Proposal of a Novel Remote Command and Control Configuration Extension for Interoperable Personal Health Devices (PHD) Based on ISO/IEEE11073 Standard

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***Abstract*—New use cases to extend the interoperability standard ISO/IEEE11073 (X73) were found during the development of recent specializations. These use cases expose the need of remote command and control extensions to allow managers to configure agents through the standard. This paper presents a proposal for an extension of remote control and configuration service able to standardize a general procedure within the newest branch of this standard called X73 for Personal Health Devices (X73PHD). In order to develop a service for remote control, several approaches have been studied and discussed in the Personal Health Device Working Group (PHD-WG). The final solution is defined following the PHD-WG guidelines and integrated with the Optimized Exchange Protocol (X73-20601) and device specializations (X73-104xx). Previous works such as the classic command and control and the extended services packages from X73-10201 and X73-20301, respectively, have also been taken into account.**

***Keywords*—Extension package, interoperability, ISO/IEEE11073, personal health, remote configuration, remote control, specialization, standardization, use case.**

I. Introduction

The ISO/IEEE11073 for Personal Health Devices (X73PHD) is a new branch of ISO/IEEE11073 (X73) and it has been especially designed for personal health solutions including low-cost electronics and wireless technologies [1-5]. This set of norms guarantees interoperability between different Personal Health Devices (PHDs) in Body Area Networks (BANs) or Personal Area Networks (PANs). The Personal Health Devices Work Group (PHD-WG), where the authors are working actively, is the organization responsible for the development and maintenance of this standard, including its mainframe the Optimized Exchange Protocol Part 20601 (X73-20601) and its specializations (X73-104xx). As part of this ongoing work, the PHD-WG has found the new use cases that show the need for additional features like service configuration and remote control in all standard specializations [6], which would improve patient-centered services [7]. The most important use cases identified by the authors of this paper were: the basic electrocardiograph (X73-10406), the Sleep Apnea Breathing Therapy Equipment (SABTE) (X73-10424), and the medication monitor (X73-10472) specializations [8-11]. For these use cases, the authors identified their requirements and classified them into two groups: operating modes and operating parameters [12]. The use case in which this proposal is based as proof of concept is the specialization X73-10415 Weight Scale.

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The classic X73 standard incorporated remote command and control mainly in the Domain Information Model (DIM) and a remote command and control profile, which where specified in the X73-10201 Point of Care (X73-10201 PoC) and the X73-20301, respectively. However, the current application context of X73-PHD proposes a lightweight version of the X73 standard that is based mainly in battery powered devices and wireless applications. Then, the classic remote command and control package needs to be adapted to the new paradigm.

The benefits provided by the implementation of this extension package are diverse [13]. Wired and wireless protocols and its application is not limited to home health environments, or BAN networks. Its implementation does not require excessive processing data from the agent, and its implementation is not mandatory and is in function of the features integrated into the PHDs.

In view of the above, this work presents a proposal for a remote control that is fully integrated within the X73-PHD framework. This proposal is developed by reusing models and extended service monitoring package from X73-10201 PoC , and adapting them for inclusion within the Optimized Exchange Protocol (X73-20601).This paper is divided as follows. The methodology used to develop this proposal, exposed in this research, is shown in Section II. The proposal consisting on DIM extensions for X73-PHD such as new model for scanner objects and the System Control Object (SCO) are presented in Section III. This proposal and the decisions taken during the development are discussed in Section IV. Finally conclusions are drawn in section V.

II. Methodology

The starting point to develop this work was to analyze the current scope of the standard. In this analysis, it was observed that there was no mechanism to provide proper remote command and control via the standard governing communications between Agent and Manager devices.

However, the implementation of an extension package therein would benefit all existing profiles and those generated in the future.

To do so, the PHD- WG decided to take into account the following considerations: First, to reuse as much as possible the control package from X73-10201 PoC and extend it appropriately. Second, to develop the extension maintaining a balance between energy consumption and performance. Third, to optimize the size of APDUs to best accelerate the exchange of information.

A general analysis of the X73-20601shows that the domain information model (DIM) is designed to allow the exchange of data between the agent and the manager. In the upper level there is the MDS object, which contains all the attributes that are supported for PHDs communication. Numeric, RT-SA, and Enumeration contain attributes that represents measurement, data context and status. These are derived from the metric base class, which defines methods, events and services commons for all objects. PM-segment and PM-Stores are used to persist metrics to be sent later.

To manage this exchange of information, each object of the DIM has methods, events, and services. Some examples are Set-time, a method to set the real time clock, or Get Service, implemented in the MDS and PM-Store classes and used to collect the values of all object attributes implemented in the agent.

The PHD service model present in the X73-20601, describes the agent device configuration, configuration event report, as well as describes the features and restrictions of profiles and its corresponding DIM, service and types of configuration (Standard or Extended) for PHDs.

Finally, the communication model defines the common communication characteristics in two ways, agent to manager and manager to agent. Also it describes: 1) How should the association procedure using a finite state machines be developed, 2) The operation procedure through which the manager request the MDS object attributes using "Remote operation invoke|Get" and receive the "Remote operation response|Get", and 3) The DataRequest message, necessary for sending measurement data where an event report is generated with the measurement data to the manager.

III. RESULTS

The result that has been obtained can be seen in Fig 1 Remote control sequence diagram. The sequence diagram is the result of implementing this proposal and described below: a) The Operating Scanner executes a remote operation invoke and enables the operational state using the attribute Operational-state. This setting must be enabled if the scanner is sending event reports. These reports are required to list the features implemented in the agent. b) The Oper-Create-Notification event is executed by the Operating Scanner, before an event report with the remote control capabilities of the agent is received. This is used by the manager to know the remote control capabilities that are supported by a PHD. c) When the manager wants to use one remote control

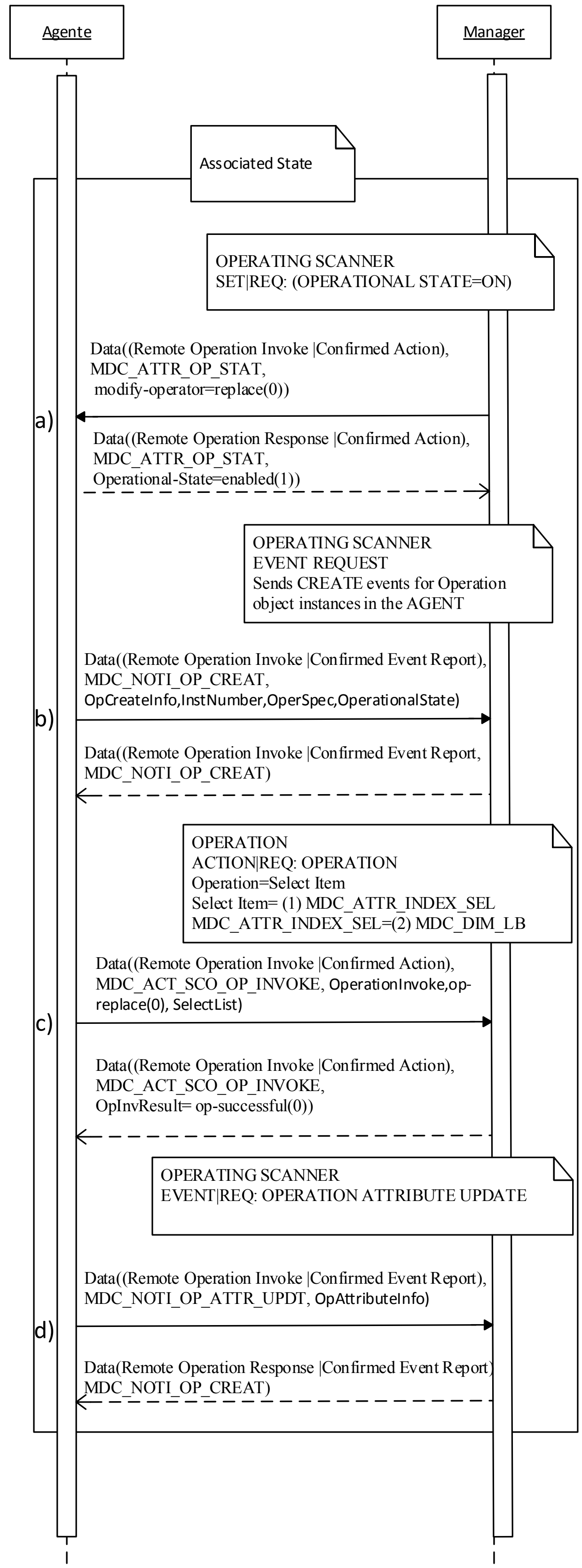

Figure 1. Remote control sequence diagram.

function implemented in the agent, the action request "remote operation invoke" is executed by Operation object using the action Operation-Invoke, then the unit parameter is selected using the Selected-Item-Index implemented in the Select Item object. d) Finally, the Oper-Attribute-Update event is executed by the Operating Scanner object to know the value changes in the PHDs. The messages shown in the diagram can be used as a typical sequence of remote control to modify any function that supports this service in the PHDs because it was not developed for a specific parameter.

The result that has been obtained, and which allowed to generate the diagram above, is a proposal of remote control extension package for PHDs, which add features to the DIM, service model and communication model.

Within the DIM, the models for the Control Package of X73-10201 PoC had been added to X73 PHD to enable X73-20601 [14] with Command and Control capabilities. All the objects of this remote control model are exposed in Fig 2.

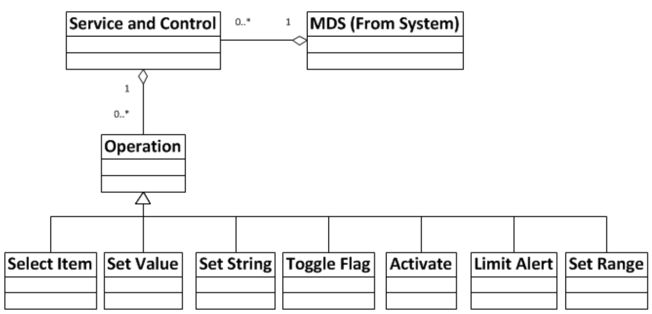

Figure 2. Remote Control Model

The SCO provides a method for the management of all remote control capabilities in the PHDs. The operation object is necessary for the manager to have the ability to modify a particular item. Through a set of operation objects instantiated by an agent during the association phase, this extension package enables the manager with the resource to develop the remote control capabilities implemented.

Before the manager can implement an operation via remote control, it must know the agent instantiated objects with attributes that support this service. The Operating scanner object, derived of UcfgScanner base class is responsible for grouping these attributes and list them in CREATE notifications event type.

For this reason, it was necessary to add the objects UcfgScanner and Operating Scanner inside of Scanner class. Fig 3 shows the new Scanner model proposed.

The operating scanner collects all information about the remote control capabilities implemented in PHDs. The classes implemented in the scanner package generate event reports with a set of attribute value changes of an object. Both parts Agent or Manager can send or request information with the actual status of the attributes values.

Table I summarizes the methods, events and services that this extension integrates to the standard. The operating Scanner use Refresh-Operation-Context and Refresh-Operation-Attributes methods to collect all information about the remote control capabilities implemented in the PHDs.

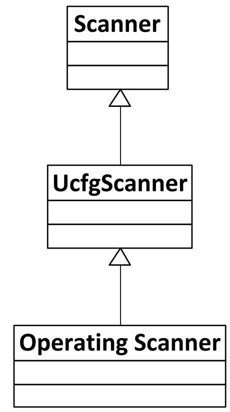

Figure 3. Personal health device scanner model.

The Oper-Create-Notification, Oper-Delete-Notification, Oper-Attribute-Update are events used for generate event reports about attributes present, changes in attributes, or attributes deleted. The SCO uses two methods OperationInvoke and CtxtHelpRequest. The first is used for developing an operation in a specific item, and the second obtains additional information about the context for SCO or Operation Object. Similarly the SCO has two events, SCO-Operating-Request and SCO-Operating-Invoke-Error. The first is used to obtain additional information about an operation, and the second generates an event report with the error information in the development of an operation.

TABLE I. METHODS,EVENTS, AND SERVICES PROVIDED BY THE EXTENSION PACKAGE

Methods		
Method/Action	**Action-type**	**action-info-args**
Refresh-Operation-Context	MDC_ACT_REFR_OP_CTXT	RefreshObjList
Refresh-Operation-Attributes	MDC_ACT_REFR_OP_ ATTR	RefreshObjList
OperationInvoke	MDC_ACT_SCO_OP_ INVOKE	OperationInvoke
CtxtHelpRequest	MDC_ACT_GET_CTXT_HELP	CtxtHelpRequest
Events		
Event	***Event-type***	***Event-info-parameter***
Oper-Create-Notification	MDC_NOTI_OP_CREAT	OpCreateInfo
Oper-Delete-Notification	MDC_NOTI_OP_DEL	OpDeleteInfo
Oper-Attribute-Update	MDC_NOTI_OP_ATTR_UPDT	OpAttributeInfo
SCO-Operating-Request	MDC_NOTI_SCO_OP_REQ	ScoOperReqSpec (optional)
SCO-Operation-Invoke-Error	MDC_NOTI_SCO_OP_INVOK_ ERR	ScoOperInvoke Error

The classes Operation, Select item, Set value, Set string, Toggle Flag, Activate, Limit Alert and Set range object do not have methods, events or services, but these objects are necessary to enable the different operations that can be performed by the SCO.

The PHD service model should include the specific methods and events exposed in Table I, used by Scanner and SCO classes for developing remote control functions. To use this service conditions as Operational-State, it should be enable to Create Notifications. Without this, it is not possible to know the controllable functions implemented.

Finally, within the service model, this proposal describes an operation procedure described in the sequence diagram of Figure 1, where it can be clearly seen how the remote control operation is developed.

IV. Discussion

This proposal has been developed based on the analysis of use cases, and, as mentioned earlier, in a way that meets the requirements of the cases raised by members of the PHD-WG. Although initially there was the proposal to add Alert package, this was scrapped because the alert object can provide service to these requirements through the SCO.

Using this extension, it is expected that the benefits of implementing the standard increase, to provide greater functionality to the services provided by the PHDs. It is also expected that the scope of application of the standard and of the different specializations is increased.

As it can be seen, this proposal suggests adding a new package in the PHD DIM, thereby benefiting specializations that choose to implement remote control functions. Futhermore, using technologies such as smartphones or PDAs, home telemonitoring services are also moving to BAN networks, increasing the quality of patient-centered services which are not restricted to a specific geographic point of application. With that, health professionals will be able to modify the service provided from data acquired in real time, by modifying the applied therapy devices in a more immediate manner, appropriate to the dynamics of the disease or can extend the application areas of sports, wellness and medical research, recollecting data for post-processing for different purposes.

The classic X73 use the GLB-HANDLE attribute as a global identifier allowing the identification of an object in a particular context, for example a scenario where the manager has to interact with devices with different MDS, as may occur in environments of home telemonitoring, where the manager should be able to assign an individual identifier to each. Discussion of the use of GLB-HANDLE of X73-10201 PoC is still open.

V. Conclusions

This article has proposed a solution that develops the required remote control functions that are needed within the framework of interoperability standard X73PHD. At this point it meets the requirements that have been exposed by the PHD-WG members, and covers the requirements for configuration and remote control features.

The main outcome of this proposal has been shown in the form of a sequence diagram. The implementation may be adapted to any of the use cases that prompted this research, from developing of testing tools in software or hardware.

Therefore, future lines of this research should focus on this validation of this remote control extension in any profile compatible to remote control functions, and it should analyze whether the balance performance of the agent is suitable for the implementation of wearable solutions where the value of this feature is extremely critical.

Acknowledgment

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