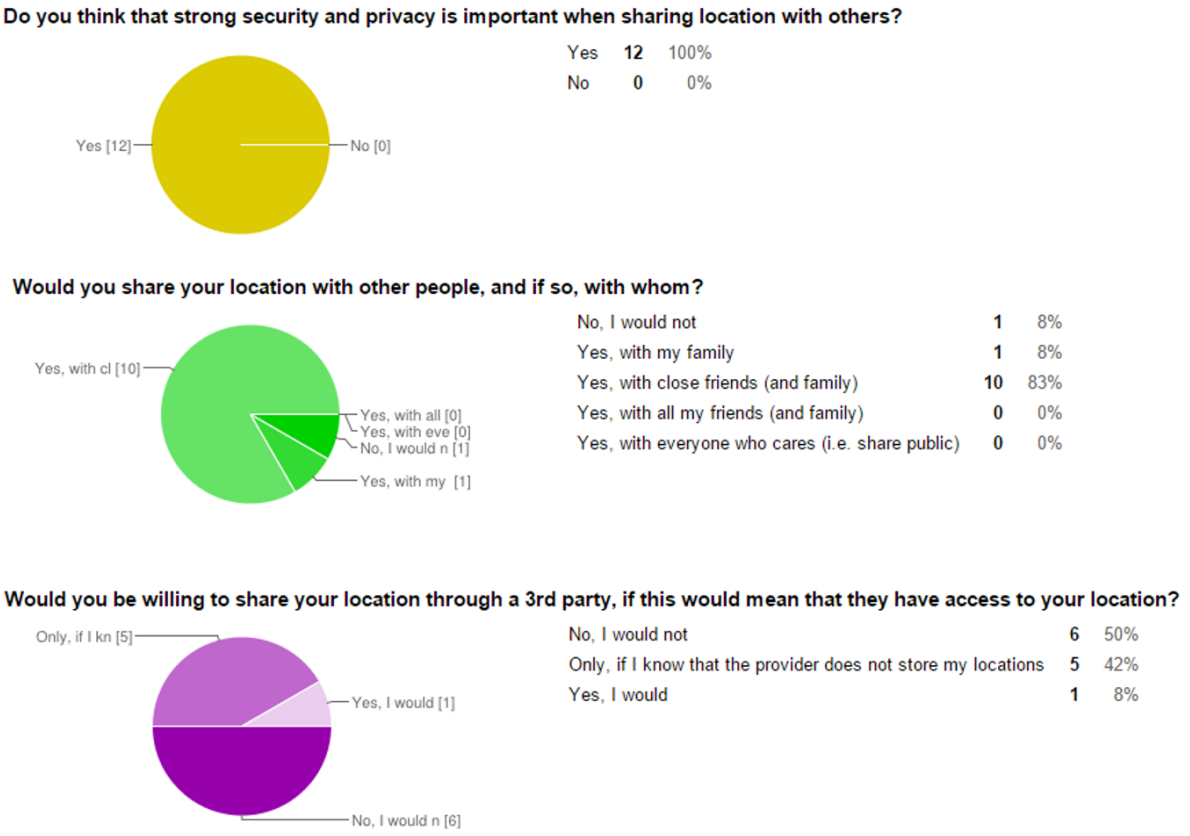

Figure 8 – Sharing Security

Similarly, when looking at the types of friends that the users would share their location with, it becomes apparent that all of them want to closely control the group of users that will have access to their location. 10 out of 12 users would be willing to share their location with close friends and 2 users would even employ more restrictive policies. None of the users would be willing to publicly share their location or to even broadcast their location to all their friends. This provides a clear indicator for the fact that users feel a strong need to control access to their location information. Thus, it is clearly important that such access controls are enabled by the privacy policy mechanisms integrated into the GAMBAS middleware.

4.3 Key Exchange

Given the knowledge about the basic composition and experiences of the user group, we now start to look at the attitude towards the user interfaces for the definition of friends that are built into the GAMBAS middleware Android application. The user interfaces encompass several screens and

physical interactions that empower to user to establish a cryptographically secured relationship with friends by connecting to Facebook or by performing a manual key exchange via NFC technology.

As indicated in the figure below, after the hands on of the key exchange with NFC technology, most of the users strongly agree that the exchange of a cryptographic key via NFC between phones that are nearby is easy to use. However, one of the users only marginally agrees with the simplicity.

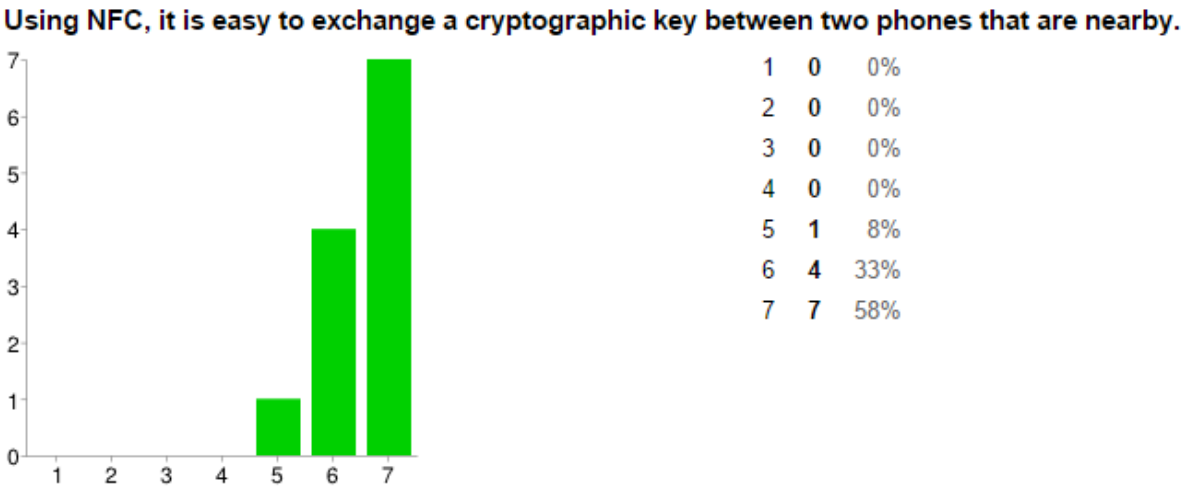

Figure 9 – NFC Key Exchange

As a justification for this rating, a closer look of the free-form question regarding possible improvements on key exchange reveals the main reason for the "negative" rating from one of the expert/developer users:

> *Actually, I would fully agree to the points above but some users might not have a NFC phone nor a Facebook account. Maybe it is worth highlighting that in principle there are further ways that could be implemented easily:*
>
> - *SMS (like it is used by whatsapp)*
> - *QR codes (like it is used by Threema)*
> - *Mail? (I think telegram or some other strange messenger also allows authentication via mail)*

Interestingly, other users reinforce this notion and state that they think that NFC is useful but not universally applicable make similar statements. For example:

> *QR code for phones without NFC*

In addition, one of the users found the necessity of the physical "back-to-back" orientation of the phones cumbersome and stated (in German) that it would be preferable to be able to keep the phones side-to-side like with Bluetooth communication. However, given the physical constraints of NFC, this cannot be done (due to the size constraints of NFC antennas). Yet, again – in a broader

context, looking at alternative “close-proximity” communication technologies such as the uprising Bluetooth LE Smart technology would be an interesting and apparently, desirable extension.

Finally, one of the users pointed out additional possibilities for improving the key exchange by providing a more robust error handling in edge cases:

> *When something goes wrong, it might be nice to inform the user as to what may cause the problem (example: when we tried the NFC-based authentication and one of the phones could not communicate over the network, it did not work due the one-way nature of the NFC communication. There was no dialog box saying "The phone has no network connection" or something).*

All these issues are clearly worth considering in order to further improve upon the direct exchange of keys with friends. Especially, when considering further developments on GAMBAS towards the provisioning of a mature software platform for a broad pickup through 3rd parties.

Looking at the attitude of the user group towards the alternative way of sharing cryptographic keys via social networking sites, the results of the questionnaire shows a split picture. While none of the users thinks that the Facebook integration is not easy to use. 4 out of the 12 users only marginally agree with the statement as indicated below.

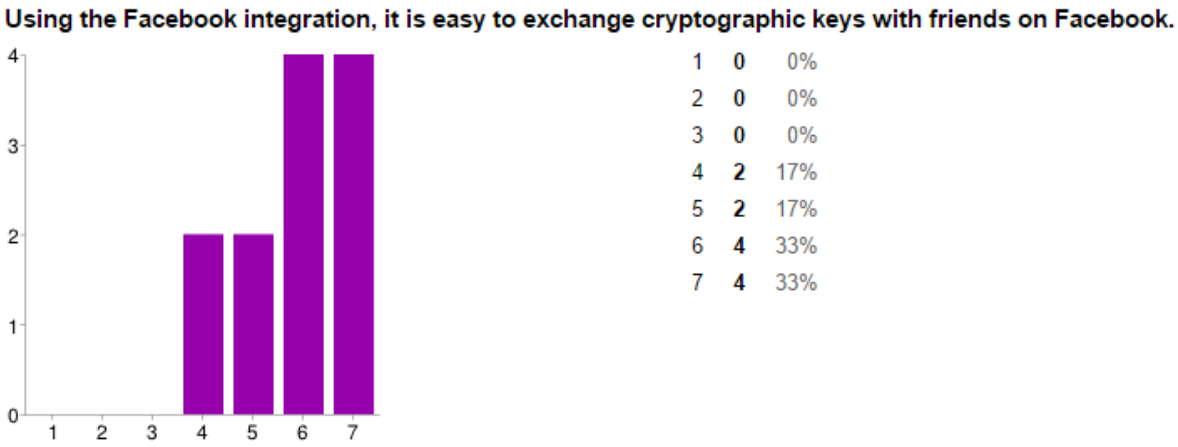

Figure 10 – Facebook Key Exchange

Analysing the background of the users reveals that there is a correlation between the use of social networking sites and the rating. From the 4 users that rated the ease of use with a 5 or below, 3 users have never used social networking sites and the 4th user has used them but is now not using them at all. Consequently, it might be possible that they do not consider this type of key exchange useful or easy as it would not be beneficial for them – since they would have to setup their friends on the social networking site first, before using GAMBAS.

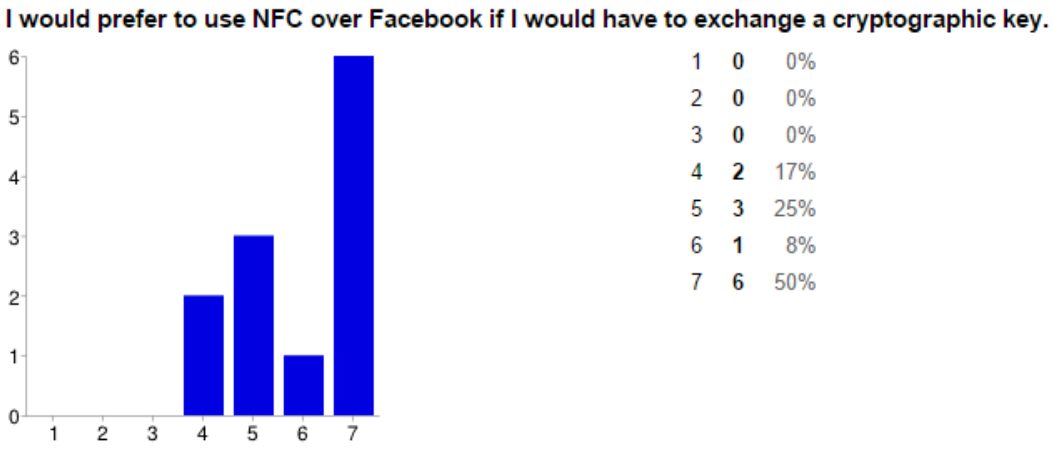

Figure 11 – Facebook Key Exchange vs. NFC Key Exchange

Based on these results, it is not surprising that most of the users agree that they would prefer a key exchange via NFC over a key exchange via Facebook as depicted above. A further correlation analysis also reveals that the ones that do not have a strong preference are primarily the users that are already using social networking sites. Thus in summary one might argue that key exchange via NFC is primarily interesting for users that are less likely to be involved into social networking whereas key exchange via Facebook is primarily interesting for users that are already actively using it.

Given the rather positive evaluation of both types of key exchange, we would argue that they are suitable – although, in a broader context, they should be extended with additional alternatives that are more broadly available (such as use of SMS, QR-Codes or other secure messaging mechanisms) and edge cases should be more explicitly indicated in the user interfaces.

4.4 Access Control

One the friends are configured, the end user has to define the access control policy. This can be done using the associated user interface in the GAMBAS middleware application. To simplify the definition, a policy generator can be used to derive suitable policies from online social services. To determine the usability of the associated interfaces, the next part of the questionnaire focuses on the configuration of the permissions.

The first question that arises is the suitability of the access control model used by the GAMBAS middleware. As depicted below, most users consider the access control mechanisms easy to understand. However, there are 2 users that do not think so. In addition, three further users only mildly agree with the simplicity of the underlying sharing model.

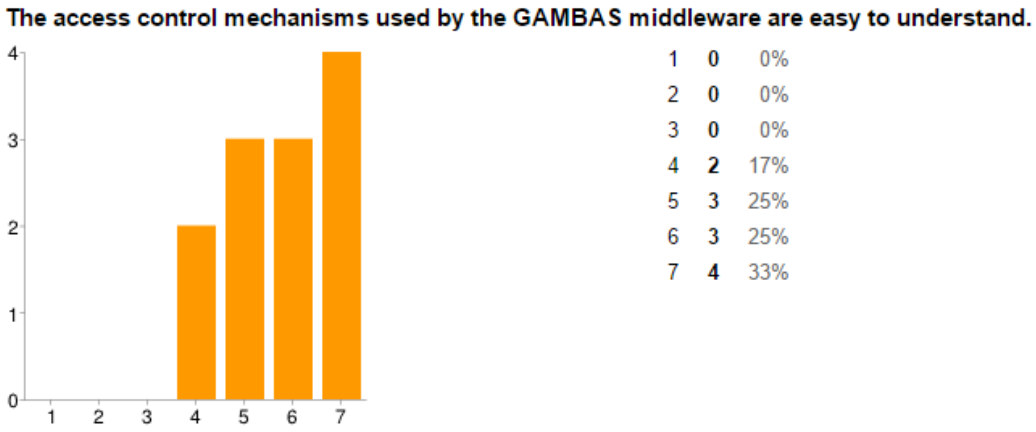

Figure 12 – Access Control Model

A closer look at their comments reveals that their issues are not necessarily centered on the model but rather focus on the particularities of the user interface. For example, one of the users feels that the sharing dialogs are not easy to access.

> *Make the sharing options more visible and easily accessible in the app.*

The other user feels that the labels are not appropriate and should be changed because the user does not understand it's meaning properly.

> *It is strange that there is the "Other" entry but I cannot do anything with it (at least I did not figure it out).*

The former problem could be solved by enabling a deeper integration of the privacy menus provided by the GAMBAS middleware app into GAMBAS-powered applications. The latter issue should be solved by providing clearer labels that better convey the meaning of the different entries.

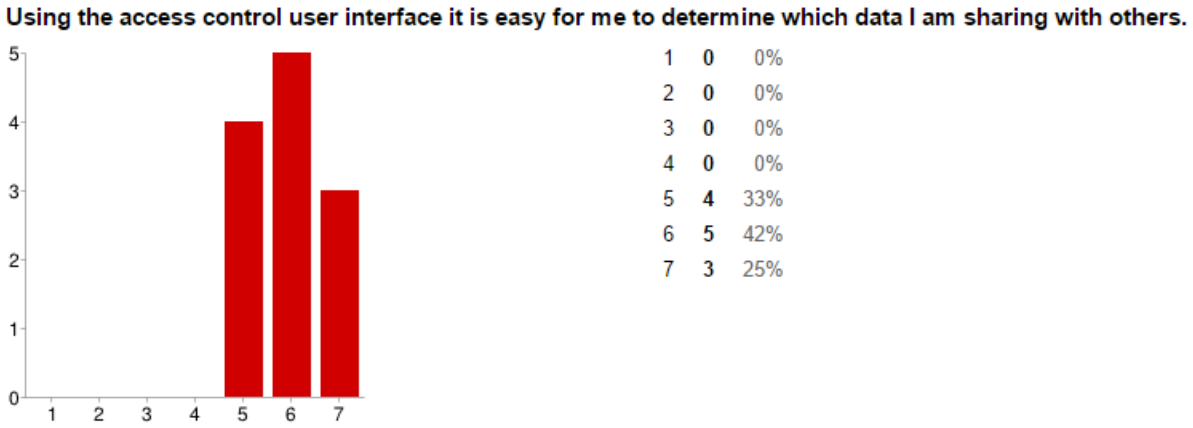

Figure 13 – Access Control Visualization

Interestingly, when looking at the visualization of the actual user interface (as depicted above), despite these issues, most users still feel that it is easy to see with whom they change what

information. However, even with this positive judgment, one of the users is concerned with the concrete labeling of the permissions. The following statement by the user illustrates this:

> *The difference between the access rights is not always clear, e.g. Location vs. Places? Can there be a description for them added to the list? Do the GAMBAS apps explain which access rights are needed?*

This problem stems from the fact that currently the names of the permissions are completely based on the class names of entities in the GAMBAS ontology. While these names are easy to understand for an application developer, they apparently are not an optimal basis to assign names to permissions. Thus, one possible optimization might be to reconsider the entity names of the ontology and to align them better with the expectations of end users.

In addition, some users would like to have additional views in order to improve the scalability of the user interface with respect to a larger number of permissions or users. This can be seen by the following two statements.

> *Enable the user to view the permissions grouped by type.*

> *For small number of permissions, list in user list "show users" for certain permission.*

Consequently, for a final product, it seems to make sense to integrate additional views that not only show permissions by users but also display users by permissions.

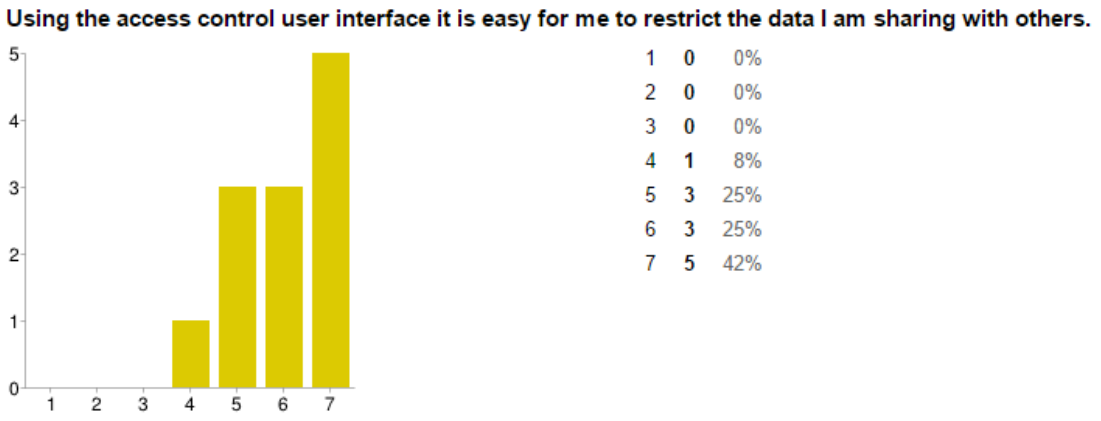

Figure 14 – Access Control Usability

When looking at the usability of the user interface, a majority of the users think that the list-based configuration is easy to use. However, several users have concerns with respect to the scalability of the user interface when the number of friends or the number of applications with different context types starts to grow. This can be seen, for example, by the following statements:

> *It should be possible to grant more than one access right at once. Currently, I need to press "+", select from the list, and press Ok in the confirmation dialog for each right.*

When a new GAMBAS application is installed that comes with a new access right, it would also be good to grant this right to more than one friend at a time.

So in order to improve the efficiency of the user interface, it would make sense to enable the user to assign multiple permissions at the same time to the same user and to enable the assignment of the same permission to multiple users.

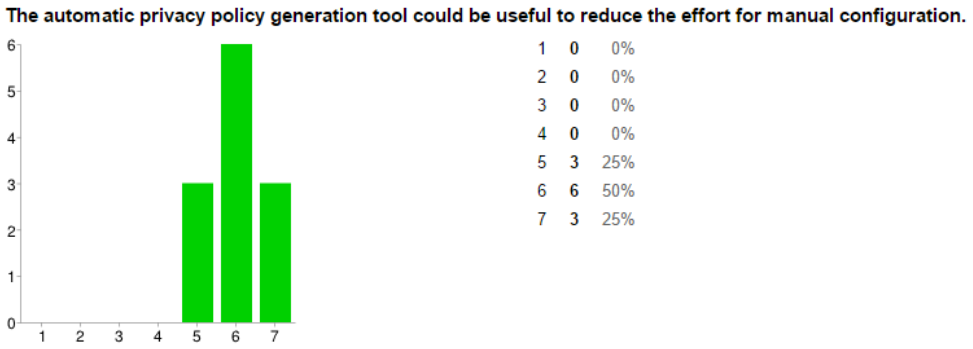

Figure 15 – Policy Generator Usefulness

Finally, the last building block of the privacy control mechanisms and interfaces is the privacy policy generator which can simplify the generation of a privacy policy by analyzing the sharing behavior of a person on a social networking site. With respect to the privacy policy generator, most users think that it can be beneficial and help to reduce their effort for manual configuration (see figure above). Interestingly, the two users that think that the privacy policy generator would be less beneficial are both users that do not use social networking services. Thus, one might argue that their responses are consistent since the privacy policy generator will only be useful for users that are already sharing information elsewhere.

4.5 Location Sharing

The last part of the user study focuses on the social user interfaces that are implemented as part of the GAMBAS Locator application. This application enables location sharing in a peer-to-peer fashion and includes the location prediction components of the GAMBAS middleware. In addition, it includes the audio measurements and processing to create the noise map. However, the following questions posed to the user group primarily focus on the location-sharing aspect of the application and in particular on the map-based and the list-based visualization of friends with their associated status messages that have been described in detail in D5.4 Intent-aware User Interface.

As depicted below, regarding the map-based visualization, most users agree that it makes it easy for them to determine the location of a friend. From the 12 users in the group only 2 users lightly agree with this. The other 10 either completely or mostly agree with the usability of the visualization to determine a friend's location.

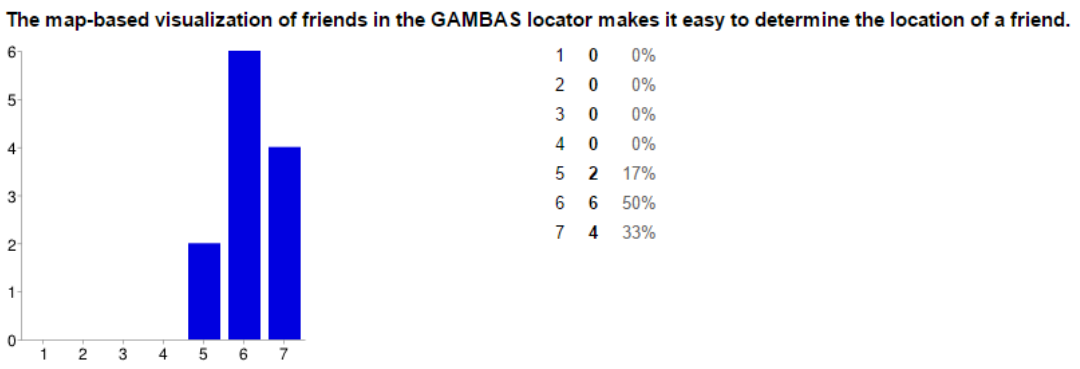

Figure 16 – Map-based Location Visualization

Looking at the comments provided by the user group on the map-based visualization, one might argue that the improvements that are proposed are primarily optimizations of the concrete implementation of the map rather than complete changes of the fundamental concepts. For example, one user would prefer a more colored map as indicated by this statement:

> *A more colored map would make it even easier to intuitively determine where my friends are.*

Another user is more concerned about the scalability of the visualization in cases where friends are distributed over a large geographical area:

> *I am not sure how this scales if friends are spread over a big area or if there are a lot of them at the same location (overlapping icons) and about the list: what if the list is very long, how does that scale;*

Yet, since the map is interactive, it is possible to zoom in and out to the different locations and thus, we would argue that basic scalability is given. However, implementing the following recommendations could clearly further improve the overall scalability:

> *Click on person in list -> jump to person on map view.*
>
> By tapping on a user, the app should highlight the location of the selected user on the map view.

A third user would prefer to get additional information about the geometric distance to the friend from the user's current location:

> *A scale could be added (map-view). It would be nice to know the distance to a friend, instead of just his/her coordinates (map/list).*

These optimizations are clearly worthwhile considering and should be implemented for an updated version of the map-based visualization contained in the application.

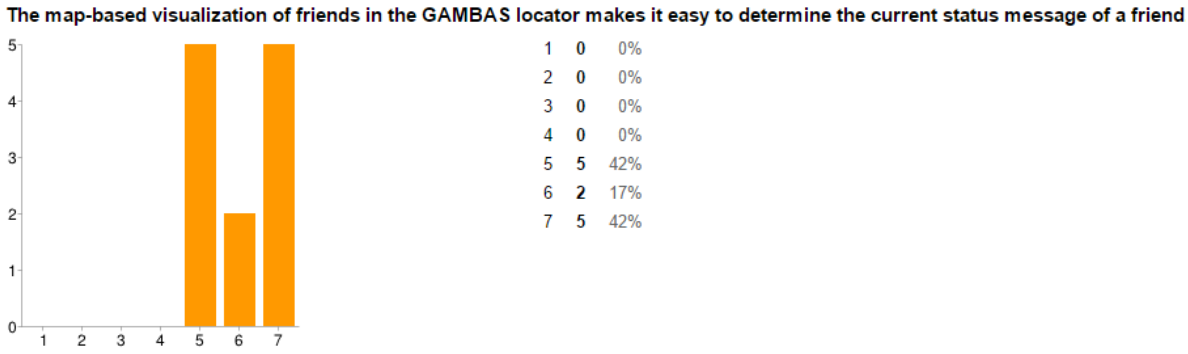

Figure 17 – Map-based Status Visualization

Looking at the suitability of the map-based user interface in order to determine the status message of a friend shows a similar picture (see figure above). Most users agree that the visualization is usable and enables them to determine the status of a friend. Yet looking at the details, the level of agreement is slightly less which can probably be attributed to the fact that in order to determine the status message of a friend, it is necessary to tap on the marker representing the friend. Consequently, in order to view multiple friend's current status message, the user needs to browse through the different markers which requires a series of interactions (i.e. move to a friend, tap the marker, read the text, move to the next friend, …). Consequently, the possible issues with scalability might be intensified.

When looking at the usability of the list-based interface in order to determine the location of a friend (see figure below), it becomes apparent that the list-based interface performs significantly worse. Most users disagree with the statement that the interface makes it easy to determine the location of a friend. Instead, the users seem to find it difficult to interpret the visualization for this task. Only two user's find it easy to use. This negative picture can be easily explained when looking through the comments that the user group made in order to improve the visualization.

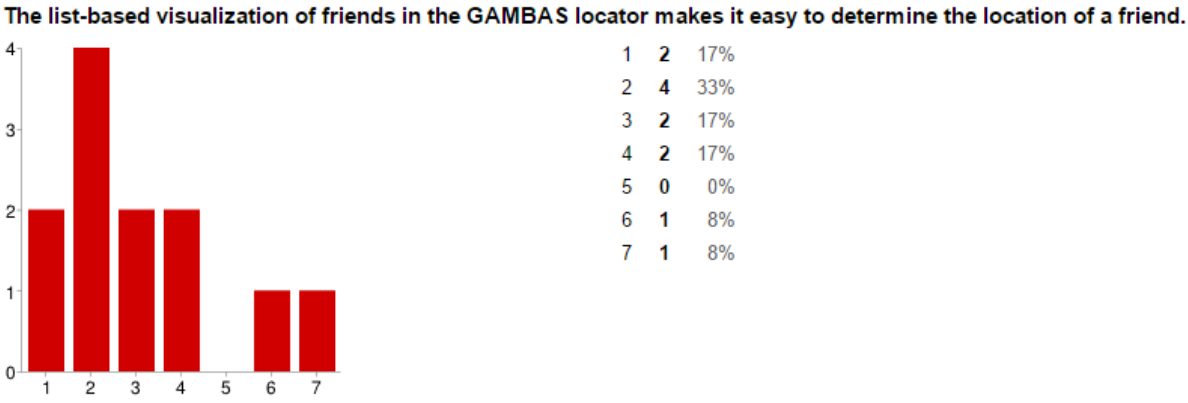

Figure 18 – List-based Location Visualization

Most proposals for improvements (listed in the following) are focusing on the fact that the WGS84 coordinates provided by GPS cannot be easily understood:

> *Instead of using coordinates within the list-based visualization, some coordinate related location name (e.g. city district/street name matching/close to the coordinates or favorite locations if the user permits his friends to see his favorite places) would be more useful.*
>
> *Address instead of or in addition to lat/long in list*
>
> *Es wäre gut, wenn sowohl in der Listen- als auch in der Kartenansicht, zumindest die Stadt, in der sich der Freund befindet, aufgelistet werden würde. In der Liste kann ich nur anhand der Längen- und Breitengrade nicht mal wissen, ob der Freund sich auf demselben Kontinent befindet wie ich.*
>
> *Resolve street names for the coordinates in the list interface.*
>
> *Coordinates are useless. It would be much better to translate this to an address, if possible. It would be great to see easily if a location is up to date. E.g. different colors could be used for this.*

Thus, in order to improve the usefulness of the list-based visualization, it is imperative to use Geocoding in order to resolve the address of the user into a human readable address where possible. Due to the importance and the uniform request of the users for this feature, this improvement should clearly be implemented for a future version of the application.

Interestingly, when looking at the usability of the list-based visualization in order to determine the current status message of a friend, the responses of the user group show a completely different picture. Most users agree that the list-based interface makes it easy for them to determine the status of a friend. When comparing the level of agreement with the statement posed in the question with the usability of the map-based visualization in order to determine the status message of a friend, it becomes apparent that several users even prefer to use the list-based visualization to determine the status of a friend. This highlights that despite its deficiencies with respect to location information, the visualization can be useful for other textual information (such as the status message). Consequently, the two visualizations seem to provide complementary strengths and weaknesses.

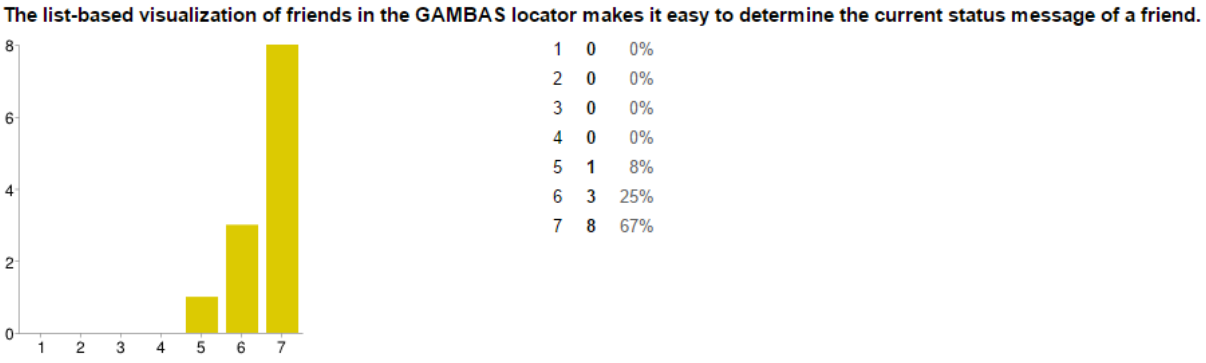

Figure 19 – List-based Status Visualization

Yet, when looking at the responses of the users, it becomes apparent that many users would prefer a more powerful filtering and search mechanism as opposed to the simple list-view that only shows “all friends”:

> *It would be nice to be able to sort the friends by name, range, time last seen...*
>
> *Filter that allow finding friends more easily. E.g by typing ""Dr."" the view could provide sufficient information for finding a safe spot to hide.*

Since such features are easy to implement, they should be considered for a future version of the application.

5 Conclusions

Deliverable 5.5 is the last deliverable of WP5. In line with the overall project organisation, this deliverable investigated usability aspects of the new social interfaces. The report contained in this document was based on a usability study that focused on a very specific aspect of the GAMBAS system, namely the visual representation of the location information as well as the associated security and privacy interfaces used to limit the access to this information. The study investigated the user perception of the interfaces and discussed possible improvements proposed by the users.

In summary, the users that have participated in the study have little problems with understanding the basic concepts of users and permissions that are introduced by the GAMBAS middleware in order to limit the sharing of information. Even if the users have little experience with smart phones or social sharing services, they are still able to determine which data is shared with whom. Moreover, the majority of users considers the automation brought to them by means of tools such as the NFC- and Facebook-based key exchange as helpful and they think that tools such as the automatic policy generator could reduce their configuration effort. This is especially important since most users are clearly concerned about their privacy and usually wish to limit the sharing of (location) information to a small group of users (i.e. close friends and family).

With respect to the social interfaces, the majority of the user's considers them to be usable in order to determine the location and status of a friend. However, they also highlight the need to use street addresses as opposed to WGS84 coordinates when displaying a location as text. Furthermore, they clearly prefer a map-based visualization over a list-based visualization when it comes to determining the location of a friend. When it comes to determining non-location-based properties (such as the status message of a friend) there is a slight advantage on list-based visualizations. As a key areas for improvements, the users mention more advanced filtering capabilities and a better interaction between the list-based and map-based visualization which could be implemented by moving the map to a friends location when the friend is selected in the list. As a positive side effect, this could also improve the scalability of the visualizations when the number of friends is growing.

The results of the user study have been used to shape the final user interface of the GAMBAS application prototype 2 and several of the proposals made by the users have been implemented already in order to improve the usability of the social interfaces.

6 Bibliography

[GPS13] GAMBAS Consortium (2014). D3.1.2 Privacy Perservation Specification 2, Public Deliverable, Available at http://www.gambas-ict.eu, Last Access: February 2015.