CREATING A LOC BASED PORTABLE HEALTH-CARE PLATFORM
Using a Universal Mobile NFC Host Environment

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Abstract: This paper presents our recent plan to provide support for a portable diagnostic health care platform (namely POCEMON) based on Lab-On-Chip (LOC) concept. The idea is based on our achievements on creating a host environment that combines mobile phones/PDAs with the Near Field Communication (NFC) wireless technology to further support mobile diagnostic health care applications. NFC enabled mobile phone based host environment works as a reference platform regardless of the phone type and the nature of the services required. In connection to this, we will describe further insights on how this cutting edge technology may be leveraged in the health care sector providing efficient point-of-care monitoring and diagnosis.

1 COMBINING LOC AND NFC FOR MEDICAL DIAGNOSIS

Use of miniaturized devices in molecular diagnostics has gained wide spread popularity. The detection of genomic and proteomic sequences has diagnostic and large prognostic value. This impact can be easily enhanced by using diagnostic lab-on-a-chip (LOC) devices at the primary care level for the diagnosis of the significant autoimmune disorders. Lab-on-Chip (LOC) refers to a single chip miniature device that performs biological procedures in analytical chemistry enabling fast response and portable, low cost analysis data suitable for real-time operating conditions for a wide variety of health and life science applications such as the diagnosis of genetic disorders or the testing of food and water supplies for contamination etc (Ghafar-Zadeh and Sawan, 2008; http://en.wikipedia.org/wiki/Lab-on-a-chip). Such devices integrate fluid-handling functions such as sample preparation, analysis, separation, and detection and combines electronics with biology to open new application areas such as point-of-care diagnosis, on-chip DNA analysis, and automated drug discovery (Hwang et al., 2006).

POCEMON (Personal Health Systems for Monitoring and Point-of-Care Diagnostics) is an ICT-Large Scale Integrating project that will have great impact on the methodologies available for both autoimmune diseases and drug discovery and consequently impact on the scope and throughput of new pharmaceutical developments. POCEMON aims to create a portable diagnostic platform supplied with advanced software and hardware technologies for the diagnosis of autoimmune diseases, coupling fundamental bioinformatics sciences with technological advances in the fields of micromachining and micro-fabrication of silicon chips will lead to a lab-on-a-chip (LOC) for large-scale diagnosis of autoimmune disorders.

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Near Field Communication (NFC) technology has gained interest among the business community and has attracted researchers to overcome interoperability, infrastructural issues as well as creating new business cases. At present there is no common secured communication infrastructure over which interested parties from diverse domains and actors can play their role with confidence in terms of security and trust. To encounter these problems, 'Store Logistics and Payment with NFC' (StoLPaN) is a European project that has defined open commercial and technical frameworks for NFC-enabled services on mobile devices and hence creates a universal environment that will facilitate the deployment of NFC-enabled mobile applications across a wide range of vertical markets, regardless of the mobile device type and the nature of the services required. The host environment also promotes the deployment of NFC-enabled mobile applications in many diverse application domains.

In this paper, we outline the applicability of LOC and mobile NFC in the diagnosis of health but particularly focusing on the insights leveraged through the proposed the universal NFC based host environment to deploy LOC functionalities and major innovations of the proposed plan.

2 PORTABLE HEALTH CARE DIAGNOSTIC PLATFORM

2.1 Identification of the Problem: Application of Mobile NFC

An NFC device with an internal power supply is considered *active*. A device with no internal power supply, such as a smart card, is considered *passive* and. Inductive coupling causes a passive device to absorb energy from an active device when it gets close enough. Once powered up, the passive device can communicate and exchange data with the other device. The ability of NFC devices to work as both passive and active enables them to function as either contact-less cards or readers (Ortiz, 2006; Leong et al., 2006). Near Field Communication or NFC technology can be used in various health care applications as a robust way of gathering, processing and automating the process of e.g. reminding patients when it is time to take their prescribed drugs, based on the prescriptions provided by pharmacy (http://www.nfcnews.com/articles/2008/01/28/nfc-competiton-winners-announced).
Moreover, NFC-enabled devices can be used for off-line monitoring of heart rates, glucose or blood pressure (http://www.parksassociates.com/digitalhealth/research/report3.htm). Other application areas would be in making our environment friendlier, which applies mainly to disabled persons.

NFC-enabled mobile platforms are rapidly evolving, getting into our daily activities and are in general interests of ordinary people. Common mobile technology used with inexpensive easily available tags, and soon possibly sensors as well, makes the functionality widely available.

Networked medical devices will enable to provide healthcare where constantly gathered and analyzed information enables to protect patients continuously with ad hoc decision support system. Furthermore, NFC-enabled health monitoring and diagnostic platform will create new opportunities for the medical health care, but as well for the whole medical device industry. In addition, some of treatments will require no more regular doctor visits and should be achievable by integration of different NFC-enabled devices.

Besides, health measurements devices can support self-care (Kaasinen, 2005), which could help societies to deal with illnesses caused by unhealthy living. For example, many of health problems might be related to overweight and in number of cases implementation of self-motivation system that stimulates efforts or eating healthy food could possibly solve, or at least marginalize the problem. Monitoring and presentation of analyzed data with goals matching could give feedback that will enable people to consciously keep fit and healthy.

2.2 Towards a Solution: An NFC Host Environment

In order to accurately address the interoperability issues currently affecting the mobile NFC technology, various usage cases are to be defined within the StoLPaN framework and tested throughout Europe. These use cases will contribute to the identification of a common set of business rules, which will define the roles and responsibilities of every player in the NFC ecosystem. The results will then be submitted for approval to the relevant industry bodies for standardization of payments, mobile, transit and ticketing as well LOC applications.

Based on these findings, the consortium will look into the specifications for technical requirements and the security aspects of NFC-enabled applications. They will also explore the connection to existing contact-less platforms, easing

the burden on individual providers. At the same time the project team will demonstrate how the business rules and technical requirements can be implemented in existing contact-less infrastructures. A NFC host application will be developed to support a range of services, including payment, access control, ticketing, loyalty, connectivity, and the retail check-out process; which consumers will be able to use with any NFC-enabled device.

The host environment developed under StoLPaN project demonstrates a universal mobile J2ME host application that will provide transparent uniform operating environment in the mobile handsets for the selected (and potentially other) NFC applications neutralizing specifics of the handset design and taking care of resource management.

The application will on the one hand, hide the specifics of the various mobile handsets – different manufacturers, different operational specifics, different versions, etc – and will on the other hand provide all the necessary resources and features – communication access, security solutions, etc.- that were identified during the technical analyses for the individual NFC use cases. There will be one generic version of J2ME host application to be run on any selected mobile handset models.

Remote deactivation of unsorted multiple smart tags without interfering with the user functionality, but at the same time providing adequate security protection for the smooth user operation as well have been addresses by StoLPaN initiative.

Specification of a new J2ME host for NFC business applications handles the basic technology and also provides a general operating environment for the various business instruments that may individually be integrated into the application. The output of this research will have to be presented for future standardization, otherwise handset independence is hard to realize. The same application would provide the operating environment for the NFC purse, establish the necessary connection between the handset's resources and the chip. This solution most probably will be based on the extension of the general NFC Java API.

Establishment of secure bidirectional transmission between wireless channels and NFC chip where the mobile purse can be recharged over the air it must be ensured that secure communication can be established between the wireless channels and the NFC chip. The same functionality and technology is necessitated for the remote management of the various NFC applications that can be stored in the mobile host environment. Similar is the requirement in case when the mobile handset acts as payment terminal, where the secure communication between the chip and the wireless channels is required into the other direction.

Creating secure NFC chip-to-chip communication for P2Pby a useful extension may be the elaboration of the technology that ensures secure chip-to-chip communication to facilitate direct purse-to-purse payment. This work does not only involve technical research, but has an operational and security aspect as well, as the applied technology must be supported with adequate operation and fraud prevention.

2.3 Proposed Platform Combining POCEMON and StoLPaN

This The POCEMON platform has been aimed to develop a portable monitoring system for auto immune diseases such as rheumatoid arthritis (RA) and multiple sclerosis (MS) (http://www.rheumatoid.org.uk/index.php?page_id=36; http://www.nap.edu/openbook.php?record_id=10031&page=17).

Health authorities aim to provide patients with personalised diagnosis and treatments, driven by state of the art diagnostic and communication technologies. The system is based on Lab-on-Chip (LOC) technologies that use microarray genotyping and microelectronics to carry out diagnostic testing at the primary healthcare level. The system provides rapid diagnosis via mobile diagnostic devices and wireless communications. Basically, it uses LOC technology to allow rapid DNA analysis from small quantities of blood/saliva. The chip functions by increasing the quantity of sample via replication of the patients' DNA, followed by hybridisation of the patients' DNA with a microarray of characteristic autoimmune disease gene templates. The microarray scanning and recording of genotyping results are controlled through the PDA via a multipurpose LOC adapter.

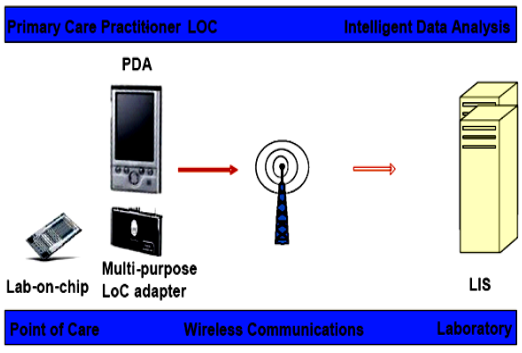

Figure 1: POCEMON Operation.

The genotyping data generated by the LOC are assessed using intelligent algorithms linked with the laboratory information system to provide detailed diagnosis and medical treatment advice. This process functions through the LOC's integration with mobile devices and communication with the laboratory information system via wireless communications.

Recent research efforts suggest the high-potential of NFC technology for short-range connectivity between health monitoring devices and mobile terminals and data stores propose practices to apply NFC to some health monitoring applications and study the benefits that are attainable with NFC. The value of these is significant, especially in long-term diagnostic analysis and in chronic disease management. From the usability point of view, wireless communication links are preferable to cables because they facilitate measurements and management of diagnostic analysis at real-life settings (Strommer et al., 2006).

The StoLPaN host application (Benyo et al., 2007) allows the collaboration among the diverse applications, diverse service providers, diverse network operators and the diverse of type of mobile devices.

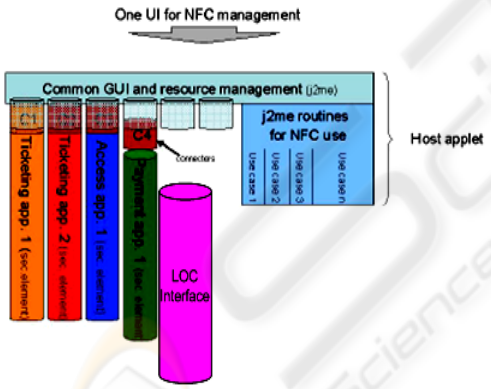

Figure 2: StoLPaN Host Environment.

The host is able to support multiple NFC services, provide access to the phone's resources and facilitates the loading, use, maintenance and deletion of third party NFC enabled applications via common API between the third party application and the mobile device's, common API between the service provider and the third party's application provisioning Platform, simplifying validation of adherence to their service level agreements. Besides a common User Interface for applications loaded into the Secure Element or the host's JAVA storage, providing value added features to existing contact-less services. It will simplify the learning curve associated with any new application.

3 INNOVATIONS OF THE PROPOSED APPROACH

Major POCEMON objectives directly arises by *the integration of multi-technology sets that underlie new functionalities, services and applications* sufficient enough to provide portable and mobile ICT systems which facilitate point-of-care diagnosis at the primary care level. Also, new diagnostic software will be developed for PDA/Mobile devices making this technology more attractive to primary care and allowing future mobile devices to be used for health monitoring, even at home (connected any time, anywhere and to many services). The development of the diagnostic Lab-on-Chip device will lead to innovative technological achievements which will strength European microelectronics industry offering smaller systems, cheaper, smarter and friendlier.

The main part for the point-of-care diagnosis of autoimmune diseases is based on the development of the appropriate software capable to perform automated micro-array analysis to measure the genes expression. The software will be implemented for desktop workstations and for PDAs.

Image processing is an important part of every micro-array experiment. Reliability of this part strongly influences the results of data analysis performed on extracted gene expressions. The image analysis functions will use the filenames and the red and green channels of the spotted images. The main image analysis software will be developed using Contrast enhancement, Sub-array extraction, Dilation and erosion, Extraction of individual spots, and Information extraction.

Also, *communication software* will be developed both for information exchange and data transmission between the PDA/Mobile Device and LOC as well PDA/Mobile Device and the desktop station (Laboratry Information Server - LIS) which will be accommodated in a laboratory of a large medical centre. The communication will be mainly wireless (except for large-distance primary care diagnostic point-of-care places) using the well established internet communications protocols and the data will be transmitted securely in a private network.

All these procedures will be developed as standalone software that will interact with the LOC from the PDA/mobile device. The detailed version

of the automatic micro-array image analysis software and the diagnosis extraction mechanisms will be hosted on the LIS. Also the desktop station software will be capable to provide treatment advices for autoimmune diseases and the knowledge will be extracted by combining all the stored gene data. In order to allow new diagnostic tests to be performed and new decision rules to be applied the PDA software and the cards will be able to change.

4 CONCLUSIONS

In conclusion, the NFC host environment provides a seamless interface for analyzing LOC data, without requiring any detail handling of hardware/software interface issue. As a result the thorough research carried out under POCEMON will be facilitated from StoLPaN environment that will provide the delivery of mobile information services in the professional primary care environment, and to present solutions for providing decision support information on small, portable or wearable platforms. The main objective of providing mobile devices packaged with relevant high-quality software tools for health-practitioners in the near future will accelerate the establishment of interoperability standards and secure communication of health diagnostic data between all involved partners of the project, including patients.

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