Building Point of Care Health Technologies on the IEEE 11073 Health Device Standards

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***Abstract*—We describe a complete point of care health system implemented using the IEEE 11073 health device standards and ZigBee health care profile and following the Continua Alliance guidelines. We exploit the interoperability and wide range of specializations to implement four physiological devices and three environmental sensors. Within our projects, we have demonstrated the versatility of the Continua architecture by implementing the AHD within a smart meter, a wall socket plugin gateway and PC based application. We are evaluating clinical impact of the integrated sensor platform to manage frail elderly and diabetes patients. Experience shows that the standards provide the advantage of a rapid development environment, and will offer an increasingly wide range of commercial devices as they are adopted.**

I. Introduction

THE IEEE 11073 Personal Health Device standards have been in development since 2006 and have now reached maturity. A base protocol supports plug and play interoperability between all devices connected using the standard, and specialization standards for 10 distinct end devices and a set of devices for independent living have been produced. The standards are further profiled by Continua Alliance with industry defined standards for Bluetooth, ZigBee and USB. IEEE 11073 may be directly mapped to IHE-PCD01 (HL7) messages for the WAN interface, providing an end to end messaging architecture that is standards based.

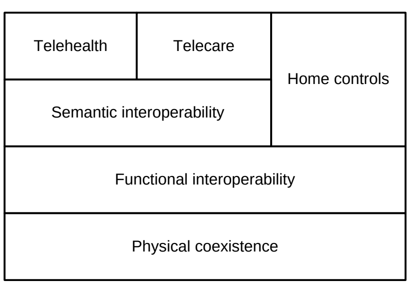

Fig. 1. Ideal semantic interoperability

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The standards cover several domains, including health (telehealth), ambient assisted living (telecare) and fitness. The objective is to make telehealth and telecare semantically interoperable so that a single system can be created to collect, send, manage, process and analyze sensor data together. In ideal semantic interoperability (Fig 1) we would have full integration between telehealth and telecare, functional interoperability with other systems in the home, and any and all other devices would coexist without interference. The alternative, and current situation, is to have separate proprietary telehealth and telecare platforms, with further proprietary platforms for niche sensors. Such an approach is expensive, and it is almost impossible to integrate data.

The Continua Alliance [1] has created a profile of standards to address this situation (Fig 2). The IEEE 11073 personal health standards provide the upper layers to afford semantic interoperability. Transport layers are given as profiles and currently USB, BT, BT-LE, and ZigBee are defined. Other ZigBee profiles would permit functional interoperability with devices in the home.

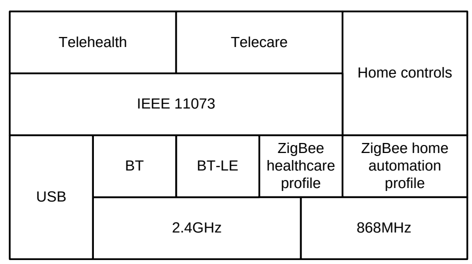

Fig. 2. The Continua Alliance profile of standards

IEEE 11073 standards are based on an object model (Fig 3) that has a restricted and consistent set of object classes and attributes that is described in IEEE 11073-20601 [2], together with ASN.1 representation of the protocol, definition of object services, and MDER as a binary presentation of data format. Nomenclature is fully defined in IEEE 10073-10101. On association between sensor and AHD, the sensor will fully describe its static information, thereby supporting plug and play interoperability. Device specializations specify define an agreed specification for standard devices to constrain terminology. The standardized object model methodology allows a unique generic mapping to IHE-PCD01 messages, which may be transported over a WAN interface using a number of transport methods including a web services interface that is also profiled by the

Continua Alliance.

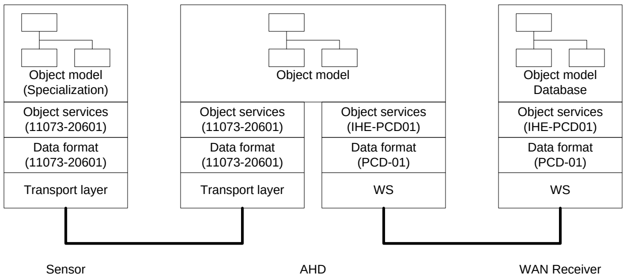

Fig. 3. IEEE 11073 and IHE-PCD01 object model and layered architecture.

The IEEE 11073 personal health device (PHD) standards are organized as a hierarchical family (Fig 4). IEEE 11073-20601 defines: the object orientated modeling approach (domain information model - DIM); a restricted set of object classes and attributes; a service model; nomenclature; message protocol; and common communication characteristics. Device specializations (-104xx) define aspects of a specific device to assist with interoperability. A technical report (IEEE 11073-00103) provides an overview. Transport layers are defined by other organizations.

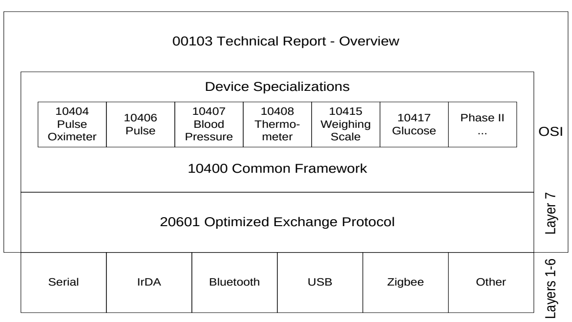

Fig. 4. IEEE 11073 framework.

II. Exploitation in Projects

A. *Hydra*

The Hydra project has been established to demonstrate use of the standards to support smart meters acting as the home gateway. Data is sent out from the home using the smart meter infrastructure, and the smart meter is equipped with ZigBee to communicate within the home. ZigBee has the advantage of being able to form a mesh network capable of covering the entire home, and have practical unlimited number of devices. The project therefore developed a set of sensors all based on the ZigBee health care profile and IEEE 11073 standards. The platform has been installed with 13 patients in order to validate. Feedback from users has been good, all appreciating the possibility to place sensors in their home to suit convenience.

The significant advantage of this approach is that the infrastructure exists and therefore is already paid for. Monitoring can be a value added service for the utility company, and costs are incremental, and therefore can be low; much lower than bespoke gateways.

The project further demonstrates that use of the standards makes it possible for the technology to be incorporated into any technology embedded in the home such as the cable tv box and may be seen as a value added service to the utility provider.

B. *Reaction*

The Reaction project has been established in the UK to develop and evaluate new methods to manage the whole population of diabetes patients using a primary care model and exploit the innovative monitoring platform. The objective of the project is to understand the needs of primary care to undertake effective management of diabetes patients at all stages of the disease, and to manage effectively their comorbidities and complications, with the intent of reducing risk of developing further complications of the disease. The can be accomplished by effective control of blood glucose though short term management (spot measurements) and long term control (HbA1C). However the problem for primary care is how to manage the complications that arise from managing many health conditions at the same time, together with the many psychological issues that arise in patients managing their chronic disease. The approach is to instigate a monitoring protocol to complement the existing routine 6 monthly check up for all diabetes patients in the UK, with a home monitoring protocol aimed at obtained physiological and environmental data pertinent to all the needs of the individual patient in advance of the check to have the data for use with the patient. The needs for monitoring are varied and many, from juvenile type I to very elderly with many co-morbidities, complications and other health issues.

TABLE I
THE PATIENT JOURNEY

Age	Event	Sensor
45	Type II diabetes	Blood glucose
55	Hypertension	Blood pressure
65	Angina	ECG
67	CHF	Weight BPM
70	Dementia	Medication monitor Environment sensor
72	Insulin dependent	Continuous blood glucose
74	Valve disease	INR
75	Peripheral vascular disease (Leg ulcer)	
76	Incontinence	Incontinence monitor
78	Fall	Fall alert
82	Death	

We start from the patient journey for a typical patient with type II diabetes (Table 1). We have identified that we might require up to 20 types of sensors in such a platform for the most complicated patients.

We also determined that the system must be simple and intuitive to use. It should also low cost and, if self-installed then this would further reduce cost. We therefore developed a purpose home gateway in order to support the rapid deploy/return cycle required for the two week monitor period envisaged for the protocol.

C. *inCasa*

The inCasa project has been established in the UK to develop and evaluate new methods to manage frail elderly patients, and investigate the impact on health and social care services participating in a collaborative approach. The frail elderly are characterized as having chronic disease and frailty as measured on the Edmonton scoring system. Integrated monitoring and management includes ability to take physiological measurements to deliver effective health care (telehealth), and observe their environment to assess issues such as dementia or impending fall, as indicated by change in habits (telecare). Our investigations reveal that there are no commercial systems available able to support integrated telehealth and telecare, and literature survey revealed no previous work aimed at analyzing combined data sets for correlation of patterns in data and clinical events. Most projects report results of technology development but without clinical evaluation. InCasa will report on correlation and use of the combination of physiological and environment sensor data.

III. Implementation

We could not identify any commercial system capable of providing all the sensors that we have identified for our separate projects, and so a system has been developed to satisfy all of our requirements. To date 7 devices have been developed for use with any patient (BPM, weight, glucose, SpO_2, motion, bed sensor, medication dispenser). All the devices are based on the standards, are Continua compliant, and therefore operate on the single platform. It is also designed to be simple to use and can be installed by the patient, thereby reducing system cost and allowing us to cycle equipment between patients on a very short term basis. The platform also includes a patient portal where patient own data may be viewed, educational information presented and questionnaire type data collected.

We have chosen to implement the sensors using ZigBee wireless as this is self-organizing mesh network. This allows us to add ZigBee routers to extend provide complete coverage of a home. This gives advantage of allowing the patient to place devices for convenience (e.g., weighing scale in bathroom, BPM in bedroom) and environment sensors throughout the home. There is a further advantage that ZigBee devices are available to operate at frequencies other than 2.4 GHz and could be used in the new MBAN frequency band.

IV. Discussion

We have embarked on developing new health care delivery models for primary care to manage chronic disease. We have identified that current monitoring systems lack the range of sensors that are required and we have developed a platform to support the work. Initial findings are encouraging, and data collection and analysis is ongoing.

Our use of the standards demonstrates that this approach has important advantages

- The platform is modular and supports multiple implementations of components
- The range of sensors is easily extended based on the standards
- Niche sensors are rapidly supported through existing gateways
- Specialist suppliers of components will emerge
- System functionality is extended and improved
- Can be built into embedded platforms (smart meter, cable tv box, etc)
- Innovative applications
- Lower cost

References

[1] IEEE Std 11073-20601™-2010. Application profile—Optimized Exchange Protocol.

[2] Continua Alliance, http://www.continuaalliance.org