Move2Play: An Innovative Approach to Encouraging People to Be More Physically Active

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ABSTRACT

Throughout the last decade, there has been an alarming decrease in daily physical activity among both children and adults. Medical experts agree that physical activity is critical to maintaining fitness, reducing weight and improving health. Yet so many people have difficulty increasing and maintaining physical activity in everyday life.

We propose a solution called Move2Play, which encourages a healthier lifestyle and motivates to participate in regular physical activity. We have integrated four essential parts that form the basis for long-term progress and sustainability — Activity Recommendation, Tracking, Evaluation and Motivation. In order to recognize and assess physical activity, we created an application for mobile phones that collects data from various sensors, such as accelerometer, GPS and GSM. We provide personalized mechanisms of activity recommendation to ensure that users engage in regular exercise, as opposed to occasional outbursts of activity which are unhealthy and even harmful. We discuss mechanisms of activity recommendation and the concept of motivation, which is key for any system that fights the sedentary lifestyle of the modern generation.

Categories and Subject Descriptors

H.1.m [**Information Systems**]: MODELS AND PRINCIPLES—*Miscellaneous*; I.2.1 [**Artificial Intelligence**]: Applications and Expert Systems—*Medicine and science*; J.3 [**Computer Applications**]: LIFE AND MEDICAL SCIENCES—*Health*

General Terms

Design

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Keywords

Physical Activity, Personalized Activity Recommendation, Activity Tracking, Activity Evaluation, User Model, Health Awareness, Ubiquitous Computing, Pervasive Technology

1. INTRODUCTION

Information technology continues its rapid development and brings us new opportunities for solving problems of our society. One of the biggest problems nowadays is the lack of physical activity and the so-called sedentary lifestyle. Millions of people all over the world suffer from illnesses such as cardiovascular disease, high blood pressure or diabetes, where the lack of physical activity is one of the risk factors. According to the World Health Organization, the main cause of obesity and overweight is an energy imbalance between consumed and expended calories, which is also caused by the lack of physical activity and an improper diet. Furthermore, regular physical activity affects our mental health, reduces feelings of anxiety, depression and promotes a sense of well-being.

From another point of view, physical inactivity and obesity not only lower the quality of life of individuals but also bring a financial burden on public health systems and national governments. Their estimated cost grew from 507 billion in 2006 to more than 708 billion in 2008 in the USA alone.

We know that people should be more active, we know that people need more physical exercise, and obviously that is not enough. We took information technology and used it to actively promote a healthier lifestyle. We propose a comprehensive process of physical activity management, driven by various kinds of motivational factors supporting its users in achieving the required amount of physical activity per day. The process consists of recommendation of the appropriate amount of physical activity in the form of a personalized daily plan and automatic tracking and evaluation of performed physical activity.

An important part of the process is the integration of different motivational factors, both intrinsic and extrinsic, which ensure the long-term sustainability of the whole process. The motivation comes in hand with education, which can

be delivered in a non-intrusive manner, taking into account the current context of the user.

We implemented this process in a solution called *Move2Play*, taking advantage of the capabilities of widely available smartphones to measure, assess and recommend physical activity. Albeit the solution is generic enough and suitable for any age group, we focused more closely on children and realized a children-specific implementation of the system called *Move2PlayKids*, putting even more stress on motivation suitable for children and involving parents in the process. We conducted experiments evaluating the individual parts of the system as well as the whole concept in cooperation with doctors and real users, which yielded encouraging results.

The paper is structured as follows: In section 2, we summarize design requirements and propose the essential parts of a system that encourages physical activity. In section 3, we provide an overview of existing solutions. In section 4, we present an overview of Move2Play. In section 5, we give a detailed description of personalized recommendation for a healthier lifestyle. In section 6, we present the realization and evaluation of the Move2PlayKids system. Finally, in section 7, we conclude the paper and discuss future work.

2. DESIGN REQUIREMENTS TO ENCOURAGE PHYSICAL ACTIVITY

There have been many solutions encouraging physical activity in recent years. Unfortunately, most of them have been unsuccessful. To find out why, we analyzed the existing solutions to identify design flaws that greatly hindered the adoption of these solutions in practice. The design requirements in this section are also based upon literature review [1, 5, 19].

1. *Give the user proper credit for activity.* Physical activity measurements should be made with sufficient accuracy as measuring less activity is demotivating. It is preferable to calibrate the measurement device so that more activity is measured rather than less.

2. *Provide personal awareness of activity level.* Self-assessment and monitoring are very effective and one of the most widely used motivation techniques. A system which tracks user physical activity should provide this kind of information in a clear and easily accessible way.

3. *Ensure fair play.* When users compete, it is important that the competition is fair and that every user has an equal opportunity to win. In case the users feel they have a certain kind of disadvantage, they become frustrated and demotivated.

4. *Provide a variety of motivational tools.* It is recommended to provide different types and methods of motivation to target a wider spectrum of population. Also, for a single user it is more engaging when there are multiple types of motivation throughout the day.

5. *Provide feedback on activity done,* as users generally don't know whether the performed physical exercise is sufficient and appropriate.

6. *Consider the practical constraints of users' lifestyles.* Activity measurement devices should be practical for everyday use and not intrusive. With an external measurement device, users often forget to take the device with them or forget to charge the batteries. Also, manual input of data into the system is often required.

7. *Provide both short-term and long-term motivation.* One of the issues that current solutions experience is that after a few weeks, users continually drop out and stop using the system [10]. It is therefore important to provide both short-term and long-term motivation to combat this issue.

8. *Support social influence.* Social relations are an important part of everyone's life. People are interconnected, and so their health is interconnected as well. If a friend starts exercising or eating healthier, it directly increases the probability that we'll do the same in the future. A recent study [6] shows that this influence is very significant and reaches as far as to social distance[1] of 4.

9. *Provide possibility of integration with existing solutions.* There already are many great projects, especially games, that we can take advantage of instead of developing new ones from scratch. The system needs a design that is open to third-party games, tools or research projects which seek to add value to the overall solution.

10. *Protect users' privacy.* It is important to protect user data concerning their physical activity. Developers need to consider both implementation and functional requirements. In implementation, they should, among other issues, address communication and database security. Functional requirements include the ability for users to determine which data are visible to their friends.

Although some of the requirements may seem obvious, they are often forgotten or not paid adequate attention to. We believe that these 10 design requirements need to be thoroughly considered in any system that encourages physical activity, as they summarize the most important user needs and expectations.

We propose to divide the aforementioned requirements into four essential parts, which we believe form the basis for long-term progress and sustainability, as shown in fig. 1.

- **Activity Recomendation.** Firstly, we need to provide personalized activity recommendation, so the user knows how much and what type of activity is appropriate. As many users are discouraged even before beginning activity, believing that they can never exercise enough to actually change anything, the purpose is to show the user that her goal is achievable and she does not need to completely and radically change her lifestyle to reach it.

- **Activity Tracking.** In the next step, we need to measure activity automatically as accurately as possible

[1]Social distance of 1 refers to a friend, a distance of 2 to a friend of a friend, etc.

Figure 1: Cycle of physical exercise.

and with the least possible extra burden on the user. A requirement to manually fill complicated charts describing the performed physical activity or to wear an additional bulky device with a large power consumption to track it automatically are key barriers to achieve long-term sustainability of the approach.

- **Evaluation.** In the next step, we need to provide feedback and statistics on activity done, which show the user her progress and above all, allow her to understand and interpret correctly recommendations from the first step.

- **Motivation.** The most important part is motivation, i.e., the reason people start exercise in the first place and persist in their activity for long periods of time. Motivation lies at the centre of the cycle to emphasize both its pervasiveness and its criticality. It is crucial to provide a variety of motivation tools, as the drop out rate, often caused by a lack of motivation, is a serious problem even in professional training programmes and can be as high as 89 % [10].

These parts have already been used separately in various research and commercial projects. However, none of them has achieved significant success, which we also discuss in the next section. We believe one of the reasons is that in order to build a working solution, all of the aforementioned parts have to be present. No system can be effective without the knowledge of the appropriate amount of activity, or without the actual measurement of activity, or with no feedback. Therefore, we need to integrate all these parts to form a solid foundation for a system that helps people be more physically active.

3. RELATED WORK

In recent years, a number of innovative solutions have been developed aiming to tackle the problem of sedentary lifestyle of the modern generation. There are a variety of applications, commercial or research projects, which study the individual aspects of combating sedentary lifestyle and encouraging people to be more physically active.

Most research projects study the means of motivating people to be more physically active as summarized in tab. 1. Chick Clique [18] is mobile application targeting teenage girls which motivates through competition and cooperation. Another motivational tool, used in Fish'n'Steps [12] and UbiFit Garden [8], is the care of pets or plants. In Fish'n'Steps, users take care of a fish in a fish tank, which has several emotional and growth levels, whereas in UbiFit Garden user physical activity is mapped to the growth of a virtual plant. Another method suitable especially for children are motivational agents like MOPET [4]. Very strong motivation can be achieved through the incorporation of rewards and games as shown in NEAT'O'Games [9], where users are rewarded for their physical activity with points. Rewards are also present in PLAYMATE! [3], where users unlock certain features of the game and get bonus points for being more physically active. ExerGames such as Feeding Yoshi [2] and RTChess [17] present another approach, where physical exercise is a part of gameplay. Although these solutions provide powerful means of motivation, they generally fail to provide activity recommendation, evaluation and in many cases even a suitable activity tracking mechanism.

On the other hand, commercial systems such as RunKeeper and Endomondo often provide activity evaluation and activity tracking. They provide various data visualizations and comparisons that are very popular among their users. Some of these solutions even feature basic activity recommendation in the form of training plans as found in Nike+. Moreover, since most popular solutions have thousands of users, they apparently provide enough motivation as well. The problem is that they target *already physically active* people, who do not require recommendation or evaluation of their activity, nor any special motivation, as they can handle all these factors on their own.

Many of the studies and existing solutions have effectively incorporated various parts of the cycle of physical exercise for different target groups. It is essential for our solution to recognize parts already proven to be effective, and consequently build on them and further improve them.

4. MOVE2PLAY OVERVIEW

Having identified the key factors influencing the process of dealing with sedentary lifestyle, we propose a solution combining all of them in a system called Move2Play, whose name represents the idea that *exercise is essential and is the foundation for us to stay in the game of life.* The goals of Move2Play are to: (*i*) encourage appropriate and sufficient physical exercise, (*ii*) promote a healthier lifestyle, and thus (*iii*) increase the quality of life. Here we discuss in short how we deal with the main steps of the overall process and how we integrated the main design requirements listed in Section 2.

4.1 Activity Tracking

Tracked activity is one of the main inputs which make the solution work as a whole. As we aim at an achievable and sustainable solution, we decided to focus on walking, which is the basic activity everybody can and should participate in and is the activity we perform naturally throughout the day (even if not in a sufficient manner, which is the core reason of all subsequent problems). Furthermore, walking is

Table 1: Overview of motivation in related projects

Project	Motivation methods	Target population
Fish'n'Steps [12]	comparison, competition, care of pets, social encouragement/pressure/support, self-assessment/monitoring, gamification	Adults
Chick Clique [18]	social encouragement/pressure/support, comparison, competition, gamification, self-assessment/monitoring	Girls (12-19)
Houston [7]	goal/target specified, social encouragement/pressure/support, recognition, self-assessment/monitoring	Adults
UbiFit Garden [8]	care of plants, goal/target specified, self-assessment/monitoring	Adults
Shakra [13]	comparison, motivation agent, self-assessment/monitoring	Adults
MOPET [4]	motivation agent, games, self-assessment/monitoring	Teenagers
NEAT'O'Games [9]	games, comparison, competition, self-assessment/monitoring, virtual rewards	Adults
Feeding Yoshi [2]	game, competition	Adults
PLAYMATE! [3]	virtual rewards, game	Children
RTSChess [17]	virtual rewards, game, competition, self-assessment	Adults

an activity that can be assessed automatically by leveraging sensors of smartphone devices, which means that building a reliable pedometer into a smartphone device would eliminate the annoying requirement to wear an additional device (in accordance to 6th design requirement).

Smartphone pedometers in general use either the accelerometer or GPS, or a combination thereof. To cover different usage scenarios and provide more accurate measurements, we decided to use both of the sensors (in accordance to 1st design requirement). However, since these sensors have a relatively high power consumption and current smartphones do not last a whole day on a single charge while the sensors are being used, we decided to employ information about available Wi-Fi access points and GSM signal strength fluctuation analysis to determine whether an activity is taking place and we should turn on the more energy consuming sensors.

Since the whole Move2Play approach incorporates different kinds of motivation to ensure long-term sustainability, we need to deal with malicious users trying to trick the system in order to get some kind of reward (such as the highest ranking among their friends) and make our pedometer immune to cheating, such as imitating steps by shaking the phone held in hand. The detection of cheating can be described as a problem of pattern recognition in accelerometer data. We successfully employ a feedforward artificial neural network to classify activity as correct or simulated with sufficient precision to discourage users from trying to trick the system.

Apart from automatic activity assessment via smartphone sensors, which cannot, by definition, recognize and assess any arbitrary activity, we provide means for entering some types of activity manually. Entered activity is assessed according to its type and duration.

4.2 Activity Evaluation

It is essential for the user to have detailed feedback on activity done and the overall performance. A monitor application within Move2Play provides users with not only different visualizations of the measured data (in accordance to 2nd design requirement), but also feedback on how much activity is appropriate (in accordance to 5th design requirement) and means to compare with friends or the general population.

We designed the monitor application specifically for parents to help them monitor their children's progress (see fig. 2). Parents exert a strong influence over their children and are key to motivating them to exercise and be more physically active [14].

4.3 Activity Recommendation

In order to become successful in encouraging appropriate and sufficient physical exercise, we need to provide recommendation personalized for individual users, accounting for different predispositions, abilities and characteristics (in accordance to 5th design requirement). We have created 3 different training plans users can choose from and 3 methods of personalized activity recommendation. We have created means of representing individual as well as general characteristics specific to this domain in form of user and domain models, respectively. Activity recommendation is further described in section 5.

4.4 Motivation

As we have already discussed, motivation is the driving force behind the whole process. However, as what keeps us motivated differs among people and changes with age, we integrated the full scale of motivational methods into Move2Play in order to cover the broad spectrum of user preferences (in accordance to 4th and 7th design requirement). We divided the system of motivation into 5 logical parts – Informative, Social, Gamified, Rewards and Avatar.

4.4.1 Informative

Self-assessment/Monitoring. One of the simplest approaches is tracking one's daily step count. Even this single piece of information can provide enough motivation to increase the daily step count for both adults and children [11].

Daily Target. Apart from providing information on activity done, we set a daily target in steps as a short-term motivation. Fulfilling a given target is far more enjoyable for users.

Figure 2: Monitor application for parents.

Goal-Setting. Goals can be both short-term and long-term. Users are free to set any goals they want, for example a goal of 30,000 steps in a week. If a social element is present, users can see the goals of their friends and join them. They can also create shared goals, where a group of people fulfils a given goal instead of a single person. When setting a shared goal, groups can compete against each other for example classes at school, departments at work, etc.

4.4.2 Social

Social influence and social networks are a great sources of motivation we can take advantage of (in accordance to 8th design requirement). We use two different kinds of social motivation.

Social Encouragement, Pressure and Support. People around us have a significant influence on our behaviour, and can change it for the better [6]. In Move2Play, users can connect with friends, see how they are doing, compare their results, and more. We also integrate with popular social networks to make this even easier.

Competition. People naturally strive to be better than others and that is why Move2Play provides means to take advantage of this fact. In our system, users compete between one another and can directly compare their progress and achieved results. Move2Play also provides various leader boards to enhance competition. To ensure fair play (in accordance to 3rd design requirement), players are rewarded based on their relative effort, instead if absolute. By relative we mean relative to their fitness and physical condition, which is represented using daily plan (see Section 5.1).

4.4.3 Gamified

Gamification is a technique which incorporates motivational methods found in computer games into everyday activities to make them more engaging, in our case physical exercise.

Achievements. Achievements present a long-term recognition of user efforts. Every achievement has three levels – bronze, silver and gold, which differ in difficulty. In order to unlock the gold achievement, the bronze and silver ones have to be unlocked first. This means that fewer achievements are used to convey the same information.

Badges. Badges are a short-term recognition of user efforts and are complementary to achievements. Badges can be obtained by doing an activity with a friend or for 20 minutes in a row, etc.

Unlockable Features. Throughout the application, there are unlockable features which the user can unlock with earned points, by avatar level and happiness (described in Section 4.4.5) or some combination thereof. For example, users can unlock achievements or special item sets for their avatar. This approach is helpful in two ways. Firstly, we do not overwhelm the user with all content at once. Secondly, we keep user engaged over longer period of time, as he seeks to explore all available possibilities.

4.4.4 Rewards

In Move2Play, points can be used to buy items in the virtual market or in external games. Being physically active is the primary means of collecting these points in Move2Play.

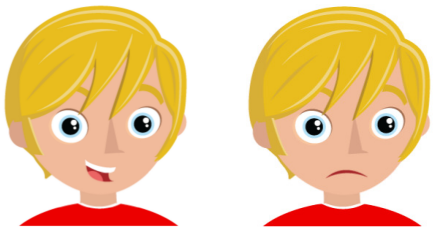

Figure 3: Different emotions of avatar.

Virtual Market. The virtual market is a place where points can be exchanged for virtual or even real items. Apart from rewards provided by Move2Play, they can be set by parents or friends to provide an additional source of motivation.

External Games. Many existing games already feature a virtual currency for the purpose of exchanging points for virtual items and are designed to integrate this kind of advantage for single users, rendering paying users stronger. With Move2Play, we can integrate our solution into these games as an additional payment provider, thus allowing our users to exchange earned points for paid items (in accordance to 9th design requirement).

4.4.5 Avatar

The avatar is an animated character which is a part of the mobile application. It integrates many motivational methods in a natural way and communicates them to the child. The avatar has a level and happiness which represent the absolute and relative value of the child's physical fitness, respectively. There are several emotional levels ranging from very sad to happy (fig. 3) which are mapped to physical activity of the child.

The avatar is also a motivational agent. It supports the child in being more physically active, tells him or her that after watching TV for one hour, it is good to stretch your body and make a few steps.

5. PERSONALIZED RECOMMENDATION FOR A HEALTHIER LIFESTYLE

To achieve a flexible recommendation solution, we represent knowledge using a set of facts and rules, which are used in inference and can easily be added or removed as necessary. For this purpose we have created a rule-based system, which works with if-then statements and implements the forward chaining method for the actual inference.

To create personalized recommendation, apart from general facts, we need to provide facts specific to a given user. For this purpose we have created two models:

- **User Model** is a user-specific model and contains attributes important in a given domain. For example, in the domain of recommending appropriate activity, the user model will contain user activity preferences. This model is built incrementally as users use the system. In order to prevent a new-user cold start problem, each user starts with a generic model, which is subsequently tailored to the user's specifics.
- **Domain Model** represents general knowledge about a given domain and the context of environment. The domain model, as opposed to the user model, holds stable facts and does not change very often.

Both models consist of multiple fact sets, which are independent of each other. It is also very helpful in improving performance, as in actual inference we try to decompose a problem into sub-problems. This way we can work with smaller sets of domain knowledge which speeds up inference.

5.1 Physical Activity Recommendation

Our goal is to provide personalized activity recommendation that will reflect the individual needs of its users. The base part of any activity recommendation is a training plan.

5.1.1 Training Plan

A training plan describes the appropriate amount of activity based on user physical fitness. In Move2Play, we support three different training plans users can choose from. In all programmes, we continually increase the difficulty, until we reach the recommended levels of activity.

- **Walking programme** is based on the well-known 10,000 steps walking programme, which sets a goal for the user to reach 10,000 steps per day.
- **Dr. Cooper programme** is based on a point system created by Dr. Kenneth Cooper. This plan is focused on performing aerobic activities, which are awarded with points. The goal is to reach a given amount of points within a week.
- **METs programme** is program similar to Dr. Cooper's. Activity is transformed into METs[2] hours with the help of The Compendium of Physical Activities. The goal of this programme is to reach 1,000 MET-minutes per week and it is capable of evaluating more activities than Dr. Cooper's plan.

5.1.2 Domain Model

The domain model represents knowledge on how we generally exercise and what factors affect the appropriate amount of exercise. While there are many such factors, we have tried to recognize the most important ones. We integrated the following factors:

- *Day of week.* Children exercise on average 20 % less during weekends and holidays than during school days [15].
- *Month.* We generally exercise less in winter than in summer [16].

[2]MET (Metabolic Equivalent): The ratio of the work metabolic rate to the resting metabolic rate. One MET is defined as 1 kcal/kg/hour and is roughly equivalent to the energy cost of sitting quietly. An MET is also defined as oxygen uptake in ml/kg/min with one MET equal to the oxygen cost of sitting quietly, equivalent to 3.5 ml/kg/min.

- *Gender.* On average, men are physically stronger than women.
- *Age.* There are different amounts of recommended physical activity for different age groups.
- *Weather.* We build on the assumption that people exercise less when the weather is unfavourable.

5.1.3 User Model

In the user model we track user behavioural patterns and characteristics. In addition to *day of week* and *weather*, which are based on knowledge from the domain model and become specialized for individual users, we track the user's:

- *Physical fitness.* As it is most important attribute when determining the appropriate amount of activity.
- *Time of day.* We track activity patterns to determine the time of day, when the user is usually inactive and when he or she is physically active enough.
- *Activity preferences.* Used when recommending the appropriate type of activity.

5.1.4 Methods of Activity Recommendation

For the purposes of actual recommendation we have created **3 methods of personalized activity recommendation**. The first is designed to recommend the appropriate amount of activity for individual users. This recommendation is presented to users in the form of a daily or weekly plan, which they try to fulfil. The second method is used when recommending the appropriate type of activity for the user which will lead to the fulfilment of the daily plan and which the user will enjoy. The purpose of third method is similar to the second one, except we recommend an activity for a group of users, using the method of spreading activation. We will further describe the first method for recommending the appropriate amount of activity.

Recommendation of Appropriate Amount of Activity

When recommending the appropriate amount of activity, we use the rule-based system as described earlier. Recommendation consists of three steps:

1. *Determining the base amount.* In this step we load facts describing the training plan and user fitness and determine the base amount of activity.
2. *Applying User and Domain models.* We modify the amount from step 1 based on factors from the domain and user models. These factors include the *day of week*, *month*, *gender*, *age* and *weather*. Modification can either be relative or absolute, which is represented with operators of multiplication or addition, respectively. Each new modification is represented as a new fact within our rule-based system.
3. *Calculating the final amount.* In the final step, we calculate the final amount by applying all modifications to the base amount of activity and we recommend it to the user.

5.2 Contextual Information Recommendation

One of the main goals of Move2Play is promoting the basics of a healthier lifestyle. The educational module has a key role in achieving this goal. Its purpose is to teach users the fundamentals of a healthy lifestyle through quizzes and advice – we assume that this part of the system will mainly be used by children, who are easily drawn to attractive packaging of less-than-healthy products. As personalized forms of education are more effective in comparison with common forms, the users are given context-sensitive information. So to select the most suitable quiz or advice, relevance within the current context is considered. The model of personalized selection compares the current context of the user and environment with quizzes and advice attributes. We use fuzzy sets to determine the suitability and also randomness to make the selection diverse.

5.2.1 User and Domain Model

The user and domain model of contextual information arises from the models described in the beginning of this section. *Fitness level* from the user model as well as the *level of the avatar* are added to it and used to determine if the user is more physically active and more advanced information is suitable. To make the learning process more effective, areas of questions in which the child falls behind are preferred. So another part of the user model is the *success rate* of the previously answered quizzes.

In the domain model, *weather* and the *time of day* are important factors. For example, different drinks are recommended in colder as opposed to warmer days or different meals at noon or in the evening. Moreover, the information is formulated differently according to the user's *age*.

5.2.2 Information Representation

We divided the set of quizzes and advice, which we created in cooperation with a doctor, into categories. We identified four important areas of healthy lifestyle, the fundamentals of which children should be taught – *physical activity, food, drinks and minerals.* Each quiz or advice is abstractly represented as a vector of intervals, which express values of those attributes of the context, for which the quiz is relevant. In the rule-based system, each of these vector elements is represented as a fact in working memory that includes the lower and upper bounds of the interval and the quiz or advice it belongs to.

5.2.3 Recommendation Mechanism

Selection of the appropriate quiz or advice is inspired by selection in genetic algorithms. Firstly, a set of the most matching quizzes or advice to the context is created. Then, one element of the set is chosen according to the success rate of answers to the previous quizzes and using randomness.

Unlike the activity recommender, in which the rule-based system is used to deduce the result matching the conditions, the information recommender uses it to assign a *relevance rate* to every quiz or advice. For assessment, we use a fuzzy set represented by a specific matching formula.

Then, each quiz or advice is assigned a value of *category selection probability* which comes from the success rate in the

corresponding category of answered quizzes. In combination with relevance rate it forms a *selection probability*.

Finally, selection of the result is performed by the recommender. It uses randomness to choose one quiz or advice from the set of the most suitable ones. The method used is the roulette method which takes into account the selection probability of each element.

The used method of assessment ensures that information which does not fit the current context is not thrown away immediately, as it can be relevant as well, and that the information the user fails to remember is preferred. The method of random selection makes the selection diverse as the context changes slightly over time.

6. MOVE2PLAYKIDS – REALIZATION AND EVALUATION

In realization we focused on children aged 10 to 18 as they are the most challenging to motivate. Move2PlayKids is built on a client-server architecture as shown in fig. 4. As the lack of physical activity concerns every age group, we designed our solution in such a way that it can effectively respond to the ever-changing needs and diversity of its users as well as the environment. We designed Move2Play to be **modular**, **service-oriented**, **multi-platform** and **open to third-party applications**.

6.1 Web Services

The architecture of Move2Play is service-oriented and the services are loosely coupled. To ensure interoperability between multiple systems, such as mobile platforms, we have implemented two types of communication interfaces: a Windows Communication Foundation interface and a RESTful interface. The web services are implemented using the .NET Framework 4.0.

6.2 Mobile Application

The mobile application provides motivation and means of monitoring user physical activity throughout the day. Prototype of application was implemented for Windows Phone 7 platform (fig. 5) featuring avatar, core motivational methods such as friends, comparison, leader boards, achievements and market.

The activity tracking module is implemented on the iOS, Android and Windows Phone 7 platforms and activity is measured using the accelerometer, GPS and GSM signal. Within the activity tracking module, each sensor is independent and described by a set of interfaces, which ensures loose coupling even within the module. This is especially important because some sensors may be not available on certain mobile phones or some mobile platforms may not provide APIs for accessing them.

6.3 Monitor Application

The monitor application provides rich data visualization with various types of statistics. It is a Silverlight 4 application and is used primarily by parents to see how their children are doing, compare their children with the general population or enter rewards into the system.

Figure 5: Main screen of Windows Phone 7 application.

6.4 Third-Party Applications

In Move2Play we have incorporated third-party applications in three different ways. Firstly, we use them as a source of motivation, as users can exchange points earned by being physically active for bonuses in online games. This principle of exchanging points is not tied to online games and is up to developers to choose what users can get in exchange for their points. Secondly, we provide the activity tracking module for external applications. We also provide means of importing physical activity data from external activity tracking solutions. Lastly, we provide statistics and measured data to authorized medical systems in order to help doctors.

6.5 Activity Tracking

As our primary goal in tracking activity was obtaining the number of steps taken and the walking distance for each day, we built a pedometer as part of our smartphone applications. Creating an accurate, multi-platform, multi-device pedometer requires extensive testing and calibration.

We conducted regular testing internally as part of the development process, using several different types of hardware. Specifically, we had smartphones from HTC, LG, Samsung and an Apple iPhone at our disposal. Using a variety of different kinds of smartphones soon proved crucial as we discovered that the values from their accelerometers differ significantly.

This extensive testing resulted in a well calibrated pedometer across different devices with a sufficient precision, compa-

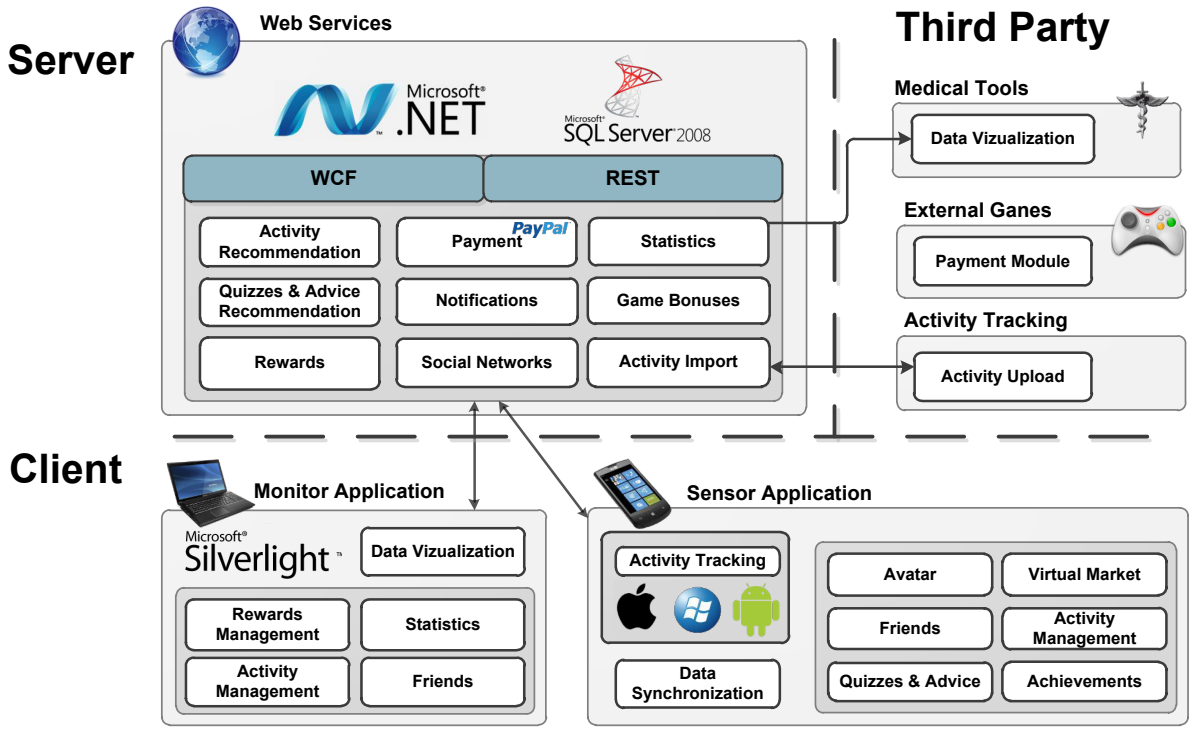

Figure 4: Architecture of Move2PlayKids

rable to or exceeding that of existing smartphone pedometer applications.

6.6 User Testing

We conducted user testing with a group of 12 children aged 12 to 13 at a primary school in Bratislava. This was done at a stage of development when all parts of Move2Play as described in fig. 1 were in a usable state. The children were given mobile phones with Move2Play preinstalled.

Their first task was to log in to Move2Play by choosing a nickname and to connect with their friends using the built-in social capabilities of Move2Play. The children had no problem understanding the concept of a social network and searching for friends using their nicknames as search keywords, having been exposed to these concepts before.

Afterwards, the children took their time to customize avatars, each choosing a different look for the animated character. The overall impression from this part of testing was that children enjoyed customizing and comparing their avatars.

We then drew their attention to rewards that we set up for them in Move2Play. We explained that they would need to collect enough points to get these rewards and instructed the children to take a walk with the smartphones in their pockets. After a few minutes, they had collected enough points and exchanged them for rewards in the application. We then handed out the rewards.

In this session with children, we were able to test most of the key functionality in Move2Play. No significant issues were found. The children were able to understand the overall concept and their reactions ranged from mild interest to more pronounced interest, such as when a few of the children, who owned smartphones themselves, asked when they would be able to download Move2Play.

For further testing and evaluation in the future, we have established cooperation with one of the largest paediatric clinics in Slovakia, the Paediatric Clinic of the Children's University Hospital in Bratislava. We have taken advantage of this partnership to leverage their experience in healthcare and to consult the entire solution to make sure it translates well into practice. We have received a positive reaction and are planning the deployment of Move2Play to children with the help of the clinic towards the end of this year.

7. CONCLUSIONS AND FUTURE WORK

In this paper we describe a novel approach to help people increase their physical activity levels and teach them a healthier lifestyle. We have identified and incorporated four essential parts that form the basis for long-term progress and sustainability: personalized activity recommendation, activity tracking, evaluation of activity done and motivation. We recognized the importance of motivation and have created various forms, both short-term and long-term. In order to put our solution into practice we created Move2PlayKids.

In this first stage, we focused on verifying the design of the system, especially the activity tracking module and recommendation. It is important to make sure that measurements are sufficiently precise and that we recommend the appropriate amount of activity.

We are open to third-party applications and we would like to

continue to be so in future. We have already incorporated an online multiplayer game called Niborea within our solution, but it is obvious that one game is not enough and we will try to include many more in future. Also, the cooperation we have established with the largest paediatric clinic in Slovakia presents an ideal opportunity to work on medical tools for doctors that will access and visualize the measured activity data.

We would also like to create a version of Move2Play for adults and older people, as the problem of insufficient activity concerns everyone.

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