Physical Activity Support Community TogetherActive
Architecture, Implementation and Evaluation

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Abstract: Reducing sedentary lifestyle and physical inactivity is getting an increased attention of researchers and health organizations due to its significant benefits on health. In the same direction we are proposing a virtual community system, TogetherActive, which supports people in their daily physical activity. The community is connected to physical activity sensors and provide social support (informational, emotional, instrumental and appraisal supports). In order to increase motivation, individual and group goals, comparison, competition and cooperation are the key concepts considered in the system. This paper presents the design, implementation and usability evaluation of the TogetherActive system.

1 INTRODUCTION

Physical Inactivity is the fourth leading risk factor for global mortality causing an estimated 3.2 million deaths globally (WHO, 2014). Moderate regular physical activity has significant benefits on health and can reduce the risk of cardiovascular diseases, diabetes, colon and breast cancer, and depression (WHO, 2014). Physical activity should not be mistaken with physical exercise. Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure (WHO, 2014). Physical activity includes physical exercises, but also can be active transportation, working or house chores, or more generally activities of daily living.

Physical activity is important for all age groups and health conditions. Only the recommendations change depending on the group ages (5-17 years old, 18-64 years old and 65 years and above) and on the health condition (healthy, acute diseases and chronic diseases)(WHO, 2014). Despite all recommendations and well-known health benefits of regular and sufficient physical activity, physical inactivity remains a global health problem (WHO, 2014).

The actual focus of many researches and organizations is to reduce the physical inactivity, such as the WHO Member States have agreed to reduce physical inactivity by 10% in 2025 (WHO, 2014).

In order to reduce physical inactivity and promote this behavioural change, researchers from several fields are involved: social sciences and computer science.

On one hand, in social sciences, researchers base interventions for behavioural change like this on a number of theories and models from social sciences such as(HHS, 1995; HHS, 1996):

- Classic learning theories (where the main concepts are reinforcement, cues, and shaping)
- Transtheoretical model (where the main concepts are pre-contemplation, contemplation, preparation, action, and maintenance)
- Social support (where the main concepts are instrumental support, informational support, emotional support, and appraisal support)

These interventions are based on face-to-face meetings and recently implemented in e-coaching systems (Kamphorst et al., 2014).

On the other hand, in computer sciences, several investigations and researches have been using Information and Communications Technology (ICT) to provide, extend, and enhance interventions to promote the level of physical activity among healthy people and chronic patients (van den Berg et al., 2007; Cotter et al., 2013). They address motivation and monitor physical activity in order to change behaviour regarding physical activity. The assessment of physical activity is important in those interventions and it is either self-reported (for examples with the use of

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e-diaries and questionnaires) or measured automatically and more objectively (for example with the use of pedometers, actometers, accelerometers and gyroscopes).

Telehealth and Telemonitoring systems couple ICT-based systems with for instance physical activity assessment tools in order to monitor the physical activity and give appropriate feedback taking into account the heath situation of the person(op den Akker et al., 2012; Tabak, 2014; van Weering, 2011). But some of these ICT-based interventions showed a decrease of physical activity after a period of time compared to the first period of use and assessment (around 2 months in (Tabak, 2014)). This decrease may be explained by drop of motivation.

Persuasive technology is also targeting at behavioural changes through persuasion and social influence. PersonA (Ayubi and Parmanto, 2012), UbiFit (Consolvo et al., 2008) and (Silveira et al., 2012) are examples of systems using persuasive technology in order to change physical activity behaviours. These systems are however limited in terms of social support, they are only focusing on the appraisal support.

From another perspective social networks and virtual communities are also used in healthcare in general and in physical activity in particular. These communities mainly provide the needed emotional and informational support. Some examples are: WebMD (WebMD, 2005), PatientsLikeMe (PatientsLikeMe, 2004) and MedHelp (MedHelp, 1994).

Our current work focuses on reducing physical inactivity and we are targeting healthy people in order to improve their health and well-being. In order to overcome drawbacks of previous systems and solutions provided by different research fields, we focus on improving their motivation to be physically active through the use of a virtual community. The virtual community uses physical activity monitoring to assess physical activity. The community aims to provide different forms of social support (informational, emotional, instrumental and appraisal support).The community supports groupings of people using the system. We introduce physical activity goals for groups and individuals. We support competition between groups and cooperation between members within group. Comparison of achievement by members belonging to the same group is also supported. All these functionalities are included in order to increase the awareness and the motivation of users.

The ultimate goal of the virtual community is to motivate people to be physically active and maintain their physical activity level in long term use. It can be used as supporting tool for achieving lifestyle changes in the health prevention and in the management for chronic patients. Lifestyle changes includes physical activity as important facet, but also other facets such as diet and medication.

In this paper we present the design and first steps towards the implementation and evaluation of the TogetherActive community system. We designed TogetherActive and implemented part of the functionalities in order to do a technically evaluation and perform a usability study in order to improve it for the next design iteration.

First we present the architecture and design of TogetherActive system, then we present the implementation and the evaluation of the first prototype. And we finish with discussion and conclusions.

2 TogetherActive OVERVIEW AND CONCEPTS

TogetherActive is a virtual community to support people in their daily physical activities. It supports them in order to get physically active and to maintain an appropriate level of physical activity. The appropriate level of activity is captured by the activity goal that can be set on an individual basis and depending on the personal context.

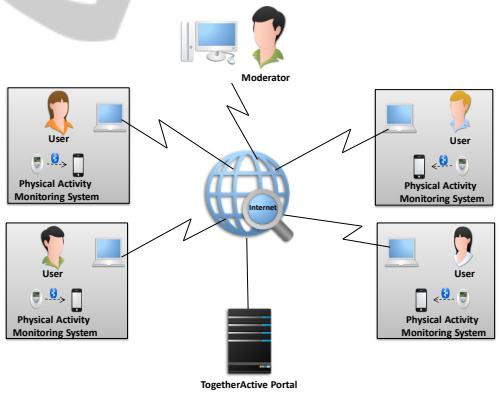


Figure 1: TogetherActive Architecture Overview.

The TogetherActive architecture consists of a number of subsystems as shown in Figure 1. First of all there is a physical activity monitoring system, composed by a physical activity sensor and a gateway (which can be a smartphone). The data collected by the physical activity monitoring system is transmitted from the sensor to the user's gateway and then synchronized with the portal.

The second component of the system is the portal. The portal is accessible from an internet-connected device (laptop, tablet or smartphone). Different views on activity and community data are shown to people depending of their roles.

2.1 Concepts used in TogetherActive

In this section we introduce the main concepts used.

2.1.1 Users and Roles

A user is a person who is using the TogetherActive portal. We distinguish different users based on their user Role. We defined two different user roles: the user role and the moderator role. In the user role people have a physical activity monitoring system. In the moderator role people are able to configure some features of the system such as setting activity goals for individuals and groups.

2.1.2 Group and Group Member

A group is composed of two or more users who interact with each other in order to motivate each other in their daily physical activity. A group is composed of peers (people sharing similar age range, or similar health condition, or similar motivation and goals, or similar physical activity monitoring system) and can include moderator(s). When a user belongs to a group, then he/she is called member of that group.

2.1.3 Physical Activity and Physical Activity Monitoring Systems

Assessing the physical activity level is typically done using a physical activity monitoring systems such as a pedometer or accelerometer. Depending on the physical activity sensor used, different outcome measures are generated by these sensors. The four main different types that can be distinguished are (Chen et al., 2008):

- Steps: represent the basic measurement unit and it can be used to calculate other derived metrics such as energy expenditure and distance.
- Time: modern physical activity monitoring systems record the duration of activities. In order to motivate people, some systems provide a countdown timer.
- Distance: this is calculated using the total number of steps and take into account the length of users' steps.
- Energy expenditure: some of the new physical activity monitoring systems are able to estimate calories consumption during various activities such as walking, cycling, etc. These algorithms may or may not include an activity recognition algorithm.

2.1.4 Goals

As mentioned in the introduction, the recommended amount of physical activity depends on many factors, including age and health condition. Hence, goals are personal and need to be make known to the system. The formation of the goal depends on the type of physical activity monitoring system used. However, in all cases the target amount of physical activity is always related to a period of time, for instance per day or per week.

Next to the personal goal we introduce the notion of group goal. The group goal is a physical activity level plan that the members intend to achieve together. The period of the goal can vary from one day to multiple days.

2.2 Functional View

As the main objective of the TogetherActive community is to provide social support, the functional blocks (Figure 2) are described and categorised according to the four types of social support (House, 1981):Informational, Emotional, Appraisal and Instrumental Support.

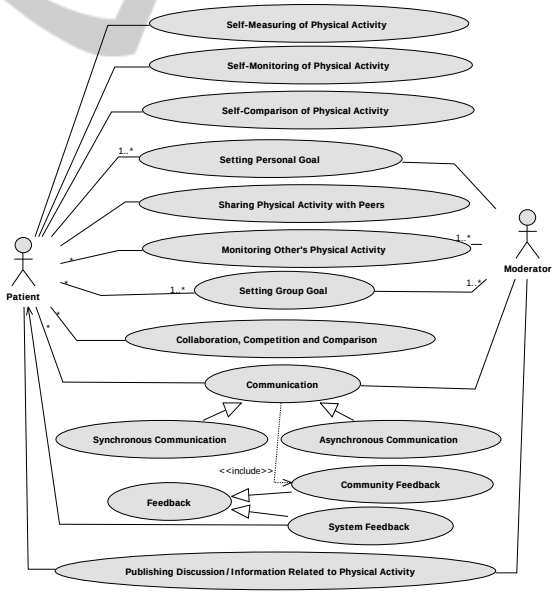


Figure 2: TogetherActive Functions.

2.2.1 Informational Support

With informational support people can receive and search information on physical activity, sensors to measure these, and general information about the pros and cons of physical activities, new facts published

about physical activity importance, and recommendations on physical activity. This information is published on a wiki related to TogetherActive community.

2.2.2 Emotional Support

Emotional support involves the provision of empathy, trust and caring. This is done with publishing discussion on a blog in the TogetherActive community. It is also supported by a synchronous communication service (chat) and an asynchronous communication service (private messaging).

2.2.3 Appraisal Support and Feedback

Appraisal support and feedback is about encouragement and giving motivational cues to people based on their physical activity achievements. In the TogetherActive system the achievement is measured by the activity sensors in relation to the personal and group goals that have been set. Appraisal and feedback can be given in different modalities and have different origins. For instance, in the TogetherActive system, the system itself may provide appraisal and feedback, and peers in the community can provide appraisal and feedback.

2.2.4 Instrumental Support

Instrumental support involves the provision of tangible aids and services that directly assist a person in achieving physically activity goals. It is realised in the community by the functionalities involving physical activity monitoring and self-management:

- Self-measuring of the physical activity: A physical activity monitoring system is provided to users in order to measure the physical activity level.
- Self-monitoring of the physical activity: Users are able to monitor their physical activity themselves in order to change their physical activity behaviour.
- Self-comparison of physical activity: Users are able to compare their current physical activity level with previous levels; such as the daily level with the previous day level.
- Setting personal goal: It is about setting physical activity level goals. These goals should be realistic and measurable. They are time-targeted, such as daily goals. The users are able to set themselves the physical activity goals, otherwise the moderator has to set the goals.
- Sharing physical activity with peers: Peers of the same group are able to share their current physical activity level.
- Monitoring other's physical activity: Peers of the same group are able to monitor each other's physical activity level in order to support and motivate them.
- Setting group goal: A group exists in order to motivate each other, have common goal. Each group can set its own goal. It is also possible that the moderator is involved in setting the goal for a group.
- Collaboration: because a group goal is set for each group and this goal is shared among the peers of the group, collaboration is stimulated to reach this group goal.
- Competition: the TogetherActive community is composed by multiple groups. The ability to achieve a common goal in each group creates the possibility to create a competition between groups.
- Comparison: within a group, peers can compare their physical activity achievement with others and give insight in similarities and differences amongst group members.

3 TogetherActive FUNCTIONAL ARCHITECTURE

The architecture of the TogetherActive portal is based on the concepts of a Service Oriented Architecture. Adapting such a flexible architecture allows a flexible integration, developers get accelerated development cycles, reusable services and composite application development.

The TogetherActive functional architecture is shown in (Figure 3). A portal is generally defined as a software platform for building websites and web applications. Portal provides personalization, single sign on and content aggregation [JSR-168:PLT.2.1]. The TogetherActive portal is composed by portlets. A portlet is a Java technology based web component, managed by a portlet container [...]" [JSR-168:PLT.2.2]. A portlet implements a reusable independent application component.

In the TogetherActive portal, portlets are divided into three categories: generic portlets, personal level portlets and group level portlets. Portlets may use services. Services are also divided into three categories: generic services, personal level services and group level services.

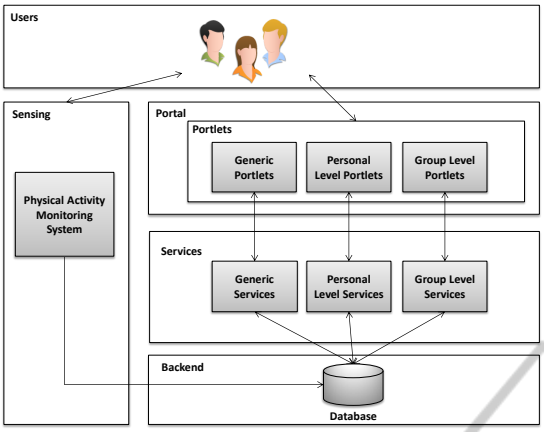


Figure 3: TogetherActive Functional Architecture.

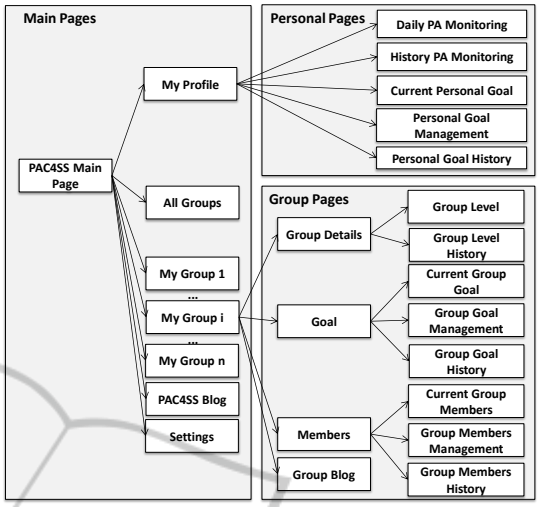


Figure 4: Portal's Pages.

3.1 Portal

The portal is composed of set of pages hosting the portlets. These are categorised into a set of main pages, a set of personal pages and a set of group pages (Figure 4).

- The main pages contain the profile of the logged-in users, their groups' list where they belongs (a user can belong to one or more groups), the portal wiki and portal blog. The pages of the main pages are accessible via the menu bar of the other pages (personal and group pages) for navigation back and forth.
- The personal pages are user-related pages. Via these pages, a logged-in user has access to his/her data such as Daily and History physical activity monitoring data, and personal goals (current and past ones).
- The group pages are group-related pages. Whenever a group is selected from the main pages, the user is redirected to those pages. It contains data and information about the group such as details about the group, the members of the group and the group goal (current and past ones).

3.2 Portlets

Each portal page contains one or more portlets. As part of the design we have defined this relationship as shown in Figure 5, Figure 6 and Figure 7 for each set of pages respectively.

3.2.1 Generic Portlets

The generic portlets are used in the design of set of the main pages. The organization of these portlets on the pages in represented in Figure 5. The portlets used are:

- User Profile Portlet: It contains the profile of the logged-in user. The content of the portlet can be seen by authorised users/peers.
- Group List Portlet: It shows the list of existing groups. Authorized user can access to some groups pages or all of them, for example a member of the group can access his or her group pages from this portlet.
- Group Leader Board Portlet: it shows the leader board of active groups based on the group goal achievement.
- Group Profile Portlet: It contains a short description about the group.
- Members Activity Timeline Portlet: It shows the list of group members' posts, such as their current physical activity level and their comments on the physical activity achievement of others.
- Blog Portlet: It is for discussion on the main part of the portal.
- Wiki Portlet: It is for posting information, article and news on the main part of the portal.
- Sensor Management Portlet: The user moderator can manage sensors (add, update or delete sensors) and manage associations between users and sensors (add, update or delete).
- Group Management Portlet: The moderator can manage groups (add, update or delete groups). Management of members and goals of the group is not done in this portlet.

- User Management Portlet: The moderator can manage users (add, update or delete).
- Portal Settings Portlets: for all general settings.

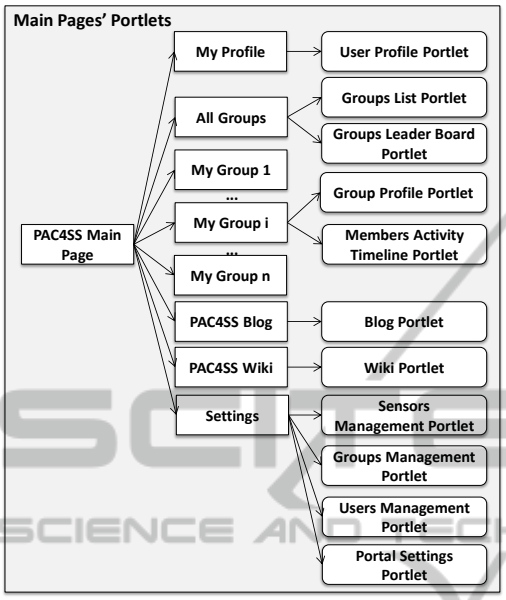


Figure 5: Main Pages' Portlets.

3.2.2 Personal Level Portlets

The personal level portlets are used to populate the set of personal pages. The organization of the portlets on the pages is shown in Figure 6. The following portlets have been designed:

- Daily Physical Activity (PA) Monitoring Portlet: It shows to the logged-in user his or her physical activity level as a graph. The graph shows the recommended level (goal of the day) and the achieved level. The physical activity data is assessed by the physical activity monitoring system. It shows also some system feedback about the achievement of the user. The content of the portlet can be seen by authorised peers such as peers belonging to the same group or the user moderator of the portal.
- Comments portlet: Authorised peers can comment and discuss about the current physical activity achievements of the concerned user.
- History Physical Activity (PA) Monitoring Portlet: It shows to the logged-in user his or her physical activity level history over time. Similar to the Daily Physical Activity (PA) Monitoring Portlet, the content of this portlet can be seen by authorised peers.
- Current Personal Goal Portlet: It shows details about the current personal goal of the logged-in user.
- Personal Goal Management Portlet: Using this portlet th, moderator (and potentially the logged-in user) can manage the goals of the user (create, update or delete).
- Personal Goal History Portlet: It shows the history of goals, both in term of goals set and achievement made.

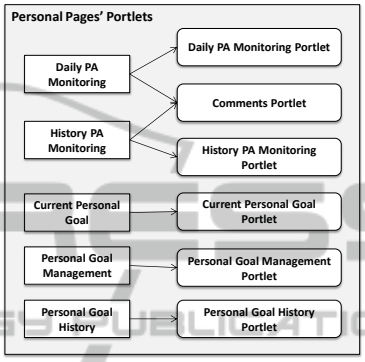


Figure 6: Personal Pages' Portlets.

3.2.3 Group Level Portlets

The group level portlets are used to design the set of the group pages. The organization of the portlets on the pages is shown in Figure 7. The following group level portlets have been designed:

- Group Details Portlet: It is a quick visual overview about the goal achievement. It shows if the member is compliant, over active, under active or if the sensor is not in use for the day.
- Group Snapshot Portlet: It gives an overview of the social activity of the members of the group. This overview is based on the number of messages exchanged such as posted/shared messages, messages replies (on own messages, or on messages from others) and the number of messages received. It measures the interaction between the members.
- Group Level Portlet: It shows the current level of the group. Every new group has a beginner level. Based on the daily group achievement, groups earn points allowing them to level-up (levels are expressed from beginner to expert).
- Group Level History Portlet: It shows the history of the levels earned by the group.
- Current Group Goal Portlet: It shows details about the current goal of the group.

- Group Goal History Portlet: It shows the history of group goals created and achieved (or potentially not achieved).
- Group Goal Management Portlet: The authorised user can create new goals and update existing ones.
- Group Members Portlet: It shows the list of current members of the group.
- Group Members History Portlet: It shows the list of users that were members of the groups over time (date when they joined and date when then left) and their contributions to the goals achieved in the group during that period.
- Group Members Management Portlet: The authorised user can add or remove members of the group.
- Blog Portlet: It is for discussions in the group.

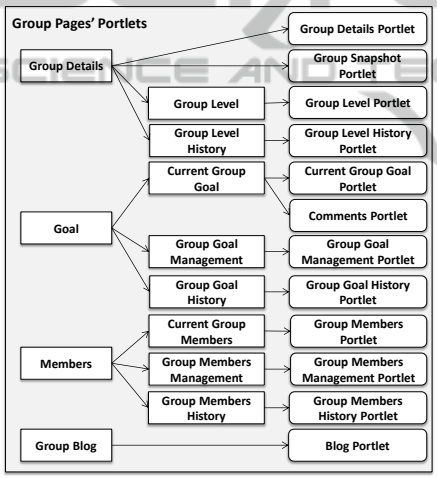


Figure 7: Group Pages' Portlets

3.3 Services

Services are responsible of storing and retrieving data. A portlet asks for data using service, and the service fetches it. The portal can then display this data to the user. The user can, depending on the portlet design, create, read, update or delete the data. If the user chooses to modify (create, update or delete) the data, the portlet passes it back to the service and the service manage and stores it in the database. The portlet doesn't need to know how the services do it. We divided the services into 3 categories depending on the portlets:

- Generic Services: includes the services responsible for fetching and modifying the data to the portal in general and generic portlets in particular.
- Personal Level Services: includes the services responsible for fetching and modifying the data to the Personal Pages' portlets.
- Group Level Services: includes the services responsible for fetching and modifying the data to the Group Pages' portlets.

The information model in Figure 8 represents the conceptual classes that are use to implement the services.

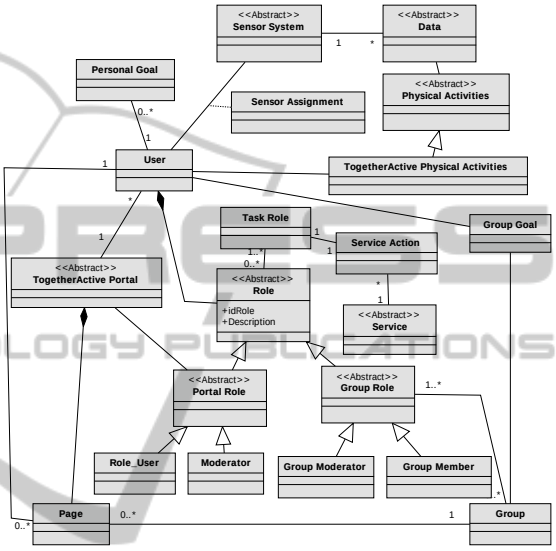


Figure 8: Informational Model.

4 TogetherActive IMPLEMENTATION

4.1 Portal and Portlets

The portal was implemented using Liferay (Liferay, 2000). Liferay is a web based platform supporting features commonly required for the development of websites and portals. It is an open architecture and open source system. Liferay offers you a full choice of application servers, databases, and operating systems to run on. Liferay provides also out of the box portlets such as Liferay CMS and Liferay Collaboration offering web publishing, content management, collaboration and social networking. It offers also a secure single sign on. Liferay users can be intuitively grouped into "user groups" and "roles" providing flexibility and ease of administration.

For implementation we used Liferay Portal 6.1 Community Edition Bundled with Tomcat. We used some of the platform built-in portlets and we implemented a subset of the portlets described in Chapter

3. Priorities were set for developing portlets which would be included in the evaluation (described in Chapter 5). The portlets that were implemented and included for the evaluation are:

- Personal Level Portlets: Daily Physical Activity (PA) Monitoring, History Physical Activity (PA) monitoring and Liferay Comments Portlets (known as Page Comment).
- Group Level Portlets: Group Details, Group Level, Group History, Current Group Goal, Group Goal History and Group Goal Management Portlets. The members' management portlet was replaced by the default administration possible with Liferay.
- Generic Portlets: Sensor Management, Group List and Group Leaderboard were implemented. The group and user management portlets were replaced by the default administration possible with Liferay.

As for the services, we used built-in services provides by Liferay and we built new services that are needed by the developed portlets using the service builder feature provided by the Liferay SDK.

4.2 Physical Activity Monitoring System

The current choice for a physical activity monitoring system is ProMove sensor (ProMove, 2011) coupled with a smartphone. The 3D-accelerometer of the sensor assesses the energy expenditure. The resulting acceleration is integrated over time, which is referred by IMA value (Bouten, 1995):

$$IMA = \int_{t=t_0}^{t_0+T} |a_x(t)|dt + \int_{t=t_0}^{t_0+T} |a_y(t)|dt + \int_{t=t_0}^{t_0+T} |a_z(t)|dt \quad (1)$$

Where x, y and z are the axes of the accelerometer and a_x, a_y and a_z the associated accelerations.

More details about the sensor and the IMA value in (Bosch et al., 2009).IMA values allow to capture the physical activity level. Figure 9 presents an example of IMA values recorded and IMA values recommended over a day. The recommended level is the level that a person is supposed to follow.

In order to assess the physical activity achievements, we developed some metrics in (Elloumi et al., 2012) based on IMA values.

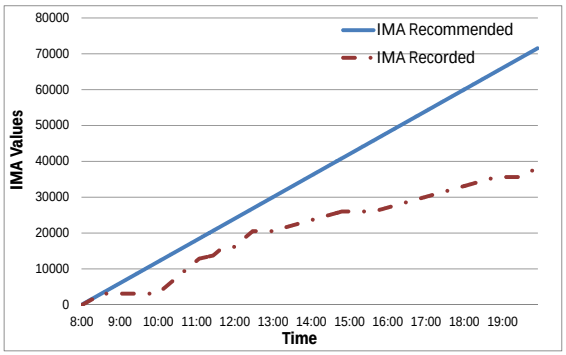


Figure 9: IMA Values - Recommended versus Recorded.

4.3 Personal and Group Goals

4.3.1 Personal Goals

The personal goal is a physical activity level that a user plans or needs to achieve during a period of time. This goal is either set by the user him/her-self, or by the moderator. The period of the goal can vary from one day to multiple days depending on the preferences. When a goal is set, the user needs to be compliant to this goal within allowed low and high thresholds. The Figure 10 shows examples of goals with low and high thresholds. Whenever the physical activity level of the concerned user is in between the low and high thresholds then he/she is considered as compliant to the goal. If the physical activity level is higher than the high threshold then the user is considered as over active, and if it is under the low threshold then he/she is considered as under active. In the current implementation only Figure 10(a) setup is considered.

4.3.2 Group Goals

The goal of a group is expressed as a physical activity level plan that the members intend to achieve together. The period of the goal can vary from one day to multiple days depending on the settings.

To be able to compute each member's participation to the plan, we take into account the personal achievement regarding a personal goal of each member of the group. We set a rewarding system with points. Points are given every episode of time (example one hour). Table 1 shows how the points are attributed.

To compute the points earned by a group during the period of the group goal, we use the following formula:

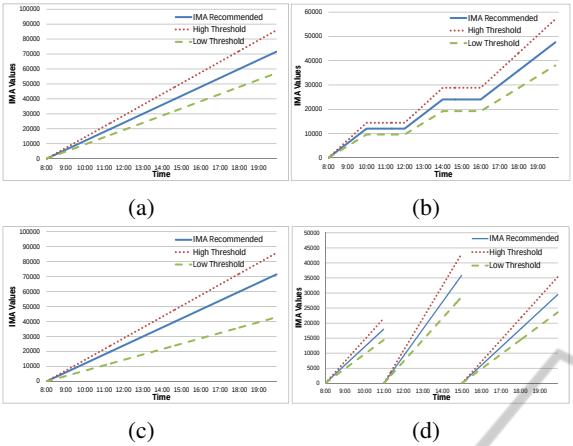


Figure 10: Physical Activity Level over time Recommended level, High Threshold and Low Threshold.
(a) Same percentage of high and low thresholds compared to the goal.
(b) No goal for periods of the day (for example in case of office-worker user).
(c) Different percentages of high and low thresholds compared to the goal.
(d) Different goals for different parts of the day (resetting to 0 for each new goal).

Table 1: Points attributing system. The value of the points varies from group to group but also from a goal to goal.

Member Physical Activity Level (Over a period of time / time episode)	Points to earn ($Points_{member}$)
Sensor off	$Points_{sensorOff}$
Sensor on	$Points_{sensorOn}$
Under Active	$Points_{underActivity}$
Over Active	$Points_{overActivity}$
Compliant	$Points_{compliance}$

$$Points_{group} = \sum_{i=1}^{N}(\sum_{t=1}^{T} Points_{members}(i,t)) \quad (2)$$

With T the total number of the time episode, for example the number of hours for which the goal lasts and N the total number of members in the group.

Then we define the goal ($Goal_{group}$) as percentage of the maximum points that a group can reach:

$$Goal_{group} = Percentage * MaxPoints_{group} \quad (3)$$

With:

$$MaxPoints_{group} = \sum_{i=1}^{N}(Points_{compliance} * T) \quad (4)$$

According to the setting of the goal, a bonus can be attributed. If a member is compliant for the full duration of a goal, $Bonus_{member}$ is attributed.

Then:

$$MaxPoints_{group} = \sum_{i=1}^{N}(Points_{compliance} * T) + \sum_{i=1}^{N}(Bonus_{member}) \quad (5)$$

5 TogetherActive EVALUATION

The implemented system has been tested and evaluated so as it determine the operational correctness and robustness of the system and its usability, these are considered in the following technical evaluation and usability evaluation.

5.1 Technical Evaluation

The purpose of the technical evaluation was to test the sensor systems and the functional correctness of the portal. During the implementation phase, individual portlets were tested using a single sensor. After completion of the implementation and initial functional tests, a more elaborated test was done. In this test ten sensors were used with imaginary users. The test was carried out continuously for two days.

This way of capturing physical activity data was tested and the processing and presentation of the data on the portal was verified.

This technical evaluation identified a number of minor implementation problems that were fixed.

5.2 Usability Evaluation

5.2.1 Protocol

The goal was to evaluate the usability of the portal in order to acquire feedback from users and improve the portal in the next design cycle.

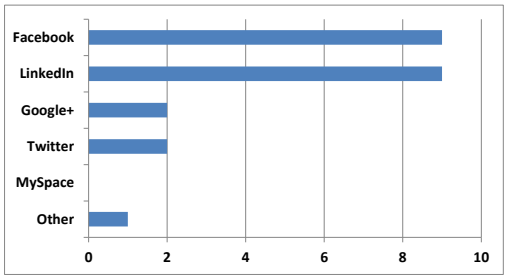
The evaluation was planned for the duration of 1 week and with 10 participants. A first meeting was planned with the participants. The aim of the meeting was to get an explanation and practice about the physical activity monitoring system ProMove, and to learn how to use and navigate through the TogetherActive Portal. Participants received their credentials to connect the monitoring system and use the community. They were taught how to use the sensor and the TogetherActive Portal. They were asked to sign an informed consent form and a borrowing form of the physical activity monitoring system.

Then, participants were divided into groups so as to test the group-based functionalities. During

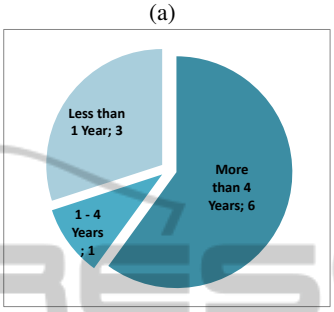
this week of evaluation, participants were asked to wear the physical activity sensor system from 8:00 to 22:00, and to use the portal.

By the end of the week, a second meeting was organised. The participants returned the physical activity monitoring systems and got a discharge document for borrowing the monitoring system. They received a link for an online questionnaire. The questionnaire was composed by 3 parts:

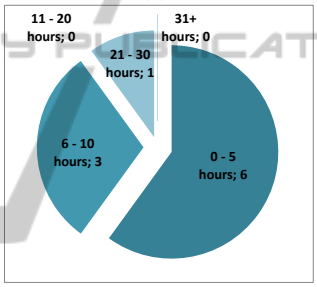
- General information:
  This part of the questionnaire is to get background information about the participants and their use of social networks and/or apps in general, and for health and well-being purposes.
- Portal usability (based on the Computer System Usability Questionnaire (Lewis, 1995)):
  In this part the usability of the portal (computer system in general) was investigated using this standardized questionnaire. This part of the questionnaire has 19 items. The responses to those items would help us understand what aspects of the portal participants are particularly concerned about and the aspects that satisfy them. Items are based on a 7-point scale, where participants can express their opinion from strongly agree to strongly disagree.
- Sensor System:
  It is for measuring the satisfaction with the use of the sensor system and see if there were troubles in its use. This part of the questionnaire is composed by 4 items (with 3 mandatory items with yes or no questions, and one optional item to express extra remarks)



(a)



(b)



(c)

Figure 11: Use of Social Networks
(a) Social networking sites.
(b) Subscription to the social networking sites.
(c) Time spent per week on social networking sites.

5.2.2 Participants

We recruited 10 participants who had to use the portal and sensor system for a week (5 working day and weekend). Participants were recruited from the University of Twente. Inclusion criterion to participate in the experiment was that participants should have some time for using the physical activity monitoring system and using the portal.

Participants were 9 PhD students and 1 Post-Doc, 2 of them were female participants. The age of participants was between 25 and 35 years old. All participants had an educational background in either technical sciences or social sciences.

5.2.3 Results

After getting all the replies to the questionnaire, we analysed the results. Figures 11(a), 11(b) and 11(c) give an overview about the familiarity of the participants in using social networking sites. We can conclude that participants are familiar with social networks (especially the popular ones nowadays), and using them for 0 to 10 hours a week. So we can assume that using our portal/social network will not be difficult for them.

Participants are not or did not use social networking site for health or well-being purposes. But 50% of the participants used apps (on android, iPhone or other phone operating systems) for health or well-being purposes. All those 5 participants used those apps for exercise/training recording, one of them for exercise/training schedule compliance and 2 of them for informational purposes. So although participants are using social networks in their daily life, adopting these social networks to health or well-being purposes is not yet fully included in their habits, the same holds for the apps.

After getting the replies from all participants we decided to exclude from the analysis the replies of 2 participants (one replied to all questions with 1 (strongly agree) and one replied to all questions with 7 (strongly disagree)).

Following the guidelines from Lewis (Lewis, 1995), the results from user satisfaction (Table 2) are summarized into 4 factors reported as mean values: overall system usability (OVERALL), system usefulness (SYSUSE), information quality (INFOQUAL) and interface quality (INTERQUAL). Based on the result we can say that the interface quality (INTERQUAL) was better judged comparing to the rest. We compared those 4 factors' results (Table 3) with usability studies done in ICT-based systems in healthcare (van 't Klooster, 2013; Zarifi Eslami, 2013). We can conclude that for this first version of our system the usability is similar to these other two systems.

Table 2: Satisfaction Results.

Score	Question Items	Average (8 participants)	Standard Deviation
OVERALL	1 to 19	3.81	1.09
SYSUSE	1 to 8	3.89	1.03
INFOQUAL	9 to 15	3.83	1.06
INTERQUAL	16 to 18	3.5	1.29

Table 3: Results from other usability studies (van 't Klooster, 2013; Zarifi Eslami, 2013).

Score	Study done in (van 't Klooster, 2013)	Study done in (Zarifi Eslami, 2013)
OVERALL	3.7	4.75
SYSUSE	3.2	4.37
INFOQUAL	3.5	4.93
INTERQUAL	4.7	5.32

Regarding the satisfaction with the use of the system sensor, 40% of the participants were not satisfied and 30% declared having problems with it. This dissatisfaction is mainly due to (based on their added remarks) large size of the sensor, uncomfortable to wear, sometimes loss of connection to the smartphone and battery charging (battery has to be charged every day). But as shown with the percentages, some participant didn't have concerns with previous list and 30% of them declared that if the sensor is aimed for real use, they would use it.

6 DISCUSSION AND CONCLUSION

The results of the scores from the Usability Questionnaire were similar to the results of the other studies. In order to get more insights in the usability, we looked at the background of participants and in particular to their use of social networks. We found no correlation between the use of other social networks and the usability scores of the TogetherActive portal.

he aim of this usability evaluation is to get feedback from users and improve the TogetherActive system in the next design cycle. From the results of the questionnaires we induced two major categories of improvements, these are:

- Suggestions on the improvement on the user interface:
  - Critical remarks were received on the used colour scheme of the portal. So, this is a point of concern in the redesign.
  - Participants expected that the graphs that display daily and history physical activity levels are more interactive and has better quality and more details. So based on this remark, quality and display of the graphs should be improved
  - Some participants experienced difficulties with navigation, for them it was not clear. Based on this remark, navigation should be more intuitive.
  - Some participants were looking for help on the portal to understand more some of the functionalities and options of the portal but they could not find it. Basically, the help function was not planned or implemented in this version. So based on this remark help function should be provided in the portal.
- Suggestions on the sensor:
  Many participants complained about the size of the sensor and for some of them they had to change their habitual way of dressing to be able to use the sensor. They also complained about the fact of having to charge the sensor every day. So based on these remarks, we should look for another option for the sensor, satisfying the constraints size, wearability and battery life.

Based on these suggestions we will improve the TogetherActive system. A second design cycle will be done along with improvement and extension of the implementation (including the portlets that were designed in this version and not implemented) and an evaluation.

To conclude, in this paper we presented the TogetherActive community system and its design. The

community uses physical activity monitoring sensors and aims to provide a full spectrum of social support. We included the concepts of personal goals and group goals. Self-monitoring, competition, cooperation and comparison are included in the system in order to increase the self-awareness and group-awareness, and motivation in order to improve or maintain the physical activity level. We presented the first implementation along with the technical evaluation. Improvements of the current implemented version of the system are planned taking the results of the evaluation into account.

The current design does not yet include physical activity activation concepts, hence feedback and feedback modalities designed to initiate physical activity. Such approaches have already been investigated in for instance (op den Akker et al., 2012). A future development we would like to explore is such an activation with involvement of peers. Future evaluations will include healthy subjects and we will be investigation the added value of virtual community in improving the physical activity level. However, the concepts presented in this paper can well be transferred to other application domains including lifestyle change support as needed in many chronic patients and also in the domain of prevention, especially in identified increased risk groups.

REFERENCES

Ayubi, S. U. and Parmanto, B. (2012). PersonA: Persuasive social network for physical Activity. *IEEE Engineering in Medicine and Biology Society.*

Bosch, S., Marin-Perianu, M., Marin-Perianu, R., Havinga, P., and Hermens, H. (2009). Keep on moving! activity monitoring and stimulation using wireless sensor networks. In *Smart Sensing and Context*.

Bouten, C. (1995). Assessment of daily physical activity by registration of body movement. In *Eindhoven Univ. Technol.*

Chen, C., Anton, S., and Helal, A. (2008). A Brief Survey of Physical Activity Monitoring Devices.

Consolvo, S., Mcdonald, D. W., Toscos, T., Chen, M. Y., Froehlich, J., Harrison, B., Klasnja, P., Lamarca, A., Legrand, L., Libby, R., Smith, I., and Landay, J. A. (2008). Activity Sensing in the Wild : A Field Trial of UbiFit Garden. In *CHI'08*.

Cotter, A. P., Durant, N., Agne, A. A., and Cherrington, A. L. (2013). Internet interventions to support lifestyle modification for diabetes management: A systematic review of the evidence. *Journal of diabetes and its complications*.

Elloumi, L., van Beijnum, B., and Hermens, H. (2012). Towards physical activity support community. In *6th International Symposium on Medical Information and Communication Technology, ISMICT 2012*.

HHS (1995). *Theory at-a-glance: a guide for health promotion practice*, chapter Theories and Applications.

HHS (1996). *Physical Activity and Health: A Report of the Surgeon General*, chapter Understanding and promoting physical activity.

House, J. S. (1981). Social support, and the quality and quantity of life. In *Research on the Quality of Life*.

Kamphorst, B. A., Klein, M. C. A., and Wissen, A. V. (2014). Autonomous E-Coaching in the Wild : Empirical Validation of a Model-Based Reasoning System. In *AAMAS 2014*.

Lewis, J. R. (1995). Ibm computer usability satisfaction questionnaires: Psychometric evaluation and instructions for use. In *International Journal of Human-Computer Interaction*.

Liferay (2000). https://www.liferay.com/. [Online; accessed September-2014].

MedHelp (1994). http://www.medhelp.org/. [Online; accessed September-2014].

op den Akker, H., Hermens, H., and Jones, V. (2012). A context-aware adaptive feedback system for activity monitoring. In *ICAMPAM 2011*.

PatientsLikeMe (2004). http://www.patientslikeme.com/. [Online; accessed September-2014].

ProMove (2011). http://inertia-technology.com/promove-3d. [Online; accessed September-2014].

Silveira, P., Daniel, F., Casati, F., van het Reve, E., and de Bruin, E. D. (2012). ActiveLifestyle : an application to help elders stay physically and socially active. In *FoSIBLE Workshop at COOP2012*.

Tabak, M. (2014). *New treatment approaches to improve daily activity behaviour*. PhD thesis, University of Twente.

van den Berg, M. H., Schoones, J. W., and Vliet Vlieland, T. P. M. (2007). Internet-based physical activity interventions: a systematic review of the literature. *Journal of medical Internet research*, 9.

van 't Klooster, J. (2013). *User-tailored E-health services.* PhD thesis, University of Twente.

van Weering, M. (2011). *Towards a new treatment for chronic low back pain patients.* PhD thesis, University of Twente.

WebMD (2005). http://www.webmd.com/. [Online; accessed September-2014].

WHO (2014). Physical activity. http://www.who.int/topics/physical_activity/en/. [Online; accessed September-2014].

Zarifi Eslami, M. (2013). *Service tailoring: a method and tool for user-centric creation of integrated IT-based homecare services to support independent living of elderly.* PhD thesis, University of Twente.