Remote Accessibility to Diabetes Management and Therapy in Operational Healthcare Networks

REACTION (FP7 248590)

D11 -1 Feedback from Demonstration Activities

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Table of Content

Figures

Document control page

DOC	D11.1 Feedback from Demonstration Activities
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1 Executive summary

The deliverable summarises the work in workpackage 11 Demonstration. The validation activities of the project have been broadened out to include limited demonstration activities to external users. This ensures that the Consortium takes a broader view of the potential user community and provides valuable input and experiences to consider when planning future exploitation and use of the Reaction results.

The activities carried out have covered many different aspects of Reaction in different countries. Demonstration activities have tested the platform in several different diabetes management scenarios, but also tested individual components in different type of monitoring applications. Furthermore feedback has been collected from meetings with potential customers, workshops with individual patients as well as developers, presentations to internal sales organisations.

The feedback from demonstration activities has given us great confidence in the exploitation potential of the Reaction platform and tools. Furthermore it has also stimulated partners to collaborate in approaching different markets in different European countries.

2 Introduction

This work has been carried out as part of WP11 Demonstration. The validation activities have been broadened out to include limited demonstration activities to external users. This is necessary to ensure that the Consortium takes a broader view of the potential user community. These limited activities have been treated as demonstration as they are part of the process of taking the project message to a wider community. It further paves the way for subsequent exploitation of project results by the partners.

The demonstration activities have been designed to prove the viability of the REACTION platform before it can be commercialised, e.g. testing of product-like prototypes. This type of activity goes beyond the validation activities internal to the project, which will be based on prototypes with limited functionality.

The target groups for the demonstrations are healthcare providers, public and private healthcare organisations, equipment and device manufacturers. The demonstration platform will be available for individual exploitation one year after the project ends.

The main objectives of workpackage 11 are:

- perform demonstration activities designed to prove the viability of the REACTION platform before it can be commercialised directly
- arrange hands-on workshops and prepare site-surveys and application analysis for potential uses and customers
- collect feedback from external users and the lessons learned
- create a demonstration platform for demonstrating REACTION functionalities to potential users

2.1 Type of Demonstration Activities

The following types of demonstration activities have been carried out.

- Customisation of the whole or parts of the REACTION Platform to new application areas and limited trials with patient/end-users
- Hands-on workshops with users and/or developers
- Site-surveys and application analysis for potential uses and customers

2.2 Purpose, context and scope of this deliverable

The work described in this deliverable has been carried out as part of work package 11 “Demonstration”, specifically task 11.1.

The demonstration activities has been closely coordinated with the dissemination, exploitation and use the training material already developed to the furthest extent possible.

3 Demonstration Activities in Sweden

3.1 Description of activities carried out

3.1.1 Hands-On Workshops with REACTION DCK

CNet and our partner Swedish Computer Society are together delivering a 2-day training course on Internet of Things for IT professionals. As part of this course we performed several short hands-on workshops with application developers to allow them to use the REACTION DCK (Device Connectivity Kit) to integrate and use some medical devices in an application.

The complexity of medical device connectivity for developers that are not familiar with the domain is quite high. During the workshops it was apparent that using the Reaction DCK lowers this barrier, which is promising for future exploitation.

3.1.2 Adaptation to the Swedish National Health Account

The Swedish government have taken a decision last year (2013) that all citizens in the country should be offered a Personal Health Account. This account will allow cloud-based storage of individual health and care related data from care organisations, for instance journal information, x-rays, prescriptions, vaccination. But the Personal Health Account will also allow users to upload lifestyle related data such as training and nutrition information. The vision is to support the individual in both lifestyle related changes as well as in health and care-related events.

The individual will own all data in the health account and can at any time decided to close the account and delete all data. The individual grants access to external actors and service providers offering different health and lifestyle services.

The government aims at establishing an ecosystem of software and service developers that can offer third-party services for the citizens to use the data in their Personal Health Account. The services could be aimed at provide health data into the Health Account as well as different type of online services and apps for using and visualising the data.

The Personal Health Account will be based on the infrastructure provided by Microsoft HealthVault. This means any system providing data into the Personal Health Account must be able to support a wide range of commercial devices on the market supporting a multitude of communication and access protocols.

The Personal Health Account represents a great opportunity for future exploitation of Reaction results and it was included in the Demonstration plan for Sweden. Unfortunately the whole introduction of the Health Account has been delayed by more than six months due to a legal dispute regarding the tender procedure. Therefore it has not been possible to any real demonstration activities, merely a technical analysis of possibilities.

3.1.3 Nutrition app for Diabetes type-2 patients

The Nutrition App ‘s objective was to develop a native platform that can integrate to the patient’s lifestyle and patients education as part of the care plan and yet based on personalised profiles and goals.

Formerly the Nutrition app was verified internally in a “living lab” environment by experts at CNet which the result of test is reflected to D2-10. Accordingly, the demonstration and tests of Nutrition APP with diabetes patients were also planned to be conducted during February 2014. The performed test was in two sections: (1) Demonstration & usability test of Nutrition App (2) workshop & semi-structured interview to evaluate how well the features could be adopted by the users. This work was performed in line with the objective of collecting feedback from external users about the platform or part of it.

The result of test and workshop is reported to this deliverable as usability validation and end users acceptance towards to this component and evaluating the potential of flexibility of the component through different national organizations and languages. For this purpose, have been allocated adult-on set /type II diabetes which is known as non-insulin dependent diabetes between ages 40 to 65. Three patients were assigned to the REACTION –Nutrition App test and workshop by their responsible nurse at Mörby Health Center, primary care in Stockholm. All participants have been diagnosed as type-2

diabetes for at least two years. All participants have diabetes type 2 and shows high interests for having better support to change their life style .Their skill and knowledge to use smartphone and similar applications as well as their own methods to change their lifestyle and managing their nutrition were evaluated through qualitative, interview approaches
With the respect of time for observations studies both the test and the workshop were performed at CNet's lab and not remotely.

The participant's responsibilities were to attempt to complete a set of representative task scenarios which represented to them in an efficient and timely manner as possible and also provide feedback regarding the usability and acceptability of the users interface. The participants were directed to provide honest opinions regarding the usability and utility of the Nutrition App and to participate in post session subjective questionnaires and debriefing.

All involved participants with the usability test were required to adhere to the following ethical guidelines:

- The performance of any test participant must not be individually attributable. Individual participant's name should not be used in reference outside the testing session.
- A description of the participant's performance should not be reported to his or her manager.

The goal of usability testing include establishing a baseline of user performance, establishing and validating users performance measures and identifying potential design concerns to be addressed in order to improve efficiency , productivity and end user satisfaction with using the Nutrition App.
Upon review of the usability test and including the dark draft task scenarios and usability goals for Nutrition APP, users acceptance were expected to be documented through capturing qualitative data and analyses.

Collecting data began already with the interview. The interview was recorded and then transcription of data involved the selection process from spoken word to the text. The qualitative analysis work began already in the data collection phase. The focus of the analysis was on what the person have experienced and described. This qualitative research interview attempted to collect as rich-ended descriptions as possible of relevant themes for the interviewee's life-world. With life-world means peoples inner world and how they experience and perceive the world around us.

3.1.3.1 Demonstration of Nutrition App and collection of feedback

The session began with an overview of the whole procedure. The Facilitator provided a history of participants through interview and defined usability and purpose of the usability testing to the participants. The Facilitator and trainer both were responsible to respond to participants request for assistance during the test. Participants took part in the usability test at CNet –lab environment after demonstration of Nutrition APP.

Each participant was asked to practice and test the GUI and the functionality of the Nutrition app based on each scenario that required. Each completed scenario by participants indicated the scenarios goal have been obtained (whether successfully or unsuccessfully) and reflected to the test script as they provided feedback to use cases. After performance of task test by each user, collected more data through a dialogue in form of semi-structured interview over an agreement with the patient/user.

User behavioural and interaction towards using the application were observed and documented as identifying the problems concerns functionality and procedural errors under the test duration. Through semi-structured interview and qualitative analysis the user's revealed significant informations about users' experiences to the Nutrition APP. The result indicates satisfaction and acceptance of this component to the users. The Table 1 views the result of usability and functionality result from patient type 2 point of view.

The usability test objectives are:

- To determine design inconsistencies and usability problem areas within the user interface and content areas. Potential sources of error may include:
    - Navigation errors – failure to locate functions, excessive keystrokes to complete a function, failure to follow recommended screen flow.

  - Presentation errors – failure to locate and properly act upon desired information in screens, selection errors due to labelling ambiguities.
  - Control usage problems – improper toolbar or entry field usage.
- Exercise the application and the prototype under controlled test conditions with representative users. Data will be used to access whether usability goals regarding an effective, efficient, and well-received user interface have been achieved.
- Establish baseline user performance and user-satisfaction levels of the user interface for future usability evaluations.

The table below shows the result of test:

Use Case ID	UC - description	Patient (A)	Patient (B)	Patient (C)	Acceptance result	Feedback and users comments
UC-01	Setting database	YES	YES	YES	Liked	Nice with different languages
UC-02	Create meal	YES	YES	YES	Liked	
UC-03	Search food Item by text	YES	YES	YES	Liked	
UC-04	Audible search food	Not successful	Not successful	Not successful	Prefers to be used by end-users	It Cool when you could talk to your app ,
UC-05	Add food to favourite	YES	YES	YES	Liked	
UC-06	Create measurement	YES	YES	YES	Liked	
UC-07	Edit measurement	YES	YES	YES	Liked	
UC-08	Unit converting	YES	YES	YES	Liked	
UC-09	Caloric feedback	YES	YES	YES	Liked	Ability to choose different type of diagram which the person is used to see and read daily
UC-10	Audible feedback	Not fully succesful	Not fully succesful	Not fully succesful	Prefers to be used by end-users	It's good to work and cool the app can talk to you. It is much easy to search food and get audible feedback if the system recognizes my word.

UC-11	View history	YES	YES	YES	Liked	Over view over one week and mount is appreciated
UC-12	Edit Meal	YES	YES	YES	Liked	Nice to have own measurements
UC-13	Access to EU standard food agencies	YES	YES	YES	Liked	Good to have Asian food too
UC-14	View Categorized food by exchanging list	YES	YES	YES	Liked	Excellent and very easy to use. It included all you need to know. Good to delete unwanted categories that you don't want to have. Knows as easy and useful as learning tools and measuring carbohydrate. It's fantastic.
UC-15	View Images guidance to measure the portions size	YES	YES	YES	Liked	Handy guide is asked to be implemented too
UC-15	View GI-LOW List of food	YES	YES	YES	Appreciated	It's good to have other categories from exchange list. Good to have ability to search and compare slow carbohydrate and fast carbohydrate.

Table 1 Usability & functionality test result and acceptance result.

3.1.3.2 Workshop and User experiences

In order to provide a better understanding out of users experiences in the direction of using other type of applications than Android and how and which could have the best effect on the best wanted from the end users , two other prototype modules were developed: on windows phone 7 panorama and Pivot application in Microsoft Visual studio 2010.

The solution integrated to the Microsoft Expression blend to collect feedback from end users and resolved in SketchFlow prototype. Those program languages which took advantages of the GUI are: C#, XAML and integrated Photoshop design environment in the expression blend while the logic program is C#. (Figure 2)

For this specific purpose a workshop was performed at CNet for capturing of users' perceptions. During testing the prototype by emulator in Expression blend 4, the user feedback was inserted to the SketchFlow prototype, Microsoft Blend Expression 4 while documented in the real time (Figure 3).

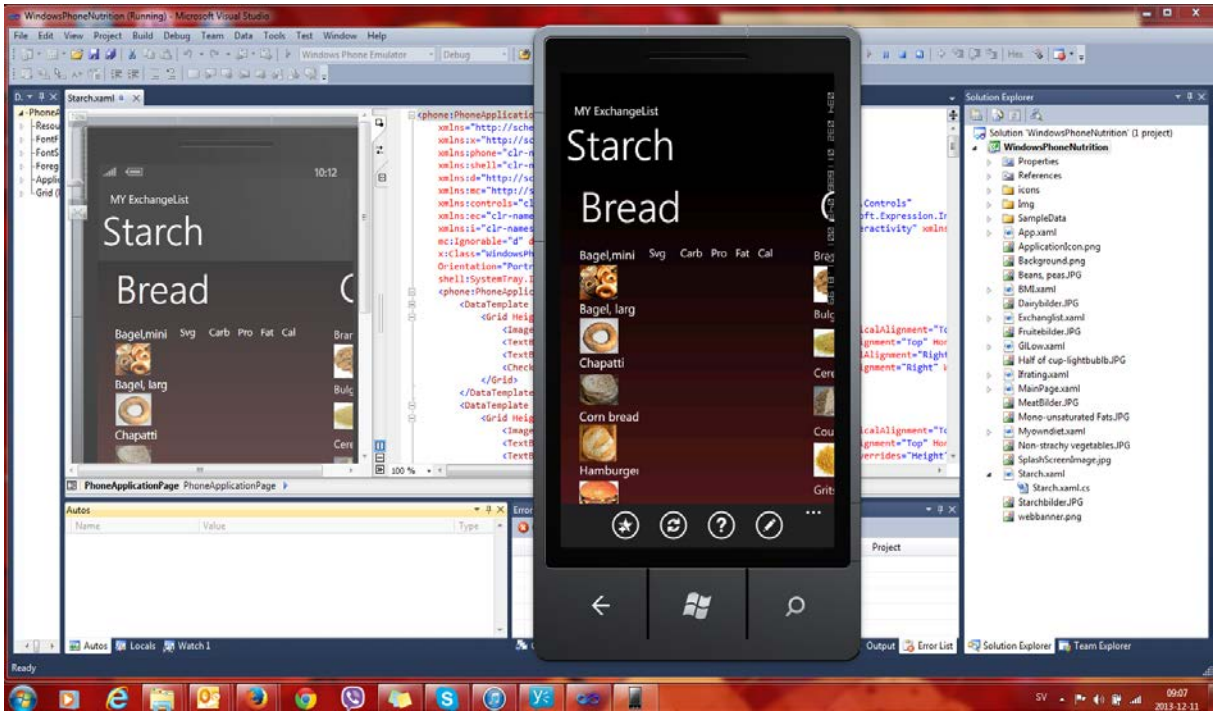

Figure 1 Ink feedback from Person2Feedback: Screenshot

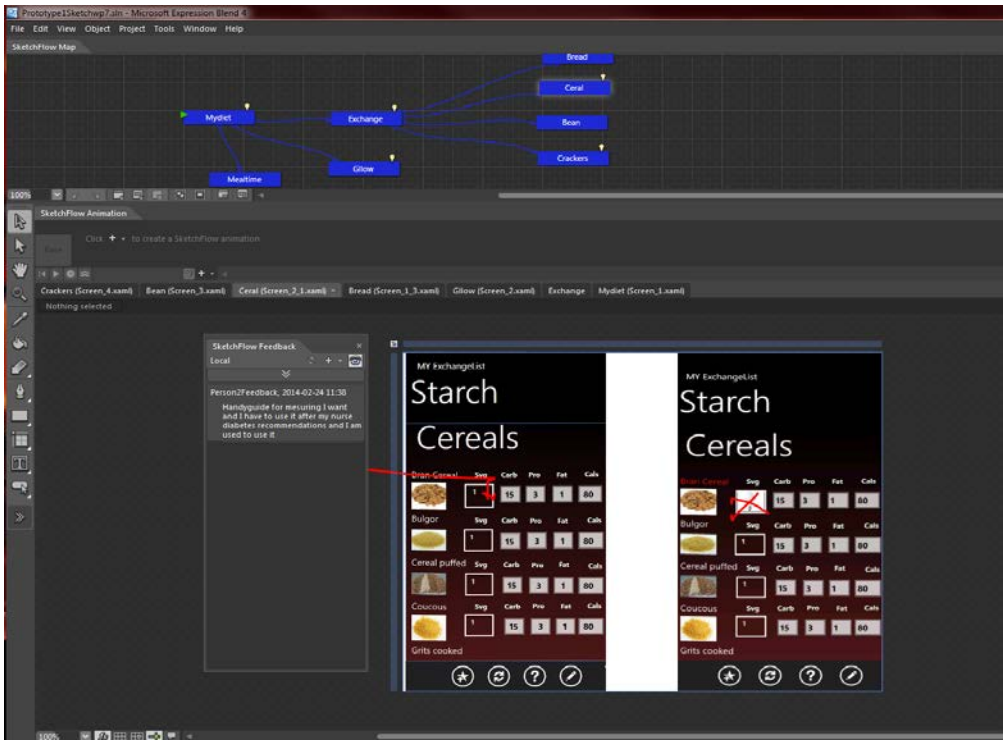

Figure 2 Ink feedback from Person2Feedback: Screenshot

Figure 3 Ink feedback from Person2Feedback

3.2 Feedback and Lessons Learned

The result of test activities is presented in Table 1. The test has performed at CNet's Lab environment with three patient types 2 which have shown high interest to have a better lifestyle with use of new technologies.

1) Each user acknowledged the utility of the Nutrition app into their lifestyle changing approaches and how simplified all complex computing of Nutrient goods both in online and offline mode.

2) The result of test also showed the interest of suing the application in a longer period into the daily routine life consequently the application enables access to the most important nutrition informations while facilitates how to measure the serving portions size based on personal wants.

3) Visualizing the historic overview on the first page raised end users /patients satisfaction highly though they don't need to go through many clicks and pages to receive the desired feedback and a historic overview over their nutrition and carbohydrates diagrams.

4) Despite of demonstrating different platform and devices which Nutrition App is running on, the participants couldn't differentiate windows phone 7 from Android but they have noticed the differentiation of the colour, design. They could only recognize differences between devices as tablet and mobile while they were testing.

5) The result showed that all of participant feels much more comfort to use mobile device into their daily lifestyle than tablet.

6) The participants confirmed that all informations related nutrient detailed and minerals are needed and the app is able to provide an informative view.

7) They acknowledged that by using the exchange-list, they could exchange food items to the same categories and having more freedom to eat what they desire and ensure to keep maintains of fat and carbohydrate.

8) Exchange-List and GI-Low module were appreciated highly as guidelines in hand but using the own system diet can accomplish the lack of other informations related to the vitamins as long as it allows them to bring all detailed information for the desired food item.

9) The more the system could calculate and operate automatically, the more it's appreciated due to the complexity of nutrition management in hand.

10) Different users had different needs and method to manage their nutrition but most of them could find their methods system in the Nutrition app.

11) Using audible feedback and search was appreciated but it was not fully successful as long as the operative system of Android doesn't all languages in speech syntax functionality but users compared it to their GPS voice function and admitted the known issues.

12) Nutrition therapy by using new technologies based on reliable guidelines may help patients to manage their blood glucose even in advance level but in a natural way that human used to use.

13) One of the participants recognizes the Nutrition App as an underlying scientific tool which provides a historic statistical overview over carbohydrate, protein, fat and calorie intake while operating smart as it provides feedback based on personal goals. The same person doesn't like to use the blood glucose meter device at all and he never used it while shows high interest to take advantage of Nutrition app to make right his blood glucose level in a natural way that human used to think and act. The result of observations analyses highlights the positive potential effect of Nutrition App on patients cognitive behavioural to encouragement to have a better control and self- management of the blood glucose level.

4 Demonstration Activities in Denmark

4.1 Description of activities carried out by IN-JET

4.1.1 Diabetes Home Monitoring

Demonstrations of the REACTION Multi-protocol Gateway with the REACTION DCK (Device Connectivity Kit) have been undertaken in two settings: The Municipality of Vallensbaek and in IBM Scandinavian Client Centre.

4.1.1.1 Municipality of Vallensbaek

The first demonstration was undertaken in a project involving Vallensbaek municipality, one of the suburbs of Copenhagen, Denmark. The Municipality wanted to deploy telemedicine to manage 2x5 diabetic citizens with several parameters to be monitored: Blood glucose, weight and blood pressure.

In-JeT ApS developed a front-end for remote patient monitoring based on the REACTION Multi-protocol gateway and using the REACTION DCK. There were multiple purposes of the demonstration.

First, the aim was to demonstrate how a Multi-protocol Gateway could provide multi-parametric monitoring and support self-management of the disease by connecting to several devices using different communication protocols. This was a prerequisite from the Municipality.

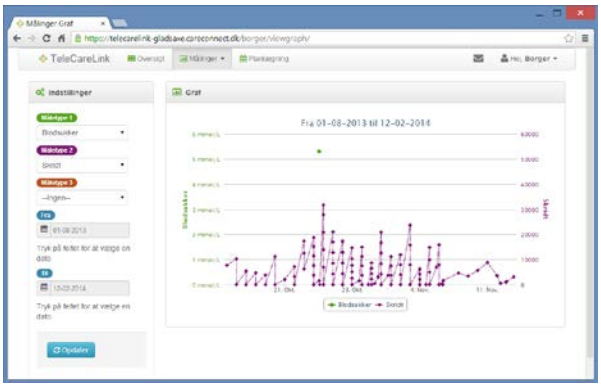

Figure 4 KMD system displaying data

The second aim was to demonstrate how the REACTION DCK can be used in applications to make them compliant with the International Continua Health Alliance reference architecture. Compliance with international standards has become mandatory for Danish telemedicine solutions since 2012, where the government launched a National Telemedicine Action Plan.

A third objective was to demonstrate how a touch screen REACTION Multi-protocol Gateway with the REACTION DCK could be used to send data to the Municipality's existing data storage system called KMD Care. KMD is the largest Danish supplier of Care Systems for municipalities with about 50% market share. KMD has developed an integration platform (CareConnect), which allows healthcare and social care workers to share knowledge and patient data by connecting data and processes in different parts of the healthcare system. IN-JET developed the citizen interaction application for the Multi-protocol Gateway, whereas CNET developed the runtime components of the REACTION DCK.

The demonstration was undertaken during November 2013 and was successful. The Municipality decided to go ahead with their project and the first phase was concluded by the end of the year 2013.

The first feedback from the citizens was rather positive. They felt that they were getting a better understanding of their condition and what to look out for. One citizen reported that she was much more cautious now about eating candy, because she could see the influence on the blood glucose level. Another citizen had taken her measurements to her General Practitioner, who was "impressed". Overall, two of the five patients had lost weight, were better managed and had their medication reduced.

The negative aspects reported were problems and delays in data transmission (mostly network and server problems) and the bulky touch screen. The transmission problem was a very negative experience with all the citizens and indicates a strong need for quality checks of the full measuring chain before roll out. A QoS (Quality of Service) tool like the REACTION Network Monitoring Service

would be very useful in order to understand the cause of the problem and identify the precise location of the problems.

Moreover, the citizens were frustrated because they could not easily see if and when the data had been received on the server. And when they reported the problem to the municipal call centre, they could not easily explain what the error was.

Figure 5 Touch screen Multi-protocol Gateway

The second aspect was the size of the monitor. The touch screen citizen interaction application was originally developed for patients with CHF (Chronic Heart Failure) who needed a very large touch surface to be able to navigate the application. The feedback from the Vallensbaek citizens clearly showed that there was a strong need for the application to be ported to a tablet platform, which is more convenient for the diabetes patients, some of which did not have a lot of space in their home. The application had already been developed for an Android platform also, but since it was not possible to find a glucometer with an open interface for an Android tablet and with CE-marking, it was necessary to carry out the demonstration using the touch screen.

4.1.1.2 IBM Client Centre

The second demonstration was carried out for IBM using the runtime component of the REACTION DCK as a frontend observation sender for their WSE RPM (WebSphere Sensor Event Remote Patient Monitoring) service. The demo is now permanently installed at the IBM Scandinavian Client Centre in Lyngby, Denmark. IBM's demand for the demonstration was that a Tablet PC or mobile phone should be used as a Continua Application Hosting Device that allowed patient to monitor health data and send them to the WSE RPM server.

The solution was developed jointly by IN-JET and CNET based on IN-JET's Android user application and a runtime REACTION DCK component that was modified to run under Android.

The demonstration was successful and the solution is now being demonstrated to potential IBM customers and other visitors. The solution was also demonstrated to other IBM organisations and attempts are underway to make a second installation in the IBM La Gaude European Client Centre in Sophia Antipolis, France.

Figure 6 Table Multi-protocol Gateway

4.1.2 GlucoTab eDSS

MSG, MUG, and IN-JET carried out demonstrations of the REACTION GlucoTab Electronic Decision Support System (eDSS) at three different hospitals in Denmark. The aim of the demonstrations was to elicit the responses from hospitals and clinics about the functionality of the eDSS and specifically, to obtain commitment for one Randomised Clinical Trial (RCT) study for the GlucoTab eDSS to be carried out in Denmark as part of the MUG initiative to carry out a multi-centre RCT in Europe.

The demonstrations were carried out on the 12 November 2013 in Copenhagen, Denmark. Partners from MUG, MSG and IN-JET participated.

Three hospitals were visited:

- The Steno Diabetes Center: This is the specialised diabetes centre owned and managed by the Novo Nordisk foundation. The demonstration was made to Martin Ridderstråle, MD, head of Patient Care Center. The principle of the eDSS was briefly presented and Dr. Ridderstråle expressed great appreciation with the GlucoTab as a tool for better diabetes management.

Steno no longer maintains bed wards and treats all patients in an out-patient setting, but he saw potential for use in the outpatient clinics also.

- Epitalet - Telemedicinsk Research Unit, Frederiksberg Hospital: This unit of the Frederiksberg Hospital constitutes a transformed healthcare provider, delivering cohesive healthcare services based on radical use of patient empowerment methods. The chief medical doctor, Klaus Phanareth, MD, Ph.D. was impressed by the GlucoTab eDSS and what it could do outside the hospital. In the Epital eco-system, the patient needs support to manage their own health from distributed health service providers. eDSS will be needed in many places to realise this ecosystem on a large scale. Specific needs are found in acute centres and home nurses working with patients in their homes.
- Department of Endocrinology, Hvidovre Hospital: This unit is one of the foremost endocrinology units in Denmark. The REACTION GlucoTab was demonstrated to the head of department, Anders Gotfredsen, MD and the chief medical doctor Kirsten Nørgaard, MD. Both were very excited about its possibilities. Hvidovre hospital has a implemented a specific care plan for glucose management of admitted diabetic patients, but it was typically not followed in the different wards. An RCT at Hvidovre Hospital was discussed as a clear possibility.

On the following day, a half-day seminar was held at Hvidovre Hospital with several staff members participating, including those mentioned above, other medical staff, and research and diabetes nurses. Subsequently, there have been several meetings the clinical specialists from MUG and Kirsten Nørgaard as well as technical meetings between IN-JET, MSG and Hvidovre Hospital. The present status is that the RCT has been decided and a letter of intent has been signed. The development of the clinical protocol is in progress and the technical interfaces are being discussed. The outstanding issue is the financing. Hvidovre Hospital expects to carry out the RCT as part of a PhD study, for which a candidate has been identified. The work will continue after the REACTION project ends.

4.1.3 Emergency Service Demonstration

It was originally planned to demonstrate a hypoglycaemia alarm in a real setting, with the exception that the hypoglycaemia would be simulated. The demonstration was to be done in the municipality of Skive, a location chosen because CNET and IN-JET had previously installed a telemonitoring platform based on the REACTION DCK to the social and healthcare department of Skive Municipality.

During event monitoring of diabetes patients, the REACTION platform must detect dangerous events such as hypoglycaemia, where immediate response from first aid or crisis teams is necessary, often within minutes. The demonstration was aimed at showing how the REACTION platform is able to forward an event safely and securely to a call centre in a ward with acute beds in the Marienlyst nursing home in Skive. The technical aims were to develop the alarm signalling protocols and test the final alarm interface to the call centre's alarm handling system.

Unfortunately, the demonstration had to be cancelled, because Skive had been planning a change to a new system and the installation was delayed to early 2014. Since there was no system to receive the alarms, it was decided unrealistic to carry out the demonstration at this point in time.

4.1.4 Feedback and Lessons Learned

The feedback from several demonstration undertaken, combined with many other discussions with clinicians, participation in conferences and exhibitions as well as practical experience with the implementation of the REACTION Multi-protocol Gateway and, in particular, the REACTION Device Connectivity Kit shows a strong interest in the solution presented and a strong willingness to carry on with real trial projects and real implementation. The demonstrations resulted in the following concrete Lessons Learned:

1. The Multi-parametric Gateway and how it can provide monitoring and support for diabetes self-management was very well received by both caregivers and citizens. They felt it was a really useful tool. Examples of positive Lessons Learned were that the data could be shared with the General Practitioner.

2. The ease by which the REACTION DCK could provide compliance with the Continua Health Alliance standard and reference architecture was a very important Lessons Learned which should be pursued in the future exploitation.

3. The extraordinary ease by which integration to two complex backend systems like KMD CareConnect and IBM WebSphere Sensor Event Remote Patient Monitoring was acclaimed. It was mainly attributed to the REACTION DCK which sends data through simple and standard web service interfaces. In both cases the integration took less than one week.

4. Transmission problems pose a negative experience with all citizens. It indicates a need for strong quality check of the full measuring chain before roll out. A QoS (Quality of Service) tool like the REACTION Network Monitoring Service would be useful to monitor network performance.

5. A well thought out, feedback message system that allows the citizen or patient to understand when measurements have been sent is strongly needed. And if the measurements were not received, what was the perceived problem. The Lesson Learned that without a simple and easy to understand feedback, the citizen has difficulties explaining to the support staff what is wrong.

6. Feedback from the citizens regarding the size of the monitor clearly showed that for citizens with good ICT skills there was a strong desire to change the application to be executed on a tablet platform. It was also the absolute demand from a market leader like IBM. The Lesson Learned here is that the diabetes monitoring platform must exist on a variety of platforms to suit the individual needs of patients as well as the needs of the customers.

7. After a successful demonstration, the solution is being permanently installed and demonstrated to potential IBM customers and other visitors to the IBM Scandinavian Client Centre. The Lesson Learned is that it is important to demonstrate the solution to other actors in the healthcare field and not just to the healthcare providers.

8. The principle of the REACTION GlucoTab eDSS obtained great appreciation from all the hospitals, where it was demonstrated. The potential use ranged from a tool for better diabetes management in In-hospital wards to support for caregivers to help patients better manages their own health. The demonstration resulted in one RCT study in Denmark being agreed.

4.2 Demonstration Activities carried out by Delta

Different ePatch demonstration systems were designed and made to demonstrate wireless data transmission. ePatches with Zigbee radios was designed to demonstrate streaming of 2 ECG channels. The Zigbee signal was received by a Zigbee data transmission circuit in a USB dongle that was inserted into a USB input of a PC. The 2 ECG channels were presented as life streaming signals on the screen. The Zigbee streaming ePatch system demonstrated how recorded ePatch data can be wirelessly transmitted. It was intended to demonstrate the integration into the Brunel University gateway system. But this would have required development of and additional data transmission protocol and additional embedded software in the ePatch to derive heart rate and not only streaming. To show this specific feature another ePatch demonstration system was made with a Blue Tooth Low Energy (BTLE) radio.

In the BTLE ePatch the heart rate was derived from one of the ECG channels. A chip accelerometer was also integrated in the ePatch and from the 3 axes accelerometer data, the posture of the patient was calculated. A dedicated app was designed and made for iPads to show and demonstrate some of the possibilities in presentation of data and derived parameters recorded by and ePatch and transmitted wirelessly with a short range data transmission. A photo of the ePatch app screen is shown below. In the left part is presented the heart rate, an icon of the posture of the patient showing if he is lying, standing/setting or active, and a calculated number for the activity level of the patient. In the right side of the screen is presented the heart rates of the last 15 minutes in a PoinCare Plot , that quickly provides an overview on possible heart arrhythmias of the patient.

The BTLE ePatch demonstrator and the iPad app have been used to communicate the opportunities of ePatch with wireless transmission with system integrators and clinical partners. This communication is very important because there are no clinical guidelines or international accepted clinical procedures for use of an ECG monitor system as part of a telemedicine solution for monitoring patients with chronic illnesses.

The BTLE eatch demo system was developed in 2013 and has been used in demonstrations with potential partners since October 2013. Further, in the last 3 month of the project period 4 partners have borrowed BTLE systems and installed the iPad app, and demonstrated it for their potential partners.

Demonstrations were planned and done to investigate new possible use of the ePatch technology in different clinical domains and settings. Below are listed the chosen demo-cases for ePatch monitoring and the external partners who have participated in trying out ePatch monitoring in specific new application fields:

Monitoring patients who are at high risk in primary care settings, where the patients are monitored 1-3 days before a consultation with their GP. The recorded data should quickly be examined before the GP has the talk with the patient and a relevant data should be presented for the patient and used as objective data on his health status in a constructive dialog:

- The demo-case was performed by the REACTION partner, Chorleywood Health Centre, CHC, and 14 patients were invited to take part.
  Results from this demonstration have been reported in D2-10. In short the feedback was that the nurses found it easy to attach and take off the ePatch, the patients were pleased to wear it, and the recorded ECG data were recorded in a quality suitable for clinical use. The ECG analyses software should be improved, but overall the ePatch could be a good tool for easy recording of objective data to improve the GPs overview of the health status of his patients.

Prevention of stroke by detection of Atrium Fibrillation (AF) of people with high risk, or patient who have had a small stroke:

- Monitoring of patients at the Stroke unit at Heidelberg university hospital. In all 26 patients has been recorded for 24 hours along with telemetric ECG recordings. The goal was to get feedback on the general user experiences and investigate if the recorded ePatch data could be the basis for automatic AF detection.

  The user feedback was positive. The recorded data had noise on some of the ECG channels and the analysis software was not adjusted to the ePatch data. In spring of 2014 more recordings will be made and adjustments of the automatic analysis software will be made. Therefore it is too early to conclude if the ECG data recorded with ePatch can automatic and reliable detect AF with few adjustments of this software, that already is in daily use en several stroke units in Germany.
- Monitoring patients with acute stroke while in a Stroke ward at Glostrup university hospital, Denmark

78 patients were recorded with ePatch for 24 hours. The user experience was good and the handling of ePatch and the data read out was quick. The clinical results of this study is not yet ready

Monitoring of patients with sleep disorders:

- Monitoring patients at home with ePatch while they were monitored for sleep disorders, Danish Centre for Sleep Disorders Glostrup university hospital, Denmark

  80 patients were monitored with ePatch along with a mobile system for detection of sleep disorder. The study results will be finished in spring of 2014. The interim results and feedback was that user experience by the patients and the nurses was high, and 2 patients were found with non-diagnosed heart arrhythmia.

Motion and activity monitoring:

- Monitoring of people doing exercise or normal daily activities, Institute for sports and biomechanics at Southern Denmark University.

  The study is initiated but not yet finished.
- Monitoring of ECG on Free diver, Stig Severinsen, during his world record attempt in swimming more than 150 meters underneath ice along the coast in Greenland

  Stig Severinsen made is world record wearing the ePatch. He is very sensitive to any devices that hinder his movements or ability to concentrate. Therefore ePatch was chosen as the less disturbing ECG device the team had found. The world record was made in spring 2013 and at that time the ePatch prototypes was not sealed against water. Only one useful ECG recording was made, in the other recordings the water short circuited the device. But this spectacular swim showed that the ePatch do not disturb even a very sensitive person

At present the following demonstration has been planned and started, but results and feedback is not yet ready

- Holter **monitoring of Infants**: LKH Graz, Kinder kardiologie, Austria
- Monitoring of **Burnout Syndrome**: Privatordination Dr. Eller-Berndl, Vienna, Austria
- Restitution of **young athletes**. Leichathletikzentrum Kornwestheim-Lundwigsburg , Germany
- **Patient applying ePatch at home**: Odense University Hospital, Denmark
- Monitoring of **Dialysis patients**. Dialysis centre in Leipzig, Germany

- Training improvements of professional **mountain bike racing team** (MTB). Germany
- 24 hours recording of **elderly patients**: GP network, Germany

More than 10 demo-cases have been made or are being performed to investigate how the ePatch can be used in new applications, and how ePatch can be used to monitor patients or persons who for practical reasons could not or would not be monitored before. In all cases the ECG recordings are expected to be valuable and the expenses in recording could be acceptable when the recorded were of sufficient quality.

The main feedback from all demo-cases was that the user experience and handling of the ePatch was very satisfactory, and the normal barrier of convincing the patients to wear an ECG monitor is very much lowered by the ePatch technology. Next step is to do more investigations on how to use the recorded data in these applications that not have been practically realistic before.
When ePatch is so easy to wear and use as indicated in the performed demo-cases new opportunities will also be realistic for diabetic patients. The most obvious two are:

- Develop the monitoring scheme of recording of health data prion to a GP consultation on comorbid diabetic patients in primary care
- To monitor activity, heart rate and energy expenditure of diabetic patients with low compliance in following the medication plans. This could be done in a telemedicine setting along with the patients doing spot measurements of blood glucose. The continuous recordings of ePatch and the trend curves that could be derived would be valuable additional information to get to know the contextual conditions for the behavior of the diabetic patients prior to making the blood glucose spot measurements.

4.2.1 Feedback and Lessons Learned

The lessons learned from the Zigbee ePatch systems were the following:

- The Zigbee data transmission embedded in ePatch worked fine to stream ECG data from 2 ECG channels each with a sample rate of 250 per sec. The transmission rate was approximately 10 meters.
- The on-line streaming demo on a PC/labtop convinced potential partners of the technical opportunities in wireless transmission of data from the ePatch, and that it is “only” a matter of more engineering to make a wireless transmission to a gateway.
- Streaming consumed 4-6 times more power than recording of ECG and Zigbee-streaming could be done continuously for 12 hours.
- High level parameters should be calculated from the ECG signals and presented to health professionals. They need to use less than 5 minutes per day to overview the health status of a patient and will not use personal resources to observe ECG signals streamed-in on-line.

Lessons learned from the BTLE ePatch systems:

- BTLE work as reliable as Zigbee transmission and effectively use the same energy to be transmitted.
- It was possible by the embedded solution in the ePatch to both record and store ECG-channels as well as streaming one ECG channel and calculate and transmit heart rate and the posture of the patient.
- The integrated BTLE solution in the iPad and the developed App. was a convincing demonstration system towards clinical users and system integrators. The demonstration resulted in fruitful discussion on how to use the ePatch data in telemedicine solutions where high level data are wirelessly transmitted, and the full recorded data set of 2 ECG channels and the accelerometer data can be transfer via a USB interphase after the ePatch monitoring session.
- The BTLE was easy and reliable to use and easy to install on an iPad. Therefor the demonstration system could be lend out to potential partners who could use it in defining

requirements and specification for their own telemedicine solutions in dialog with their clinical partners and potential customers.

5 Demonstration Activities in Greece

The main objective of the REACTION's SMS service is to provide advanced and targeted alerts and notifications to the end users, with the use of an instant communication method, the Short Messaging System, which is available over GSM networks, to mobile users. The key issues for this service are the advanced user profiling and the cognitive techniques which can be used in order to dynamically compose and send alert and notification messages to the end users of the REACTION platform, depending on their particular personal profile and attributes (carers or patients). SMS services provide specific advantages not only to the medical domain, as it has been applied in the REACTION project, but also to a large number of domains ranging from targeted information services to advertising. The range of potential customers and users is extensive. One example of an existing "customer" is the Forthnetgroup of companies which has already integrated some functionalities of the SMS service developed within the REACTION project framework to provide targeted information and notifications to its customers. This service can be promoted and applied to a number of other interested companies in Europe.

The REACTION Network Monitoring Service for Mobile Devices is a java library for remotely monitoring/managing mobile devices using the Simple Network Management Protocol (SNMP). The NMS monitors data traffic and assesses the transmission quality between the Patients' Sphere and the Carer's Sphere, the REACTION backend and other cooperating systems such as the hospital information system (HIS) and EPRs in primary care.

Furthermore, it is able to analyse network traffic data and present them in graphical format; to generate email alerts to warn network or system administrators of abnormal network conditions or attacks; and to offer additional analysis about the behaviour of these attacks. With the growing network and the ever increasing network security breaches, the need for a robust and resilient network management system is utmost essential. Since the NMS developed within the REACTION project framework can be considered as a stand-alone application, it provides a number of attributes for any potential customer, such as costs reduction and fewer outages through the automatic process of the system, leading to improved productivity and increased customer satisfaction. Potential customers for the NMS include mainly SMEs who are planning to use an integrated approach for their network data collection and analysis, as well as to identify network bottlenecks and discover network-based attacks in real time. The NMS can be applied in a number of businesses, since it can be parameterised according to specific needs.

Demonstration activities carried out by Forthnet during the fourth year of the REACTION project includes both the individual modules developed by Forthnet (SMS & NMS services as described above), as well as the REACTION system as a whole.

5.1 Description of activities carried out

Telemedicine Technologies S.A.S. is a software engineering company specialized in online information systems for healthcare professionals: clinical research, assistance case management, telemedicine, distance education. TT provides an existing penetration in the French medical domain market and collaborates with a number of companies like TeleSpazio S.A and **MEDES – INSTITUT DE MÉDECINE ET DE PHYSIOLOGIE SPATIALES**.

Forthnet operates an extensive network of Points of Presence (PoPs) in Greece, while an extensive network of more than 130 retail shops (Forthnet Shop) serves all major metropolitan areas. To this extent, a demonstration of the REACTION project has been performed to the executive members of Forthnet shops operations, in order to discuss and identify possible paths for promoting the project results through Forthnet Shops located around Greece. The main idea was to provide demonstration and information points within the shops, where more emphasis would be given to the home care applications of the project. The main aim is for the customers of Forthnet shops to be able to interact with the platform at the demonstration points, in order to learn its capabilities and provide feedback on how interested they would be if such a platform was to become available as an integrated product installed at their homes for remote monitoring.

The Reaction platform has also been demonstrated at the "Prefectural Innovation Committee of Crete" under the action "Health Services". This committee was responsible for identifying the excellence provided by the local academia, research and industry sector, in order to define and propose the priority axes of the Region of Crete under the Smart Specialization Strategy, proposed by

EU for the next years. Reaction was presented as an innovative healthcare service able to support citizens and -mainly- visitors suffering from diabetes in the Island of Crete, focusing on the medical tourism domain.

5.2 Feedback and Lessons Learned

The demonstration of concrete, tangible benefits of the REACTION project is essential, when it comes to creating awareness among potential users and customers.

As more people become aware of the dangers imposed by Diabetes and the increasing rates, the interest for knowledge, prevention and monitoring is proliferated. To this extent, all the activities mentioned above had an overall positive feedback with the people involved, identifying the importance of the REACTION platform and its capabilities.

A number of marketing and promotional techniques have been discussed, but the main concern on all of the above mentioned demonstration activities was on providing a convincing marketing plan and how such a platform could be advertised and efficiently promoted to the Greek and European markets. Public and private partnerships have also been discussed, in order to identify possible associations with the public health sector in Greece, since one of its main aims is to minimize health care costs. An additional concern that has been raised through the demonstrations is related to the protection and confidentiality of patient data, which is crucial to patients' acceptance on adapting new methods and technologies, especially within the home care framework. In that sense, additional security issues have been discussed, apart from the ones that have already been applied within the REACTION framework, in order to enhance patient data protection.

6 Demonstration Activities in Spain and beyond

ATOS plans were to investigate the possibility to perform demonstrations of the REACTION functionalities and potential features at two different levels: 1) internal to Atos, 2) Atos existing customers and potential customers. First steps are to be taken in Spain, but as the company has business units in most European countries, demonstration activities are planned to explore a wider geographical dimension.

The chronology depended on the opportunities, availability of people and receptivity, but the idea was to start with internal demos to Atos relevant account executives that are in constant relation with customers in the health sector in the different geographical units. The objective was to make them understand at best what REACTION can offer and enable them to prepare customers to adopt innovations that can benefit their businesses. Plans were to present and demo REACTION to:

- Atos Spain Innovation Director, located in Madrid, Spain.
- Atos Global Health Portfolio Manager, located in Vienna, Austria.
- Atos UK Health & Welfare Market Innovation Forum, located in London, UK.

The next target would be to demonstrate the REACTION platform to associations that group various players in the field of healthcare. ATOS is member of some of those groups and is regularly invited to present innovative solutions. Thanks to its active role in FENIN for example (see more details below), ATOS has the possibility to organise customised events that may include the performance of a demonstration to a selected amount of members followed by discussion and feedback gathering.

Finally, once Atos sales force is fully convinced of the real benefits and functionalities of the platform, they can help organise workshops with selected customers where the REACTION platform can be demonstrated.

To save costs in travel and equipment, the demo can be partly performed remotely. Atos presents the portals that can be accessed through the internet. Functionalities offered by the clinicians and the patient portal can be demonstrated. To show how the gateway works with the devices, measurements may be taken by the C-NET team with whom a teleconference can be established. In case customers are interested in a demo of the Gluco-Tab, the video produced by MSG/MUG can be shown and then a video conference can be establish with the team to show more details of how it works. If customers in Germany or Austria are interested, MSG may be invited to come over.

Here is a short description of potential entities in Spain that have shown interest in REACTION and to which a demonstration session has been proposed:

- **FENIN** is a multi-sector federation that groups manufacturing, import and distribution companies and associations of healthcare technologies and products whose common characteristic is that they are suppliers to all the Spanish healthcare institutions. The companies and business associations that make up FENIN are responsible for more than 80% of the total sales to the Spanish Health Technology market, of which about 72% corresponds to the public health sector, with an approximate volume of business of some 6.600 million Euros. FENIN supports the research and technological development of the companies that form part of the Federation, as these companies contribute healthcare products and services that help not only to improve the patients' quality of life but also to prolong it. **Contact person**: Angel L., President of FENIN.
- Within *Servicio Madrileño de Salud* (SERMAS), *Dirección General de Sistemas de Información* (DGSIS), under the Deputy Ministry of Health Care of the Community of Madrid, is competent for planning, implementation and deployment of information systems and management to the organization and operation of the Public Health Service of the Community of Madrid. The Innovation Technology Programmes & Strategic IT Projects Division is responsible for the management of initiatives and research projects conducted in the area of SERMAS, constant improvement and transformation of processes and project leadership within strategic lines of the entity.
- **QUIRÓN** is an important private hospital group in Spain with 21 hospitals. The experience and the investment in the latest technology are complemented by new generations of responsible and committed professionals who contribute to an extremely important added value for the company. Quirón's organisational model focuses, in turn, on innovation, creativity,

experimentation, teamwork and proactive approach. These characteristics shape an organisation which is continuously innovating by means of precise technical knowledge participation and co-cooperation between the different hospitals of the company to the benefit of our patients. **Contact person**: Antonio F., R&D Director.

6.1 Description of activities carried out

According to the initial plans, several stakeholders have been approached:

Atos internal demonstration events:

- **Atos Spain Innovation Director** (Jose E., Head of Innovation, located in Madrid, Spain). His role is to gather information about innovative solutions and promote them internally. He has influence in the distribution of small investments for piloting innovations in cooperation with interested customers. He is member of the Atos Scientific Community, which "aim is to help Atos anticipate and craft its vision of upcoming technology disruptions and the future business challenges that will be faced by the markets it serves"[1]. A formal meeting was organised, during which most features of REACTION were demonstrated (video of GlucoTab, visit of clinical portal features, including Notification Handler). As a result, a list of next steps was established:
  - To include the REACTION in the list of demonstration that can be performed in the Madrid Business Innovation Centre, as well as in the Paris located "Business Technology & Innovation Center (BTIC), a customer experience platform aimed at tangibly promoting Atos Global Portfolio of solutions and Global Key Offerings"[2].
  - To take into account when innovation workshops will address the health sector (not in the near future).
  - However, it can also be introduced to customers interested in health solutions. This has been the case with Vodafone Spain (see below).
- **Atos Global Health Portfolio Manager** (Roland N., Head of Global Healthcare Portfolio Management, located in Vienna, Austria). He is in charge of studying all Healthcare solutions provided by Atos different Global Business Units worldwide and including them into a portfolio of offerings that can be presented to customers. A webinar was organised, during which REACTION features were presented and some components (e.g. Clinical Portal) shortly demonstrated. As a result REACTION project description was included in bids as innovation reference.
- **Atos UK Health & Welfare Market Innovation Forum** (Conveners: Simon R. and Sally S., Head of Health & Welfare Strategy, located in London, UK). This forum is market centred and brings together the market team, sales and solution lines in order to agree on potential innovations and associated investment. A first approach was made in May 2013, during which different components and features of the REACTION solution were presented, as well as its potential market added value aspects. As a result, the following actions were planned:
  - Confirm IPR ownership of what is being developed and piloted.
  - Review the ability to monetise the project to qualify as an offering (market potential, commercial model, revenue share, platform and architecture, authentication and security and offering differentiators).
  - The follow-up meeting has not taken place yet at the time of preparing this report.

REACTION in innovation workshops with selected customers

- **Vodafone Spain Innovation Workshop.** (Organiser: Alicia L., Account Director Vodafone Sales, located in Madrid). They are principally interested in Smart Mobility. Demonstration of REACTION features was performed during the Innovation Workshop organized by Atos Spain in Madrid. Interest was shown, but no further actions were planned yet.

[1] http://atos.net/en-us/home/we-are/insights-innovation/scientific-community.html
[2] http://atos.net/en-us/home/we-are/insights-innovation/business-technology-and-innovation-center.html

- **Vodafone Global M2M eHealth vertical (NL and Turkey)**. Their interest focuses on eHealth / Smart Mobility / Big Data. A preparatory meeting was organized with sales managers Jan-Joost von K. and Roland van A. (Led by Fulya P., Vertical Practice Manage Telco & Media, SI, located in Istanbul, Turkey). Having read information about the REACTION, "they were particularly interested in the project". Material about the project was shared and a short demo was performed. Detailed feedback has not been provided yet.

- **Assistance Publique- Hôpitaux de Paris** (**APHP), France**. In principle, not interested in the Diabetes part, but in Mobility Solutions. An innovation workshop was organised by Nicolas T., Health and Public Sector Market Director for France, and Xavier L. Responsible for the Social Health Sector, in the Business Technology Innovation Centre at Atos Headquarters in Bezons, Paris. Mobility elements (remote monitoring) of REACTION were put forward and demonstrated to the *Directeur du CCS Système d'information Patient*, responsible for 38 Hospitals in Paris region. As an outcome, Josema C., Director of Atos Research and Innovation, has been invited to visit Hospital Rotschild, for further discussions.

- **Quiron (Private Hospital in Spain)**. A demonstration meeting is planned, to be organised by Blanca J., Head of Health Sector at Atos Research and Innovation, but has not taken place yet at the time of preparing this report.

6.2 Feedback and Lessons Learned

Meetings and discussions with sales people are crucial to discover barriers to adoption and commercialisation of the REACTION platform and components. In particular, it shows how flexible the solution has to be to accommodate to existing needs and expectations, which may not be fully addressed by the current REACTION developments. Additionally, it helps identifying the gap between a demonstrator and deployment at wide scale in real business.

In the very first steps, even the terminology used and the emphasis must be geared towards the expectation of customers. For instance, APHP, a major potential customer in France, had particular interest in Big Data and Mobility solutions. Although an undeniable growing disease, diabetes care was not their top priority. Therefore the demo and presentation of REACTION had to focus on remote monitoring aspects and the project outcomes having a major impact on mobility of patients and healthcare professionals.

A similar approach had to be applied when presenting and demonstrating REACTION features to Vodafone (Spain and NL). This potential customer is looking to improving its telecommunication business. Therefore emphasis was put on mobility aspects of REACTION, such as remote monitoring for primary care settings.

Getting formal and constructive feedback from customers is a long process, especially when presenting and demonstrating research results or innovative solutions. Although it is very difficult to obtain immediate results, it is often a small step in the customer relationship process that can quickly become business opportunities when all elements become reality, such as user adoption, funding /investment, involvement of lead decision making, etc.

7 Conclusions

WP11 has been a short workpackage that ran only for the last year. But the feedback from demonstration activities has given us great confidence in the exploitation potential of the Reaction platform and tools. Furthermore it has also stimulated partners to collaborate in approaching different markets in different European countries.