Health Pervasive Systems Workshop (HPS 06) in conjunction with ICPS 06
29 June 2006, Lyon, France
http://liris.cnrs.fr/hps06

Aims and Scope

Health care systems cannot today be imagined as closed local information systems. Patients care quality requires all care practitioners to communicate their medical data, wherever they come from: hospital, general practice, private consulting… Moreover, the medical file has to be a unique but distributed record that should be accessible from any place at any time by care practitioners. Mobility, ubiquitous access, interoperability and adaptation are thus key topics that we have to consider.
The Health Pervasive Systems workshop aims at facilitating exchanges and discussions between researches, industrials and other contributors working on these topics.

List of topics

We welcome the submission of papers from the full spectrum of issues related with health pervasive systems. Papers may focus on architectures, methods, technologies, protocols, prototype developments, case studies, applications, practical experiences on health pervasive systems. The list of topics includes, but is not limited to:
Care practitioner mobility
Patient mobility
Empowering patients to manage and improve their own health
Care networks and information sharing
Distributed patient record
Sensor networks
Health standards for pervasive systems
Health ontologies and pervasive systems
Information systems for emergency, ambulances, 911…

Paper submission and proceedings

Authors are invited to submit original manuscripts, which should be written in English and with a very precise and concise presentation of no more than 6 pages in IEEE double-column format. Authors are invited to send their manuscripts as an attachment (PDF or PS format) by email to the workshop chairs at hps06@liris.cnrs.fr Submission implies the willingness of at least one of the authors to register and present the paper. Proceedings publication is under negotiation.

Important dates

Submission of papers: March 31, 2006
Notification of acceptance: April 20, 2006
Camera-ready version of papers: April 31, 2006
Workshop date: June 29, 2006

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Accepted papers and workshop program

Not yet available

Registration

Registration fees: to be announced

Accommodation

Hotel rooms in various price categories will be booked in Lyon, France.
To find hotel information, please refer to the ICPS'06 web site

Venue

Details will be found in the ICPS'06 web site

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AUTHOR(S): *Bing Wu and Kudakwashe Dube*

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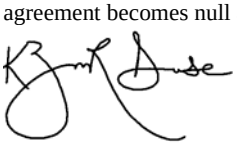

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Diet and Lifestyle Analysis, Advice and Monitoring for the Public Healthcare Domain: A Framework and a Prototype System for Supporting Diet and Lifestyle Guidelines

Bing Wu and Kudakwashe Dube, *Member, IEEE*

Abstract*— It is well recognised that nutrition, diet and lifestyle play major roles in the improvement of quality of life and disease prevention and management in modern society. With the advances in Information and Communication Technology, it has now become possible for a 'modern' system and a new approach to be developed that exploits pervasive computing technologies in addressing the problem of the ready and easy accessibility of diet and lifestyle advice and monitoring, which is crucial for the management of clinical problems such as diabetes. With an easily accessible and reliable system, not only does each individual stand to benefit with an improved quality of life, but also, society as a whole will benefit through an overall improvement in public health and disease management. This paper presents a framework, DLAM (Diet and Lifestyle Analysis and Monitoring framework), and a prototype system, DLAAS (Diet and Lifestyle Analysis and Advice System), providing, within the public domain, user-specific diet and lifestyle advice, monitoring and feedback service based on the on-going analysis of the user's diet and lifestyle within a pervasive computing infrastructure. The approach presented uses a maintainable and flexible knowledge base from local domain expertise and the experts' interpretation of published national and international diet and lifestyle guidelines.

***Index Terms*—clinical practice guideline, ECA rule paradigm, diet and lifestyle, pervasive computing, active database**

I. Introduction

National and international guidelines on diet for the public have been developed but largely remain paper-based and difficult for administrators to disseminate and for the population to access within the public healthcare domain. The easy dissemination and availability of this type of information would allow people to take charge of their own diet and lifestyle-related health. Furthermore, the public healthcare system will benefit from significant healthcare quality improvement and cost reduction arising from improved diet and lifestyle and the containment of medical complications in various clinical problems, such diabetes and asthma, within the population. These benefit could be realised through the development of a system that will: 1) elicit dietary and lifestyle information from a user; 2) analyse this information; 3) determine the appropriate advice to give to the user with respect to diet and lifestyle improvements on an on-going basis; and 4) exploit the pervasive computing technologies. The approach used in our framework, *DLAM (Diet and Lifestyle Analysis and Monitoring framework)*, and its prototype system, *DLAAS (Diet and Lifestyle Analysis and Advice System)*, contributes a readily available environment that provides expert diet and lifestyle advice and on-going monitoring service with ease-of-use to the general public without special training. The ultimate aim is to create a software platform for the delivery of a long-running diet and lifestyle advice and monitoring service within a pervasive computing environment. Most existing systems do not provide a comprehensive user monitoring and feedback service. Furthermore, these systems and approaches require the user to have some knowledge of diet and nutrition.

The rest of this paper is organized as follows: Section II outlines the background to the problem and our research work; Section III related work; Section IV presents a description of the problem that is being addressed in this paper; Section V presents the conceptual approach and *DLAM*, the *Diet and Lifestyle Analysis and Monitoring* framework; Section VI presents the design of the proof-of-concepts prototype system, DLAAS (*Diet and Lifestyle Analysis and Advice System*); and Section VII outlines on-going and future work; and Section VIII summarises and concludes this paper.

II. Background of Study

While there is general public awareness regarding what is a healthy diet for an individual member of the public, there is a lack of easily accessible expert diet and lifestyle advice and monitoring services and tools for the general public. The aim of this work is to investigate the problem of using a computer-based guideline approach in order to give dietary and lifestyle

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improvement service, which is: 1) specific to the individual, 2) provided on an on-going basis with ability to monitor and give feedback, 3) accessible within the public healthcare domain, and 4) enabled for the pervasive computing environment. Currently, there is an ongoing research work in the K-Camp Research Group in the School of Computing at the Dublin Institute of Technology (DIT) whose main aim is to develop a generic framework together with its supporting specification, manipulation, query and replay language set and computing software environment for managing complex and complicated information that is involved in supporting the management of computerised clinical guidelines. This paper puts into practice the overall conceptual approach to computerised guideline management as developed in the on-going research work within DIT [1, 2].

III. Related Work

Research and practice on computerised clinical guidelines [3] have been conducted for a relatively long time. A number of approaches and methods for supporting the management of computerised clinical guidelines has emerged from various research works. For a detailed review of these works, the reader if referred to Miksch [5] and de Clercq et al [7]. The problem of providing easily accessible and expert personal diet and lifestyle advice and guidelines has been identified before [4, 5]. The *Interactive Healthy Eating Index* (IHEI) system [4] is relevant to the work presented in this paper. The IHEI system is difficult to use, as the user must search for individual foods eaten in a day. The food search engine can have difficulty in finding some foodstuffs. The user's history is stored using cookies, so can only lasts 20 days. The *Dietsure* system [5] is another relevant work in which the user must answer a questionnaire in order to get an analysis of dietary intake. The final advice given is difficult to decipher because of the large amount of information that is irrelevant to the individual user. This work seeks to address the limitations of existing systems by investigating and providing a solution to the problem of providing, in a readily accessible way, expert diet and lifestyle analysis, advice, monitoring and feedback service based on local expert interpretations of published national and international guidelines. The major advantage of the approach and system presented here is that it adopts a generic guideline-based approach that allows for monitoring and feedback and combines this with the exploitation of the pervasive computing environment in order to ease accessibility and adoption. The significance of the generic guideline-based approach is that it allows different guidelines to be specified and used with the system as well as supporting customization of these guidelines to suit and individual user's circumstances such as diabetic conditions, obesity and allergic conditions.

IV. Problem Statement

This paper addresses the problem of empowering the public in managing and improving their health through diet and lifestyle adjustment and assisted self-monitoring. The paper addresses this problem by presenting a framework and describes a web-based tool for personal diet and lifestyle analysis, advice and monitoring based on national and international diet and nutrition guidelines. The framework and prototype system presented in this paper aims at facilitating users to get advice regarding the following aspects of their diet and lifestyle:

1. *Adherence to the food pyramid rules;*
2. *Weekly alcohol consumption;*
3. *Nnutritional content of their daily diet;*
4. *Adjustments to be made to their daily physical activity and exercise;, and*
5. *Reviews of past and present progress through querying the database of user diet and lifestyle information.*

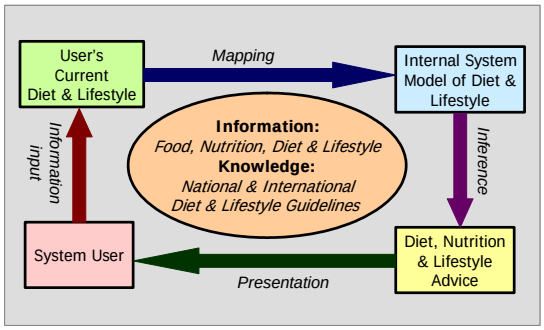
The knowledge used in diet and lifestyle analysis and advice exists in the form of the national and international guidelines. There are a number of different methods used by dieticians to assess a person's diet while also taking into consideration the person's lifestyle. They all take account of what a person eats and lifestyle activities, compare this to a healthy diet, and advise the patient regarding what their diet should be and what lifestyle adjustment should be made. The model used as the basis for a healthy diet is is mainly based on a food and nutrition guideline [1]. As illustrated in Figure 1, the core diet guideline is commonly expressed as a food pyramid.

Fig. 1 The Irish National Food Pyramid (INFoP) Guideline

In general, the diet guideline advises one to consume large amounts of grains, vegetables, and fruits with moderate intake of meat, milk and dairy products. In DLAAS, the food pyramid is converted into a set of rules, which are used to analyse the users diet [6].

V. The Framework for Diet and Lifestyle Advice and Monitoring (DLAM)

In the approach used in this paper, the users' current diet and lifestyle are analysed and user-specific advice is generated. This advice is currently being presented through a web-based interface to the user as messages pertaining to the various aspects of their diet and lifestyle. A programme of actions that specify what the user must do in order to improve their diet and nutrition-related lifestyle, is also generated. The

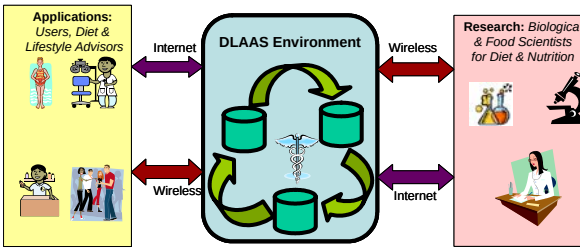


1. *Fig. 2 The Framework for Diet and Lifestyle Analysis and Advice via the web*

ultimate target is eventually to enable access to the overall service through a pervasive computing environment.

Figure 2 outlines the major aspects making up the Diet and Lifestyle Advice and Monitoring (DLAM) framework. To achieve the DLAM's objectives and build the computerised environment for delivering computer-generated personalized diet and lifestyle advise, personal diet and lifestyle information must first be acquired.

This will include facts relating to user's current diet (specifically fruit and vegetable intakes) and lifestyle, knowledge about an adequate and healthy diet as well as a knowledge about their willingness to make behavioural changes. In bringing about a change in dietary behaviour, greater success has been achieved when individual components of the diet have been the focus of the intervention compared to interventions on the whole diet. In deciding which of the many possible dietary behaviours to target it is important to consider which dietary changes will be likely to bring about the most cost-effective health gain. The dietary behaviour being targeted in this work is fruit and vegetables consumption. The reasons for this choice are two-fold: 1) Fruit and vegetable consumption in Ireland is extremely low at less than 200g/day among Irish adults. This is just half the recommended intake of 400g/day; 2) Fruit and vegetables are a component of the diet for which there is unanimous agreement for a beneficial effect from increasing their levels. A diet high in fruit and vegetables is protective for numerous cancers. This work is investigating the type and structures of knowledge required and how best to capture, structure and store it for use in a computerised environment. Techniques, mechanisms and computerised tools to support this are being investigated. As illustrated in Fig. 2, the DLAM framework involves the following tasks: 1) the system needs to acquire dietary information from the user; 2) this information is then mapped onto an internal model of a diet; 3) this mapping results in the generation of dietary advice; and 4) the advice should then be presented back to the user. The system needs to have 1) facts relating to user's current diet and lifestyle; 2) knowledge about an adequate and healthy diet; 3) knowledge about the effect of lifestyle on a diet; and 4) knowledge about the relevant dietary advice



2. Fig. 3 The context and environment for DLAAS

VI. DLAAS: The Diet and Lifestyle Analysis and Advice System

A. *The High-Level Context Model for DLAAS*

The main aim the DLAAS system will be the establishment, for the general public as well as health professionals, of an interactive advanced pervasive computing information environment on human nutrition, diet and lifestyle. Fig 3 illustrates the context and environment for DLAAS. As illustrated in Fig 3, the key stakeholders for DLAAS are the public in general, health professionals and the health research community. The ordinary members of the public who use the system are provided with easily accessible and reliable information on nutrition, diet and lifestyle to improve quality of life. Health professionals are provided with an improved dissemination environment to assist in providing existing services. The healthcare research community is provided with an improved, easily accessible databank of the individual diet and lifestyle information for research purposes.

B. *Requirements for DLAAS*

The main requirements for DLAAS are illustrated by the Use Case Diagram in Fig 4 and can be summarised, from a functional perspective, as to:

1. Capture diet, lifestyle and nutritional information and guidelines;
2. Use a knowledge representation formalism to capture and exploit the diet and nutrition guideline knowledge in analysing a user's diet and lifestyle;
3. Generate user-specific diet and lifestyle advice or guideline;
4. Present the advice to the user using a readily accessible mechanism;
5. Monitor and provide feedback to the user and the domain expert;
6. Provide diet and lifestyle statistical data to researchers;
7. Accept and store food and nutrition information from researchers;
8. Provide tools for managing investigations or trials over user populations; and
9. Provide communication interfaces to pervasive devices.

As illustrated in the Use Case Diagram of Fig 4, members

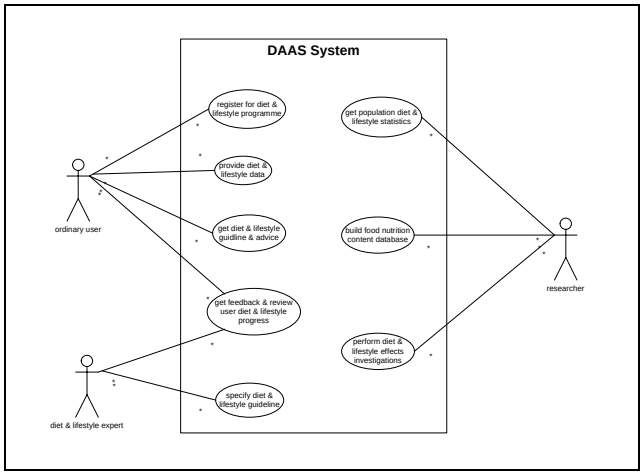


Fig. 4 Use Case Diagram modelling the requirements for DLAAS

of the public, diet and lifestyle experts and biological and food scientists can use the DLAAS system. The ordinary user, a member of the public, registers into system and provides his/her diet and lifestyle information, which results in the output of diet and lifestyle advice, while a dietician can provide the diet, lifestyle and nutritional guideline specifications as well as maintain the these specifications. The scientific researcher can get statics, build the food and nutrition content database, and perform diet and lifestyle effect investigations or trials.

C. Modelling the Guideline Knowledge for DLAAS

In the current version of the proof-of-concepts system, the production rule formalism is used to represent the diet and lifestyle guideline knowledge. The Irish Food Pyramid [6] has been used as a case study example guideline, which was encoded into a set of rules developed with the help of expert nutritionists in DIT. The following rule illustrates an example of one of the rules developed to model the Irish National Food Pyramid (INFoP) guideline:

> *If the number of servings per day of category 1 is greater than 6, the relevant advice is given, e.g., that the user is getting more than the recommended amount. If the number of servings is less than 6, the user is told they are getting less than is required. If the number of servings is 6, they are told they are getting the correct amount. 4 or less servings per day is designated as less than the accepted minimum.*

Thus, all the knowledge associated with each of the layers of the INFoP guideline as well as guidelines on alcohol consumption, and nutritional intake are encoded into rules that are then stored in the system's knowledge base.

D. The Conceptual Architeture of DLAAS

Fig 6 illustrates the proposed conceptual architecture for the DLAAS system. The system aims at facilitating accessibility to its services via a pervasive computing infrastructure. In

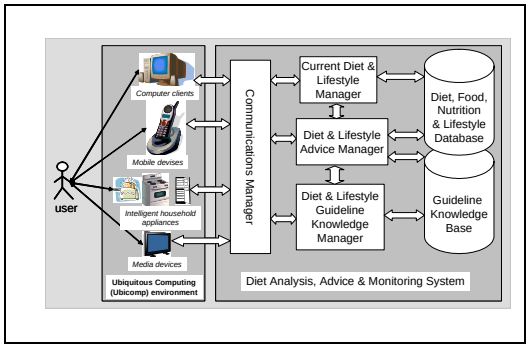


Fig. 6 DLAAS system architecture

order to analyse the user's diet and lifestyle and generate appropriate advice, a database, knowledge base and an inference mechanism are required to hold and apply the diet and lifestyle information and knowledge provided by national and international guidelines. The communications manager handles information flow between the system and various devices within a ubicomp environment.

The system acquires dietary information from the user via a variety of computing devices. Guidelines, such as the Irish food pyramid, are held in the knowledge base from where it can be manipulated, maintained and dynamically applied in the determination of diet and lifestyle advice. Thus, the knowledge base is used to generate the required advice that is specific to an individual user. The user's computed diet model is compared to an internal diet model, which is based on the guidelines as stored in the knowledge base. This comparison generates advice to be presented back to the user via a device of choice.

E. The Support for Diet and Lifestyle Monitoring and Feedback

The monitoring of an individual user's diet and lifestyle is achieved through the user's input using pervasive computing devices such as the mobile phone or the PDA as well as through data delivered by intelligent home devices such as radio frequency identification (RFID) tags on food items, "intelligent" fridges and waste bins that can monitor item inflows and outflows. Thus, DLAAS requires diet and lifestyle information to be gathered by using intelligent house appliances, such as intelligent fridges, and sensor technologies such as radio frequency identification (RFID) tagging and portable or in-built bar-code scanning devices. For instance, a user may carry a portable device for use to input food item information during a grocery shopping session at the supermarket. Monitoring of the user's diet and lifestyle is made possible by information gathering from various pervasive computing devices that are wirelessly connected in the user's environment. The user's diet and lifestyle model is continuously revised on the basis of the collected information. Assessment of the goals is achieved by comparing this model with the ideal model constructed from the diet and lifestyle guidelines. This generates further advice that will have the

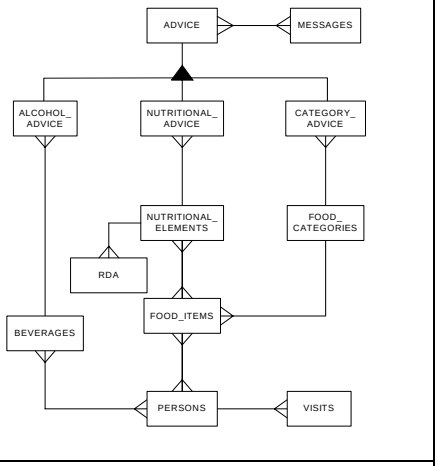


Fig. 7 Extended entity relationship diagram (EERD) for DLAAS

effect of moving the user's diet and lifestyle model towards the desired and ideal diet and lifestyle model. The same communication links among pervasive computing devices within the user's environment are exploited in sending feedback messages to the user. Such a monitoring and feedback mechanism is useful in the diabetes domain where diabetic patients require close continuous diet and lifestyle monitoring and feedback in order to attain the goals of the diabetes care and management guidelines. One of the aims of this research work is to investigate the application of the DLAM approach and system, DLAAS, in the diabetes domain at a local hospital.

F. Proof-of-Concepts Prototype of DLAAS

Fig 7 illustrates the core data model in the form of an extended entity-relationship diagram (EERD) for the proof-of-concepts prototype system, DLAAS. The *person* is the core entity in the system. DLAAS stores information relating to each *visit* a user makes to the system. The system must accept the *food item* information the user consumes at various time during the day. The relationship between a person and a food item is the person's *die*t. Each food item belongs to a *food category.* Food categories contain information about the five layers of the food pyramid [6]. Each food item is also composed of various different *nutritional elements.* The relationship between these two entities is the *nutritional value* of the food item. Each *nutritional element* has a recommended daily amount (RDA), which a person should consume. This RDA depends on the users demographic information. A person's diet is analysed according to the amount of alcohol they consume in a week. The *beverage* entity represents information about alcohol. The user will be given three types of advice: *alcohol advice*, *nutritional advice* and *food category advice*. The *advice* that the system will offer the user will be made of a number of advice *messages* concatenated together. The ERD illustrated in Fig. 7 forms the basis of the diet and lifestyle schema for the database used in DLAAS.

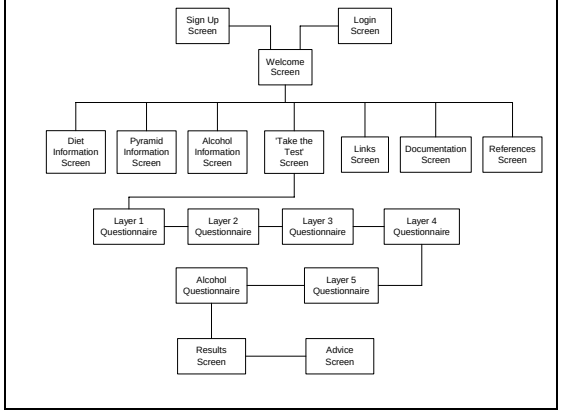
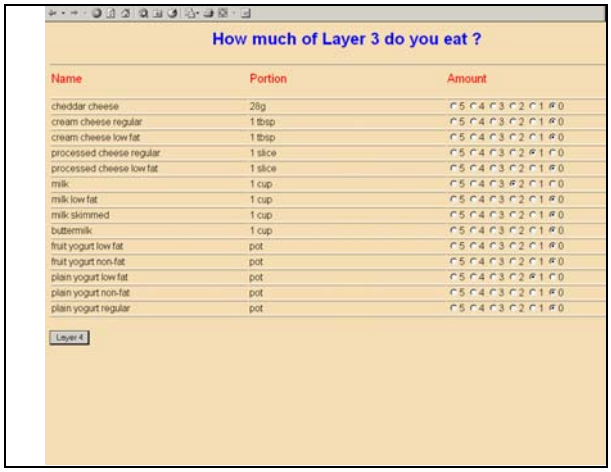


Fig. 8 The web-based interface model for DLAAS

G. The Web Interface and Deployment of the Proof-of-Concepts Prototype of DLAAS

Although the ultimate objective is for DLAAS to operate and deliver diet and lifestyle advice and monitoring information within a pervasive computing environment, the initial and current version of DLAAS uses a web-based interface. Fig 8 presents the web-based user interface model of the DLAAS.As illustrated in the figure, there are a number of routes the user can take through the system, but when they begin the test they must continue until they receive their dietary advice. The site is composed of a number of screens that provide the user with information about DLAAS (Fig 8), diet, the food pyramid, and alcohol intake. There are also pages with links to other relevant sites, references, and the documentation of the system. The user can also 'Take the Test' where they are taken through a number of screens where they are questioned regarding the amount of foods they eat from each layer in the Food Pyramid [6]. The user is shown screens, one of which is illustrated in Fig 9, questioning them about their daily intake of the food category layers in the INFoP guideline, and their weekly intake of alcohol. This information is used to compare the users diet and lifestyle to the ideal diet and lifestyle model stored in the knowledge base. The advice relevant to the user and their diet is then outputted to the screen. Further development of DLAAS is necessary before the system can be put into productive use for evaluation. The critical components of the system are: 1) the database for Irish food nutrient content database; 2) the Irish and international diet and lifestyle guidelines;and 3) a mechanism to deliver the system services within a pervasive computing environment that includes mobile phones, PDAs and handheld clinical instruments used by diabetics. The development and computerization of these key elements of DLAAS are inter-disciplinary tasks that require consideration effort and time. The K-Camp Research Group is currently putting together a multi-disciplinary team composed of researchers in computing, dietetics, food science and electronic engineering for the purpose investigating the



3. Fig. 9 Layer 3 questionnaire

development of these key components of DLAAS.

VII. Outline of Ongoing and Future Work

Further enhancements of DLAAS are currently ongoing. The key aspects of DLAAS that are being enhanced are: 1) the Irish food nutrient content database; 2) the formalization of the Irish and international diet and lifestyle guidelines; and 3) a mechanism to deliver the system's services within a pervasive computing infrastructure that includes the devices: mobile phone, PDA and a portable glucometer that is used for measuring blood sugar levels in diabetes patients. The development of these key components of DLAAS is an inter-disciplinary project within the K-Camp Research Group including researchers in computing, dietitics, food science and electronic engineering. On-going investigations are focusing on providing dietary advice and monitoring for the special clinical problem domains of diabetes and food allergies. As part of future work, the DLAM framework and the methods developed for it will be further enhanced to incorporate results of our on-going work on supporting complex information management for computerized clinical guideline support [1,7].

VIII. Summary and Conclusion

This paper has addressed the problem of empowering the public and health professionals in the task of managing and improving an individual's own health by providing an easily accessible diet and lifestyle advice and assisted on-going self-monitoring service. The paper presented the conceptual approach and framework DLAM (Diet and Lifestyle Analysis and Monitoring) together with the method and a proof-of-concepts system, DLAAS (Diet and Lifestyle Analysis and Advice System), for diet and lifestyle analysis, advice and management. The system addresses the need to have individual members of the public to be in control of their own diet. Making such a system available in the public healthcare domain would ensure that people have readily available expert-level diet and lifestyle advice and continuous monitoring based on a system that uses knowledge from consultation with dieticians and national diet and lifestyle guidelines.

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