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A Model Driven Approach to Care Planning Systems for Consumer Engagement in Chronic Disease Management

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Abstract
This work demonstrates a model-driven approach to the development of care plan systems, amenable to: (a) a flexible and extensible definition of care plan scope; and (b) deployment of care plan viewing and tracking functionality to a wide range of physical computing devices. The approach utilises a care plan domain model from which guideline implementers formulate care plan templates aligning to specific clinical guidelines. A clinical end user would subsequently constrain that template (e.g., selecting a subset of available activities and specific targets) to create a care plan instance for an individual patient. An XML care plan visualisation definition created using the Marama tool is transformed to OpenLaszlo script from which Shockwave Flash objects can be compiled, creating Flash applications that run on a variety of hardware for both clinical and patient users. The approach is illustrated with respect to an overweight and obesity guideline.

Keywords: Health care planning, Mobile Health Applications, Model-driven Engineering, Electronic Health Records

1. Introduction

There is obvious potential for benefit from the provision of electronic support for chronic disease management. Warren et al. [1] demonstrated that the intent of chronic disease management guidelines could be accurately modelled in a decision support tool for care planning. More recently, in New Zealand, the PREDICT CVD/Diabetes tool for cardiovascular risk assessment and management is now widely deployed and is contributing to improved documentation and understanding of cardiovascular disease risk factor [2,3].

E.H. Wagner's Chronic Care Model envisages 'productive interactions' between an informed, activated patient and a prepared, proactive practice team [4]. Such a model mandates the engagement of both the health provider and the health consumer in creation, monitoring and maintenance of a shared care plan. Successful systems have emerged for components of the Wagner process: e.g., (a) the Ferret system has been installed in more than 50 community clinics in Queensland, predominantly in the northern areas, to provide electronic care plans and chronic disease management support for a range of common chronic conditions [5]; and (b) the STOMP system has demonstrated significant improvement in smoking cessation via a txt messaging based dialog direct to consumers [6]. With the emerging success of individual systems, the question is how to achieve more general platforms to support dissemination and tracking of individually tailored care plans, and how to encompass both healthcare providers and health consumers in the scope of a single software solution.

We describe a prototype care plan design environment utilising a concept of "Domain-specific Visual Languages" to enable health practitioners

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to model, tailor and deploy chronic disease care plans on mobile devices. A generic care plan for management of a chronic disease is specified including key health activities, performance metrics, and assessments. A generic care plan is then tailored to an individual patient's situation, specifying particular health activity intervals, duration, reviews, targets and metrics. A mobile application is then generated completely automatically from this tailored care plan description and deployed to the patient's mobile PDA or Smart Phone. Data is periodically uploaded from the device for monitoring by the health care provider and to facilitate patient/provider dialogue.

2. Methods

We have developed a domain model for care plans where care plans consist of performance measures (e.g., BMI), activities (e.g., jogging, or taking a specific medication) and, recursively, of sub-care plans. Activities have supporting attributes, notably schedules and instructions. Figure 1 provides a simplified representation of the care plan domain model. A domain-specific language (DSL) has been created using the Marama tool suite [] with an associated visual editor which permits production of XML definitions of care plans. Figure 4 shows an example of a generic care plan constructed using the DSL editor.

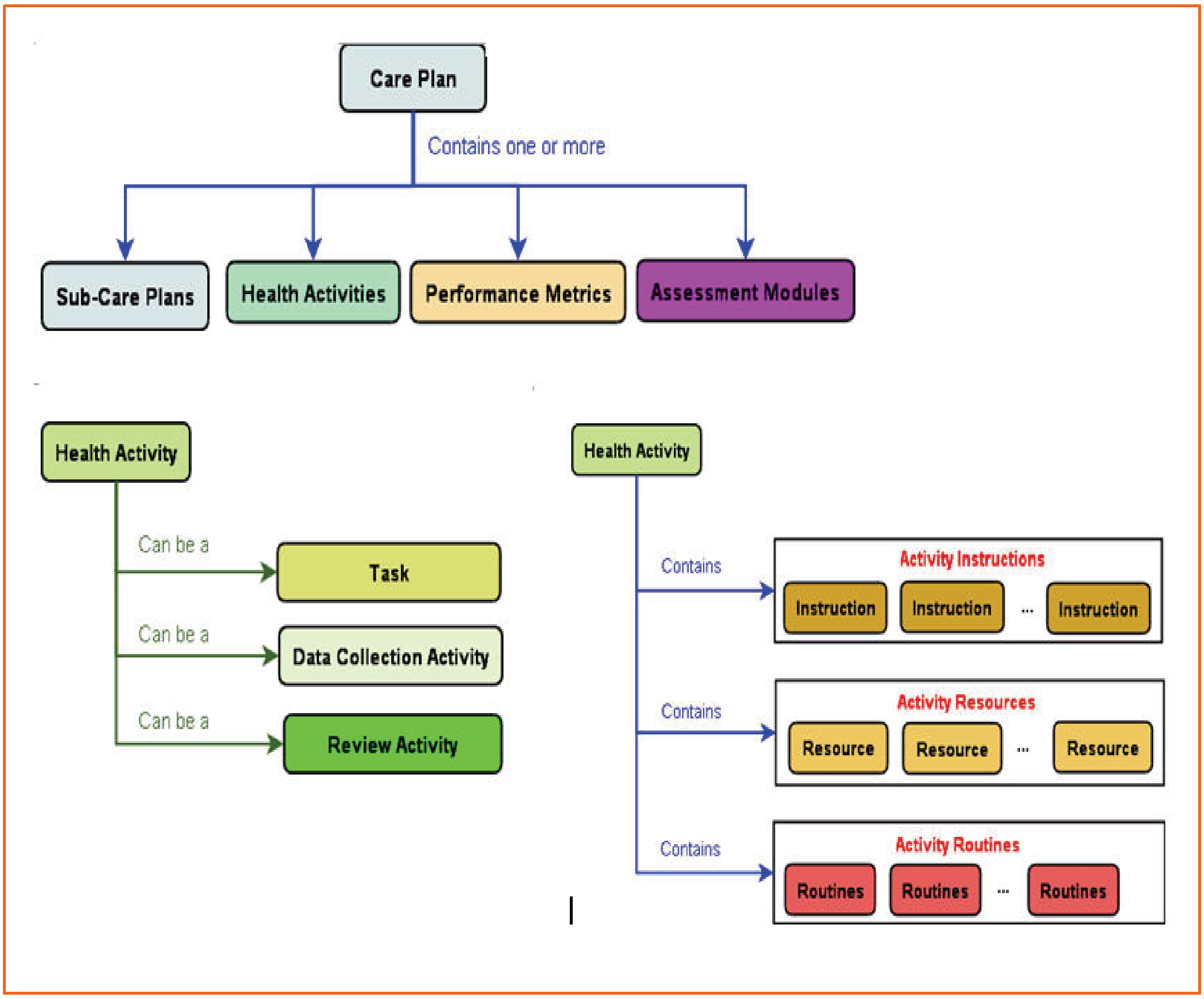

Figure 1. Key aspectsof the care plan domain model.

Our model of care planning calls for a two-stage application of the care plan DSL: (1) at a knowledge engineering stage, a care plan template is created to suit the requirements of an evidence-based clinical practice guideline; (2) subsequently, when a template is applied to a patient, the model can be edited to tailor the care plan for instantiation (e.g., to include individualized instructions, eliminate specific activities as being irrelevant and so on). At this second stage a specific timeframe for the duration of the care plan and its review schedule would be introduced.

A second modelling tool permits the instantiated, but still abstract, care plan to be mapped to a suitable graphical user interface. This step allows for the wide variation in form factors of mobile devices that the plan could be deployed to for patient use. The resulting concrete care plan may then be downloaded to the patient's preferred device (PDA, phone, etc) and executed using a generic Flash or DHTML based interpreter (we have used OpenLaszlo [] to develop this). We examine use of this approach to care plans on a conventional PC system for a GP tailoring and reviewing a care plan; and for reviewing and logging notes to adhere to specific activities on a smart phone device for a patient.

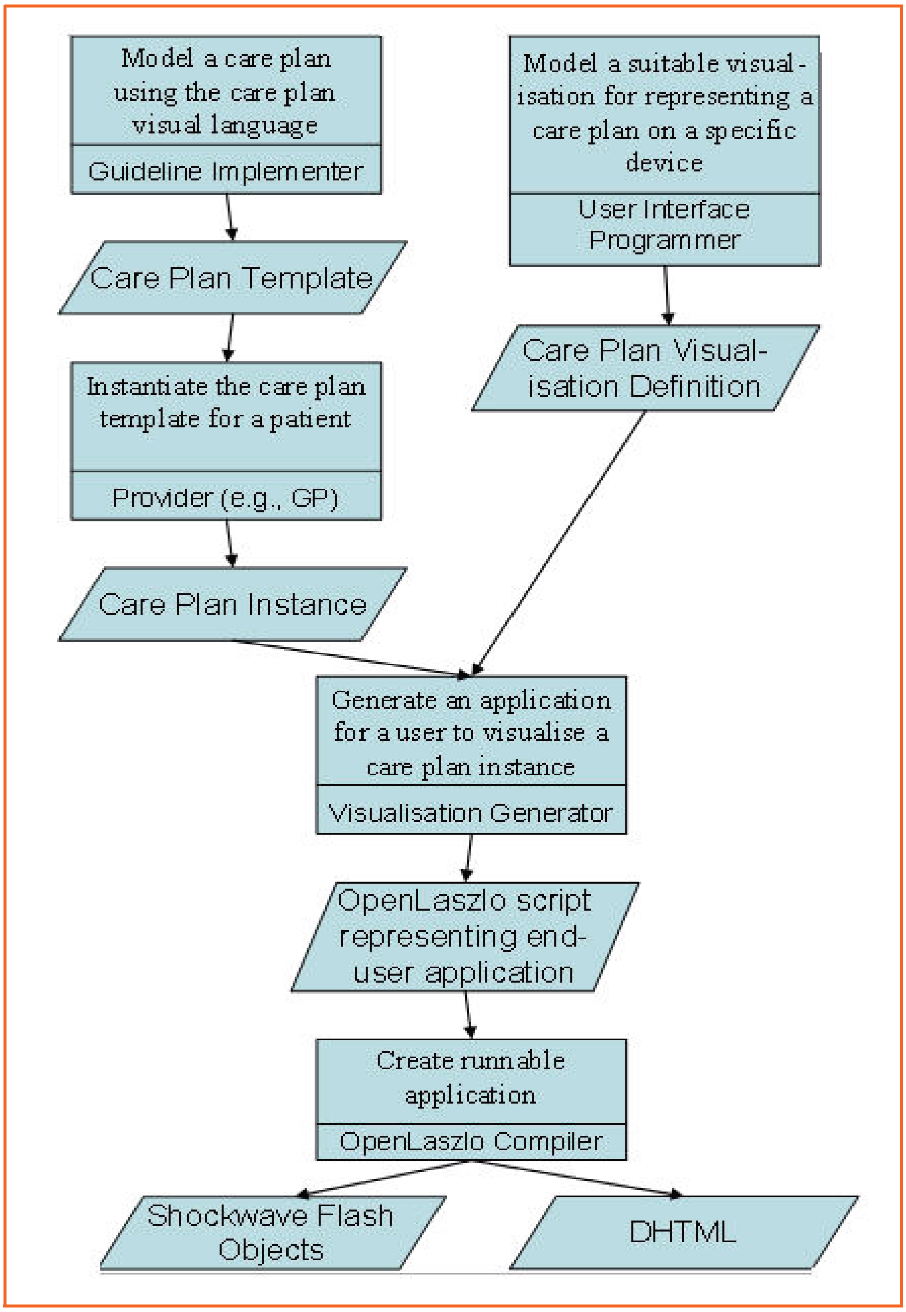

Figure 2. Care plan design and implementation process.

Figure 2 depicts the care plan development and implementation process. Chronic disease care plans are reusable and can be updated over time to improve treatment practice. Individual tailored care plans can be modified over time or even different versions of the care plan for the same patient developed and changed over time. The interface for the mobile care plan application can be tailored over time to better support the patient's needs.

3. Results

To illustrate the care plan modelling, tailoring and user interface implementation approach we use a US National Heart Lung and Blood Institute guideline for managing overweight and obese adults [9] as the source for formulating a care plan template. Figure 3 provides a simplified illustration of some of the care plan template components for the overweight and obesity guideline based on our care plan domain model. In this example, a periodic review of the obesity care plan is to be undertaken. The management plan includes periodic glucose measurements, two alternative exercise activities (jogging and swimming) and a Reductil pharmacotherapy treatment plan. The glucose measurement activity consists of a set of instructions for using a pricking needle, a testing meter, and a gluco testing card. Readings are to be taken every six hours

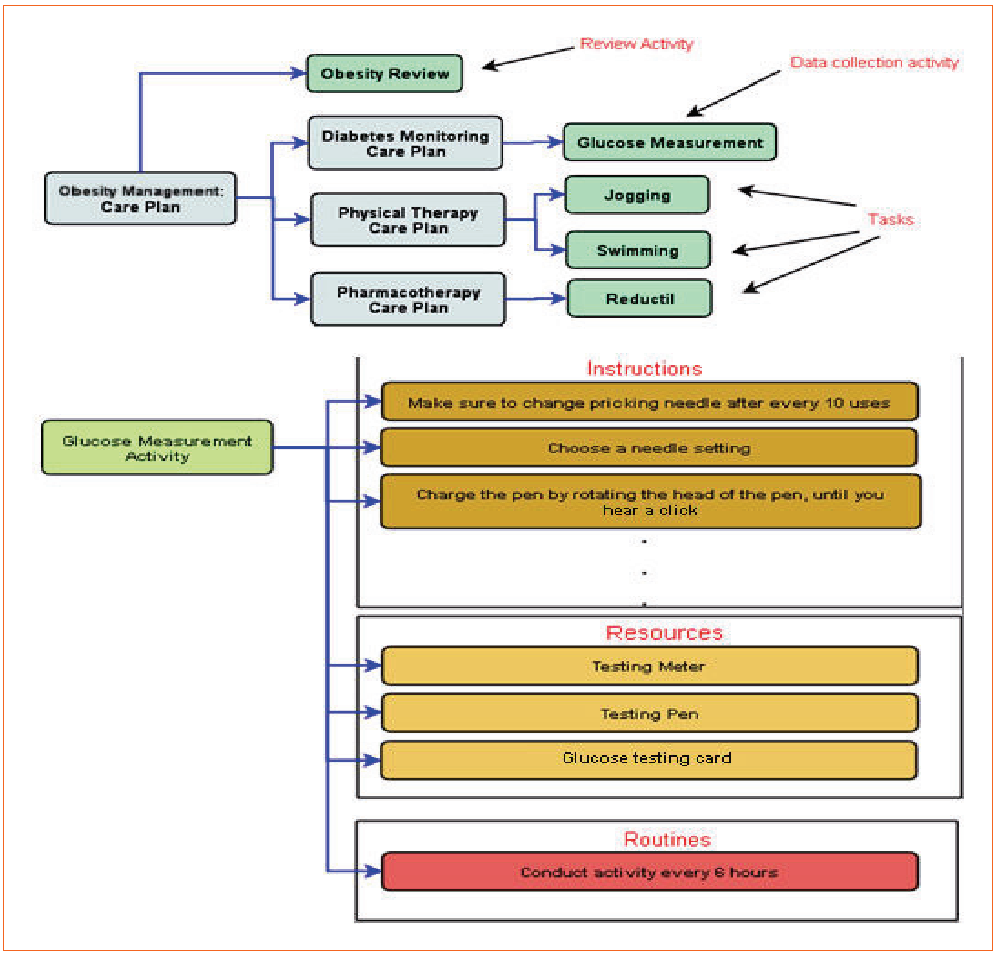

Figure 3. Some of the care plan template components for a care plan based on an overweight and obesity guideline [9].

To create mobile care plan applications based on the guideline requires care plan visualisation definitions to be created. Figure 4 shows part of a diabetes care plan model specification for the example in Figure 3 using our DSL editor. The result of this specification is a generic care plan definition, which can be tailored for a particular patient and then transformed to OpenLaszlo script. This script can then be compiled to an end user application. A second visual language is used to specify how the items in the care plan are represented by elements in a mobile device user interface.

Figure 5 shows screen shots of a care plan instantiation screen used by a care coordinator on a desktop PC. This allows a generic care plan to be tailored for individual patient use. In this example the patient will use jogging as their physical exercise activity, every two days for 20 minutes. The swimming activity in the generic plan has been removed (by deselecting it) as being inappropriate for this patient.

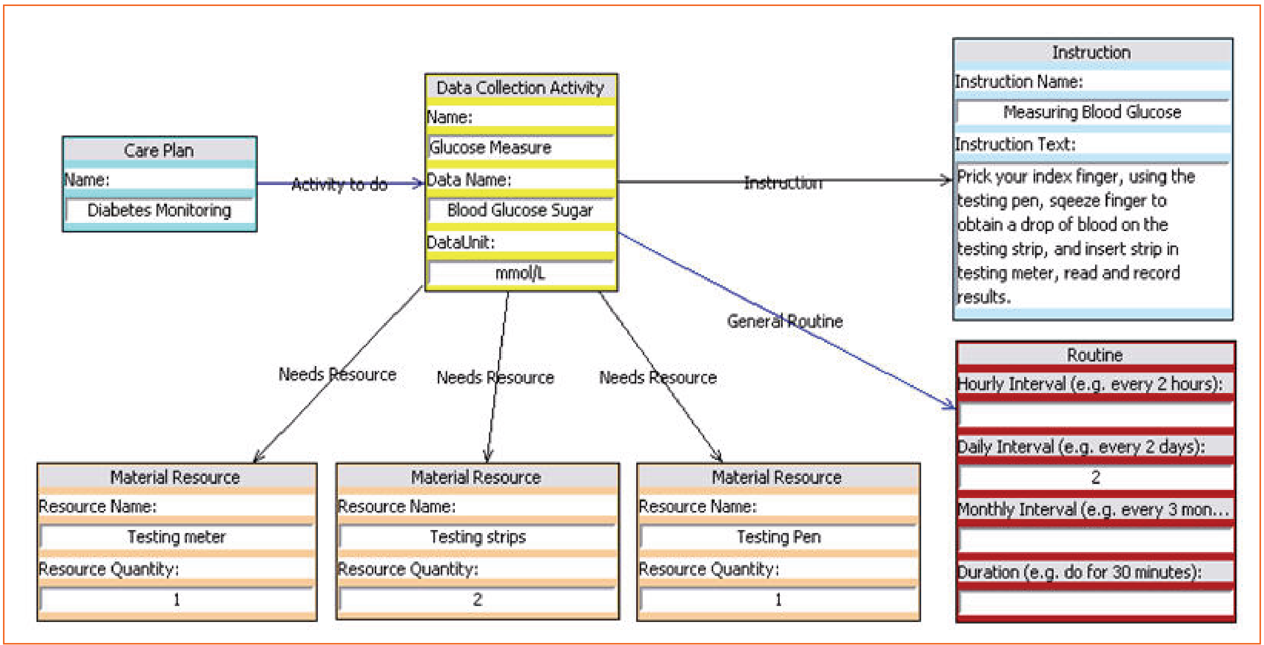

Figure 4. Screen shot of part of a diabetes monitoring care plan: a data collection activity for the collection of blood glucose sugar measurements.

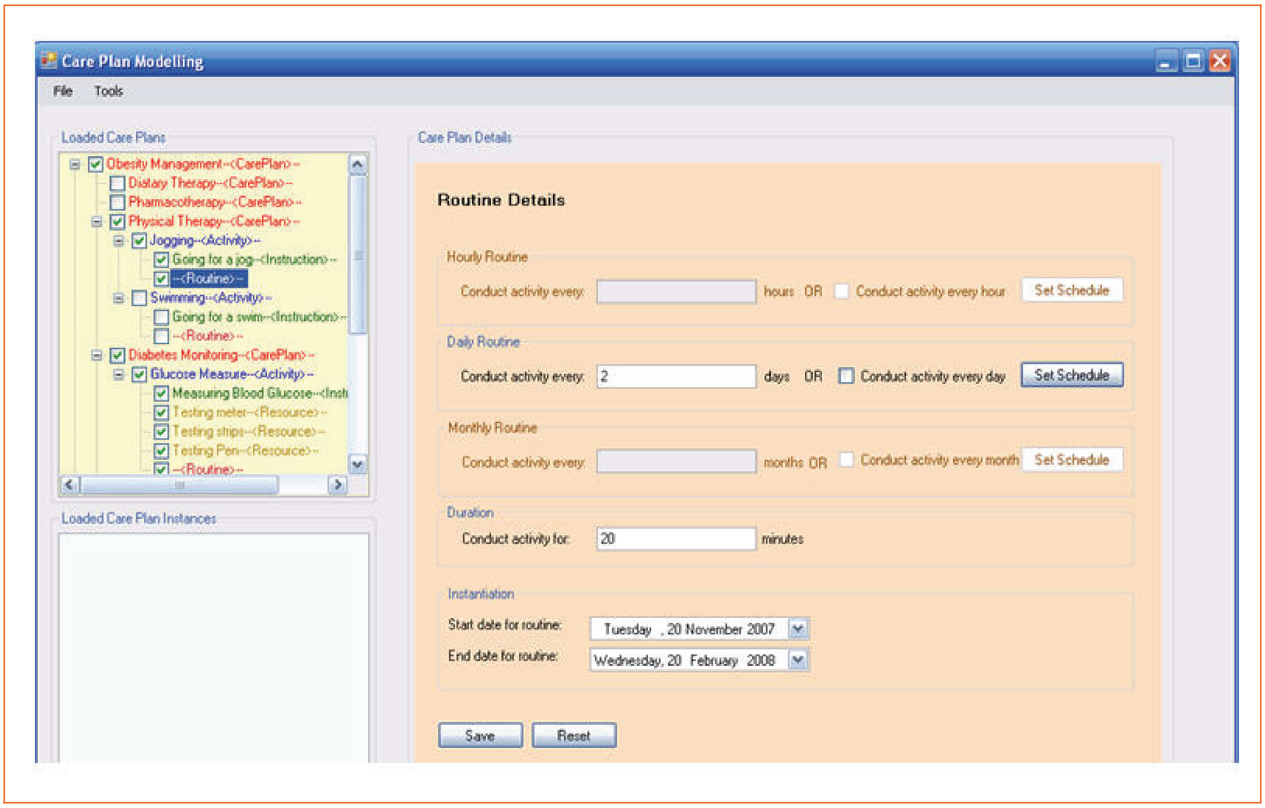

Figure 5. Screen shot of part of a diabetes monitoring care plan being tailored in our care plan instantiation application.

Figure 6 shows use of the second DSL used to specify the user interface for the generated care plan application. The target user for this DSL is currently an interaction designer. The specification in Figure 6 is a generic one representing the hierarchical structure of an individual health care plan to patients. It maps the data structure for an instantiated health care plan into an aggregated set of menu lists.

Figure 7 shows screen shots from the running mobile obesity care plan application that was generated from the tailored care plan specifications. The general care plan view specified in Figure 6 is shown instantiated with the obesity management care plan data at the top of Figure 7. Figure 7 also shows a list of scheduled Glucose measurements (left), a specific one opened and values entered (middle). Instructions if needed are provided (right).

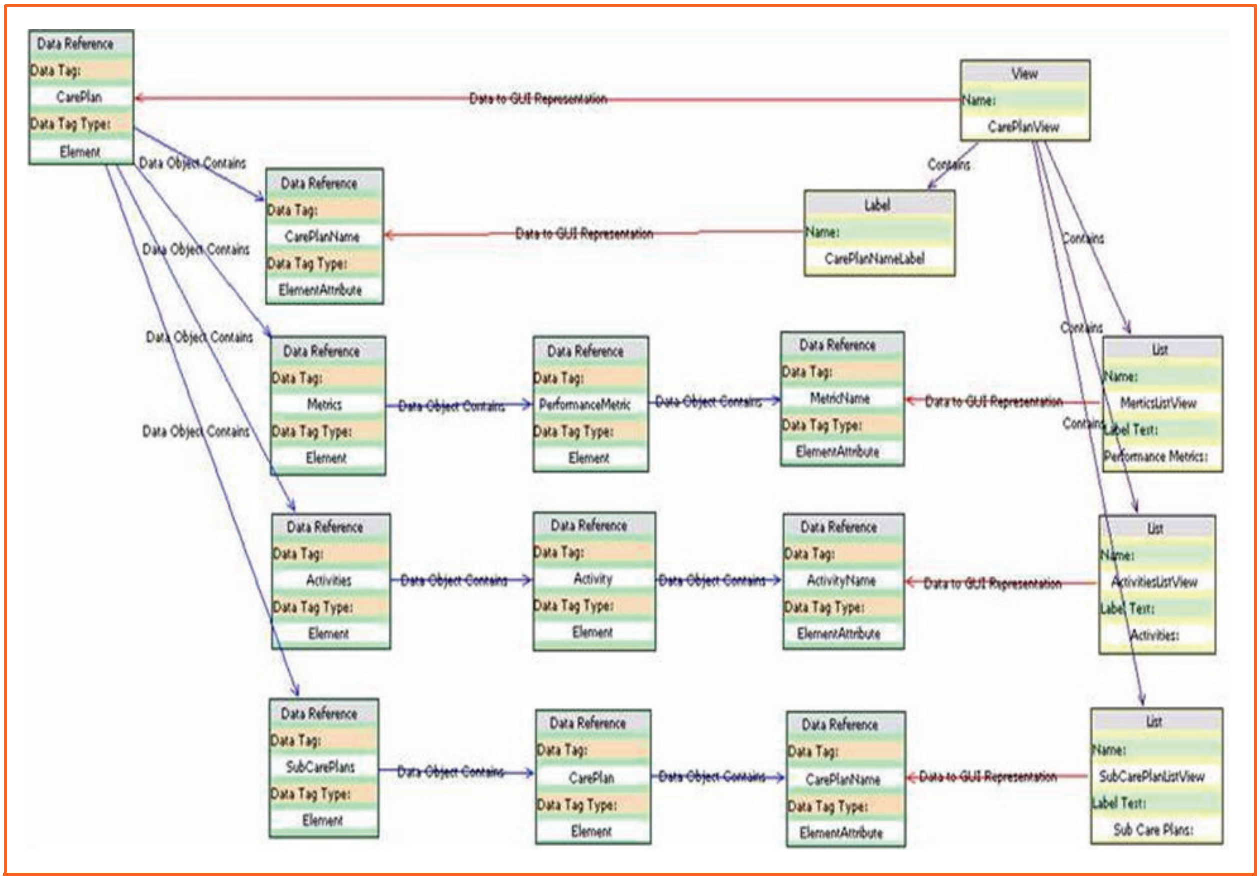

Figure 6. Specification of the main screen for the patient application.

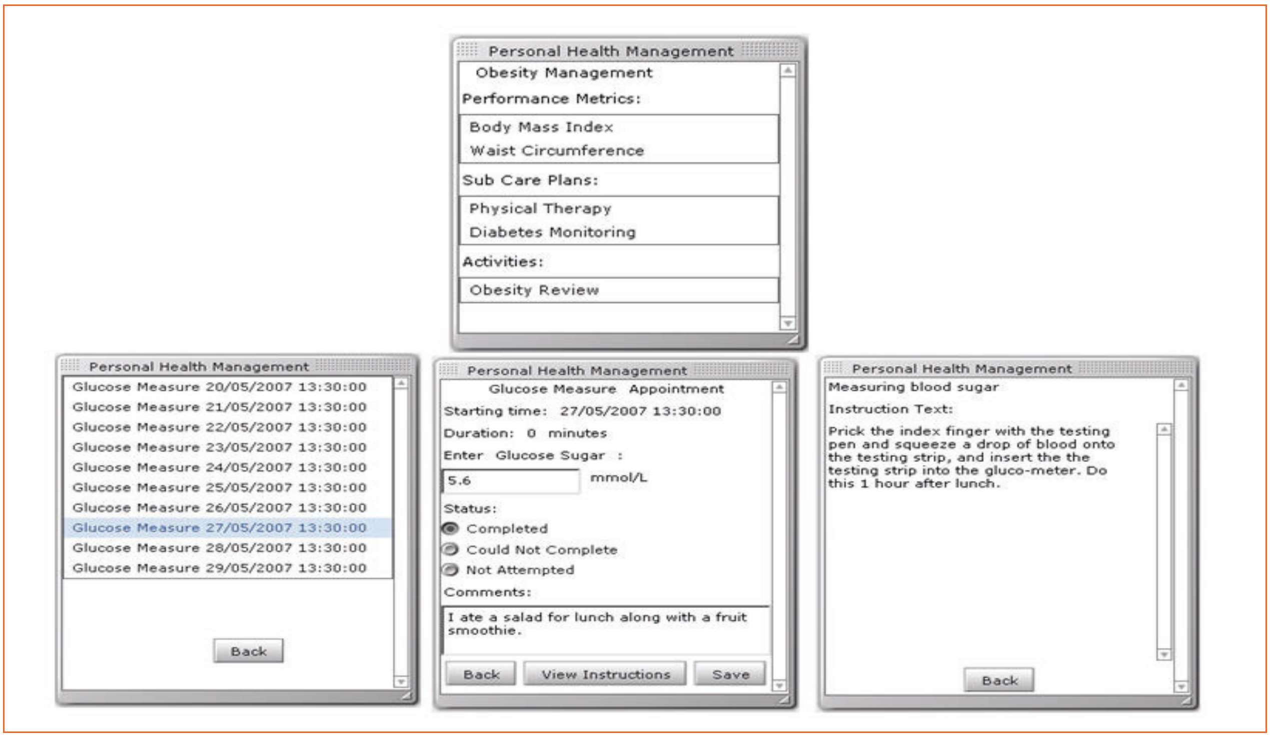

Figure 7. Screen shots of the end-user Flash application compiled from OpenLaszlo.

4. Discussion

We have described a staged domain specific modeling approach to the development of care planning systems. This approach allows a growing library of care plan templates to be mapped to a broad range of devices. This in turn supports the distribution of care plans between providers and patients, and the opportunistic use of desktop or mobile devices, with ready extension to new devices as they emerge.

There are in fact a large range of technology options for the key stages of our architecture (including Microsoft technologies). The specific languages and editors of our solution are just one possibility for achieving a model-driven approach to care plans; however, we contend that any approach should have similar stages.

Use of this approach in a healthcare system as found in New Zealand or Australia would require integration with existing software infrastructure, notably the practice management systems employed by General Practitioners (GPs). It is likely that GPs would favour care plan template selection and tailoring using their familiar tools, requiring compatible components to be implemented in the popular commercial software (or for that software to embed the care plan components). Further user testing is required for both healthcare provider and health consumer users, and it must be recognised that model generated user interfaces may lack the flair of purpose-built screens.

We envision the most direct pathway for initial use of the approach proposed herein to be applications concerning relatively simple activity tracking and reminder applications. Obvious applications include weight management, diabetes monitoring and management and activity promotion (as illustrated); one's imagination can easily extend to other self-management contexts, particularly for a relatively able user, or to be followed by a family member of someone less able. Fairly simple online education integrates easily (as Activity Instructions). Activity Routines, for which we have only illustrated (and only implemented) simple periodic timers, could be extended to invoke on specific trigger conditions of arbitrary complexity to yield care plans that extend to contingencies. Much greater exploration of use cases, however, is needed to determine just how extensible the proposed care plan model is. Moreover, the present proposal is best considered as a way of architecting consumer engagement applications, rather than as a one-size-fits-all solution for a complete integrated care system.

An important direction for this sort of work is to achieve alignment with key international standards. Of most relevance would be establishment of correspondence of the individual care plan template concepts to SNOMED CT. Success of Hrabak et al [Hrabak K, Campbell J, Tu S, McClure R, Weida R. Creating interoperable guidelines: requirements of vocabulary standards in immunization decision support. Proceedings, MEDINFO 2007: 930-4.] in mapping automated guideline components to

SNOMED is promising in this regard. Also relevant is the alignment of the care plan in a larger sense to HL7, both in terms of alignment of the domain model to the HL7 Reference Information Model and of instances based on care plan templates to HL7 Clinical Document Architecture (CDA).

5. Conclusion

We have developed a tool for modeling care plans for chronic disease management using a domain-specific visual language. These generic care plans can be tailored for specific patients, taking into account patient-specific exercise, medication, measurement and informational needs. A mobile device application interface is then specified using a second visual language, describing how care plan elements will be realized in a mobile device application. An application generator is used to completely automatically generate a mobile device care plan application. The care plan model, patient-specific tailored care plan and mobile application interface can all be tailored and improved over time using these high level tools.

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