Wireless Standard-compliant e-Health Solution for Elderly People with Multiuser Identification

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ABSTRACT

Objective. One of the main problems in e-health environments for developing an accurate multiuser identification is in the large number of patients, especially with itinerant medical devices and elderly people. This paper aims to contribute with two approaches to be included in ISO/IEEE 11073 family of standards as a standardized procedure for multiuser identification that can be used for a large variety of medical devices, regardless of their brand or model. From this contribution and to validate it, this work proposes a standardized e-health solution, including multiuser identification, implementing it in real health environments for elderly people, and evaluating their usability, interoperability, and adoption in daily living.

Materials and Methods. This works implements the internationally recommended Personal Health Devices ISO/IEEE 11073 standards as a multiplatform environment (Windows / Linux / Mac OS) and fulfils the paradigms of scalability, modularity, portability, maintainability, and robustness. The standard e-health solution has been implemented in 26 health environments in several cities in Spain (Madrid, Barcelona, Sevilla, Zaragoza, etc.), consisting of 118 health professionals, 319 senior patients, and 18 technical professionals.

Results. The proposed multiuser identification reduces the human error rate (from 13.3% to less than 5%) with positive evaluation: almost 70% of users are satisfied, with usability and time savings that are more than 50% in all the groups (nursing, medicine, and caregiving) and environments (residences, health centres, and hospitals).

Discussion. The use of e-health solutions within multiuser identification, as it is proposed through two standard-compliant approaches, permits advanced services and data analysis for a large variety of medical devices, regardless of their brand or model.

Conclusion. This paper contributes an open interoperable e-health solution as alternative to the closed and commercial solutions and enables third-party developers to work collaboratively and extend the already implemented features, owing to the design based on plugins, value-added services, and multiple transport technologies and protocols.

KEYWORDS
e-health solution; elderly people; interoperability; ISO/IEEE 11073 standard; multiuser identification; wireless technologies.

I. INTRODUCTION

A key advantage of the application of e-health in health environments, such as hospital services, health centres, and residences for the elderly, is the improvement in healthcare quality owing to the reduction of human errors and time consumption caused by manual data acquisition and entry (patient identification, vital signs, samples, etc.) [1]. Recent studies [2] have shown that the most frequent errors in patient misidentification are due to missing wristbands (34%), incorrect charts or notes in files (20%), administrative issues (19%), and incorrect labelling (14%). Although a full elimination of such problems may not be possible, services based on e-health systems approach an error rate close to zero by employing automatized devices for data collection, instant communication with the centralized database, and accurate information of their measurements, samples, or treatments [3]. In this multiuser context, the contribution of e-health solutions is especially useful for the correct identification of elderly people: follow-up of chronic diseases, digital management of residences, assistive technology, etc. [4].

Nowadays, patient identification is confirmed using several methods [5], [6] such as personal health cards, Radio Frequency IDentification (RFID) tags, or bracelets with barcodes. There are several devices available in the market that can read the identification of the patient, including *Patient Monitor Mindray* VS600 [7] and *Philips SureSign family* [8], among others. It is also noteworthy the initiative Health Level 7 (HL7): a set of standards to facilitate the electronic exchange of clinical information that uses a formal Unified Modelling Language (UML) notation and an Extensible Markup Language (XML) metalanguage. Within HL7, Fast Healthcare Interoperability Resource (HL7 FHIR) is the specific standard for health care data exchange [9].

However, personal health devices present a disadvantage because they are not completely plug-and-play, so they require standardized procedures to ensure interoperability in communications [10]. In this context, Personal Connected Health Alliance (PCH Alliance) is the main initiative in the world concerning patient/consumer-centred health, wellness, and disease prevention [11]. Among the standards recognized by the global community (within PCH Alliance), the international recommendation for interoperable communication among medical devices is ISO/IEEE 11073 [12]. ISO/IEEE 11073 includes several families of standards: Point-of-Care (PoC), focused on using wireless communication technologies for medical devices that exchange vital signs through information technology (IT) infrastructure; Service-oriented Device Connectivity (SDC), focused on defining an architecture for service-oriented distributed PoC medical devices and medical IT systems over web services; and Personal Health Device (PHD), focused on evolving PoC and SDC with specific features for patient-centred environments. This PHD family is the object of this work due to its innovative functionalities of real-time monitoring, plug-and-play services and wearable technologies [13]. However, ISO/IEEE 11073-PHD is not optimized for handling a large number of users, such as hospital services, health centres, or residences for the elderly, which is the focus of this paper. Therefore, the adaptation of ISO/IEEE 11073-PHD for these e-health environments requires new approaches that ensure interoperability between medical devices, facilitate the transmission of information safely, and ensure the reliability of communication, independently of brand or mode. Furthermore, the user-friendliness of these standard-compliant e-health solutions and their non-intrusiveness in the lives of patients are required acceptance criterion to verify adherence to the provided services and their adoption in daily living [14]. Moreover, evaluation, not only from a technological scope but a usability and cost-effectiveness perspective, is a key element for the success of these contributions [15].

This paper aims to contribute with two approaches to be included in ISO/IEEE 11073 family of standards as a standardized procedure for multiuser identification (see Section II) that is implemented in a wireless e-health solution (see Section III). Section IV presents the results of the technical validation and user evaluation to assess its suitability for elderly people in multiuser environments.

II. MULTIUSER IDENTIFICATION

As previously mentioned, a key problem in standard-compliant e-health solutions is conducting unique identification in an environment with a large number of users and wireless medical devices that are carried by staff from room to room to take measurements from different patients. To solve this, it is necessary to ensure that the measurements taken with a medical device (with its identifier, Device ID) are safely associated with the patient identifier (Patient ID) to avoid errors and confusion. Because the internationally recommended standards do not implement user identification systems, this paper proposes two approaches to build an ISO/IEEE 11073-compliant procedure for a standardized multiuser identification.

The first approach is to add an accessory that the healthcare professional can use to identify the patient and associate the measurement device identifier (Device ID) with the Patient ID so that the information can be sent and stored safely in an Electronic Health Record (EHR) server, as shown in Fig. 1. This method is not fully compatible with ISO/IEEE 11073 but integrates nonstandard medical devices by sending the Patient ID and Device ID using a nonstandard protocol and sending the measured data using an ISO/IEEE 11073-compliant protocol.

Thus, with this first approach, the stages of identifying the patient and sending the information are designed to verify that the measured data is associated with the correct Patient ID, reducing the possibility of confusion and corruption of information. The steps are identified in Fig. 1 with parenthesis. First, the healthcare professional reads the tag of the patient and the tag of the medical device (agent) and connects to a mobile computing device acting as coordinator (manager) (1). Then, the agent sends the patient identification data and checks whether the patient exists (2). Next, the professional takes the measurement, and the agent sends the data to the manager (3). To verify that the tags initially read are correct, the professional reads the tag of the patient and the tag of the device again (4), and the manager checks whether the new ID sent is the same as that sent in stage one (5) and, if it is the same, an acknowledgment is sent before disconnecting the device (6). This method verifies that the measured data is associated with the correct Device ID and Patient ID.

In this case, an external Check Device ID (an RFID wearable device) that can identify the medical device and the patient is necessary. Thus, the healthcare professional taking a measurement would perform the following steps: first, read the tag of the patient with the RFID wearable device; second, read the label of the device; and third, take the measurement (SpO_2, glucose level, blood pressure, etc.). Finally, the professional would read the tag of the patient again and the Device ID to confirm that the data acquired has been associated with the correct Patient ID.

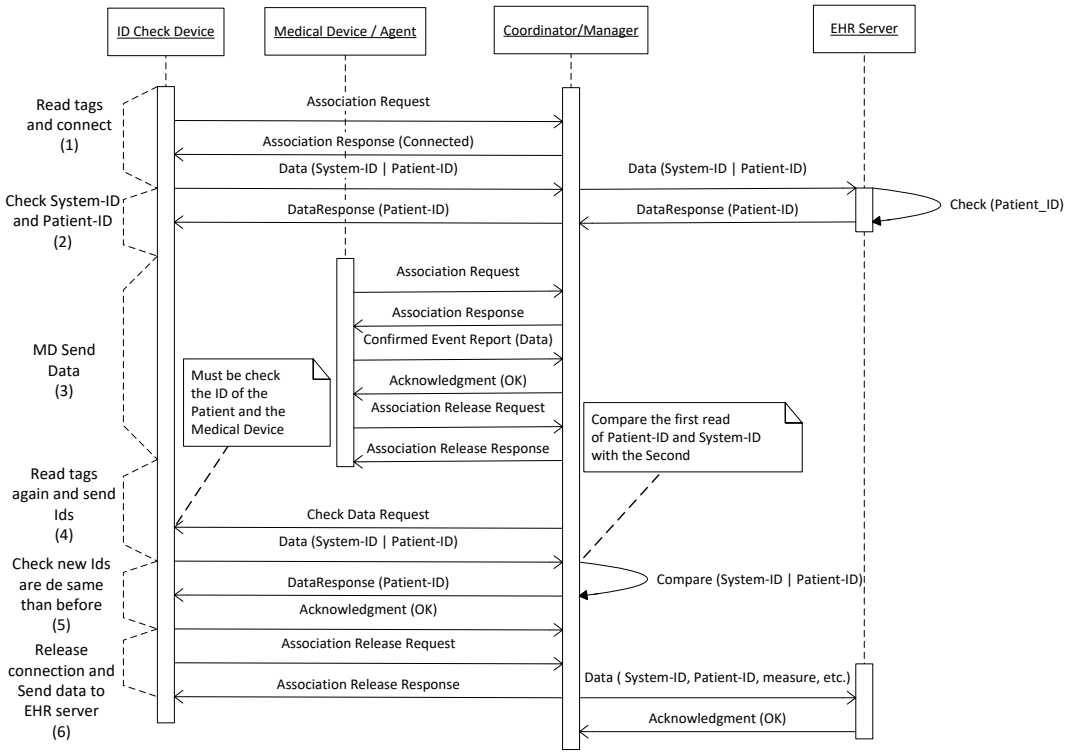

Fig. 1. Patient ID identification with an external Check Device ID

The second approach is fully compatible with ISO/IEEE 11073, using a device that can read the Patient ID label, represented in Fig. 2, with the steps identified in parenthesis. The procedure can be conducted as follows: the medical device reads the RFID tag and stores the information within the Patient ID, inside its PM-Segment. When it connects to the server (1) and sends the unique Device ID, which is mandatory in ISO/IEEE 11073-compliant medical devices, the server queries the database to determine if the medical device is itinerant (2). If it is, the server requires sending the patient data (PM-sec-Person-ID in ISO/IEEE 11073-PHD) to the medical device (3). It later sends the measurement data (4), disconnects the medical device (5), and sends the data to the EHR Server (6). This method permits using the identification of the patient in itinerant devices, instead of the traditional method used on ISO/IEEE 11073, where a device is linked to a patient, and the system uses the unique Device ID for identifying the patient.

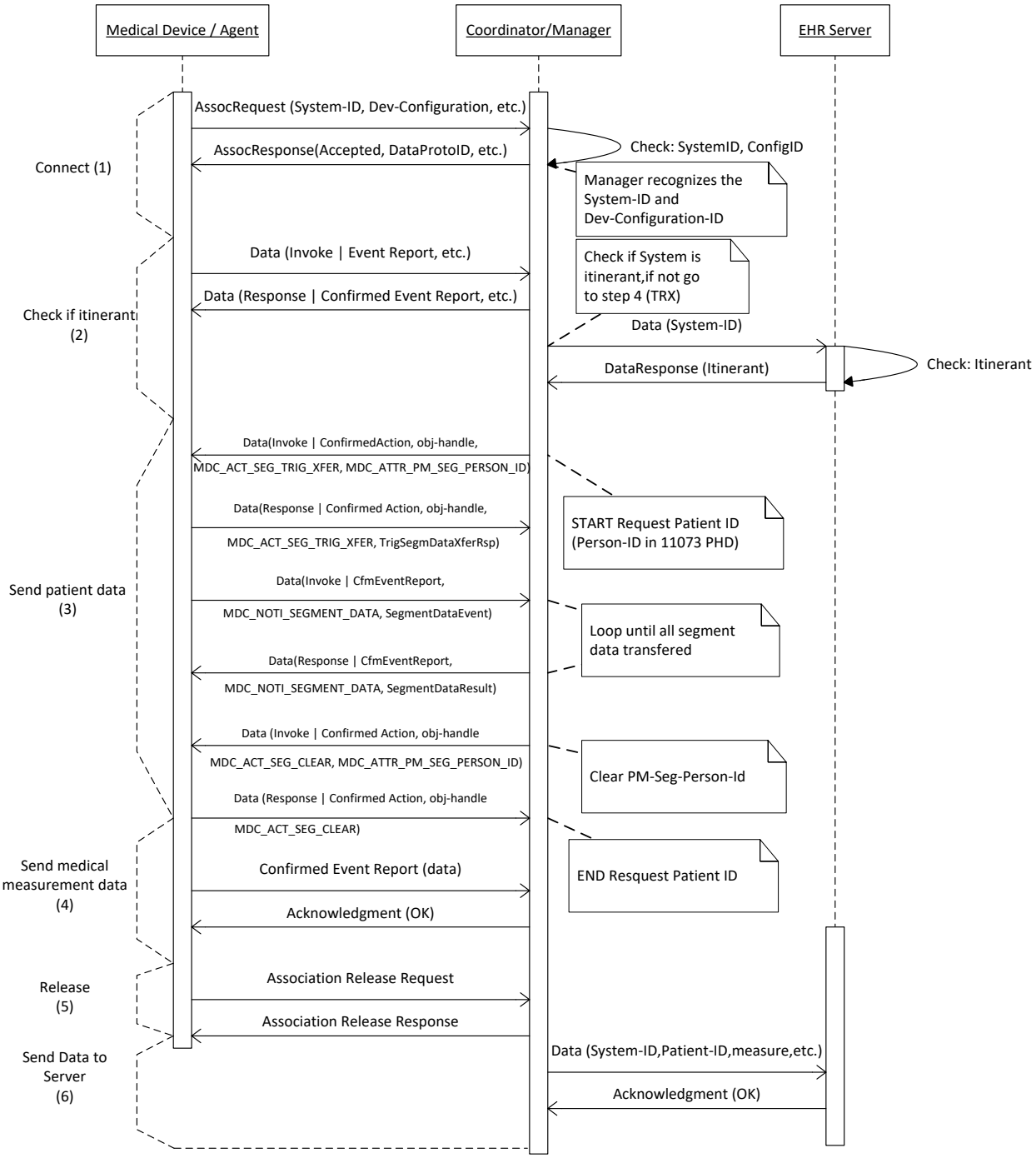

Fig. 2. Patient ID transmission when the RFID reader is included in the medical device

III. MATERIALS AND METHODS

The design criteria to respond to the challenges raised above include three key elements: wireless interoperability, security, and usability following the ETSI Guide 202 487 guidelines [16]. The proposed ISO/IEEE 11073-PHD architecture fulfils the paradigms of scalability, modularity, portability, maintainability, and robustness following a modularized architecture (detailed in Fig. 3) with three conceptual layers (Technology, Communications, and Application), within two-harmonization shim layers (Transport and Protocol).

The Application layer (upper area shown in Fig. 3) provides a user interface to manage the state of the medical devices and other value-added services, such as events, notifications, messages, through the Protocol Harmonization layer. The Communication Layer (middle area shown in Fig. 3) implements the three-level ISO/IEEE 11073-PHD stack: Device Specializations (ISO/IEEE 11073-104zz), Optimized Exchange Protocol (ISO/IEEE 11073-20601), and Transport Communications Protocols through the Transport Harmonization layer. The Technology Layer (lower area shown in Fig. 3) integrates several wireless technologies, such as Bluetooth (Health Device Profile, HDP), Near Field Communications (NFC PHD class), and ZigBee (Health Care Profile, HCP), among others wired technologies such as USB (PHD class).

As an example of the layer interaction workflow in a real operation, Fig. 4 details the connection procedure between an agent and a manager following ISO/IEEE 11073-PHD over Bluetooth HDP. This example shows the transitions between each architecture layer (in white colour) and each harmonization layer (in grey colour), within the state changes applied through the ISO/IEEE 11073 Communication Model. Thus, a manager is initially in a *Disconnected* state, where it does not process any data, only connection events. Then, when a connection event (Event.Connection) occurs, the manager moves to an *Unassociated* state. From this state, if the manager receives a message event (Associating Request) from the agent, both move to an *Associating* state, and after receiving the appropriate ISO/IEEE 11073-PHD configuration (SendingConfig), if needed by the manager, they proceed to the *Operating* state to start exchanging medical data.

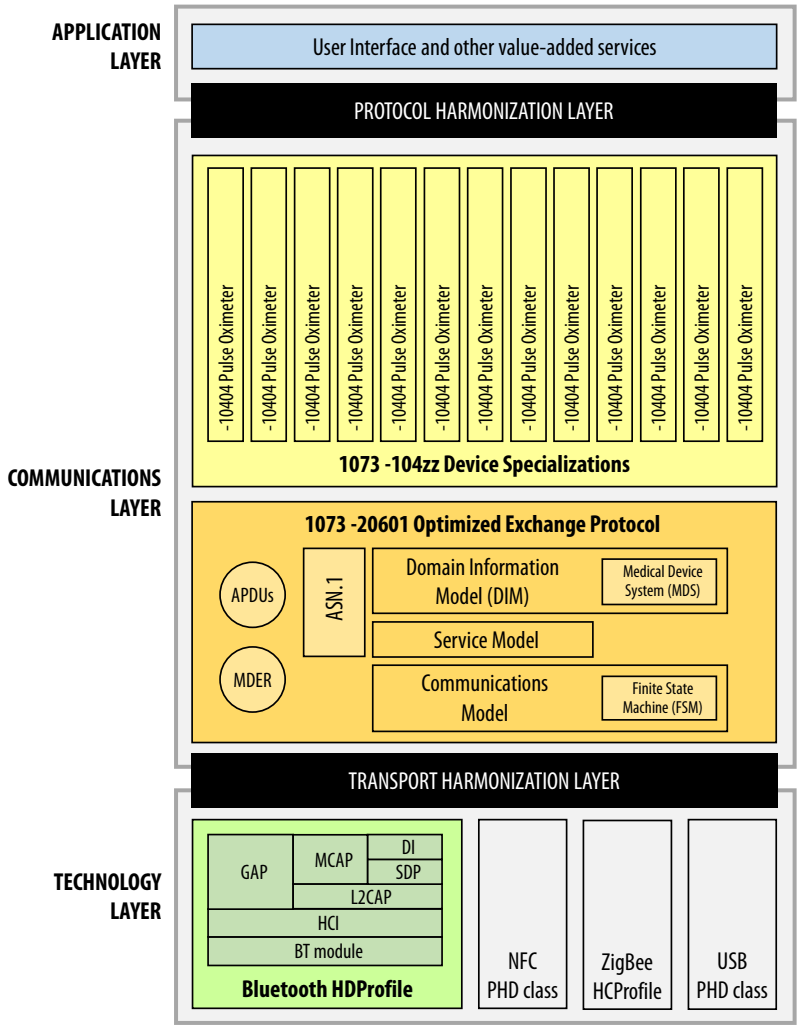

Fig. 3. Proposed ISO/IEEE 11073 architecture based on a three-layer model (Technology, Communications, and Application within Transport and Protocol harmonization shim layers) including the wireless protocol stacks

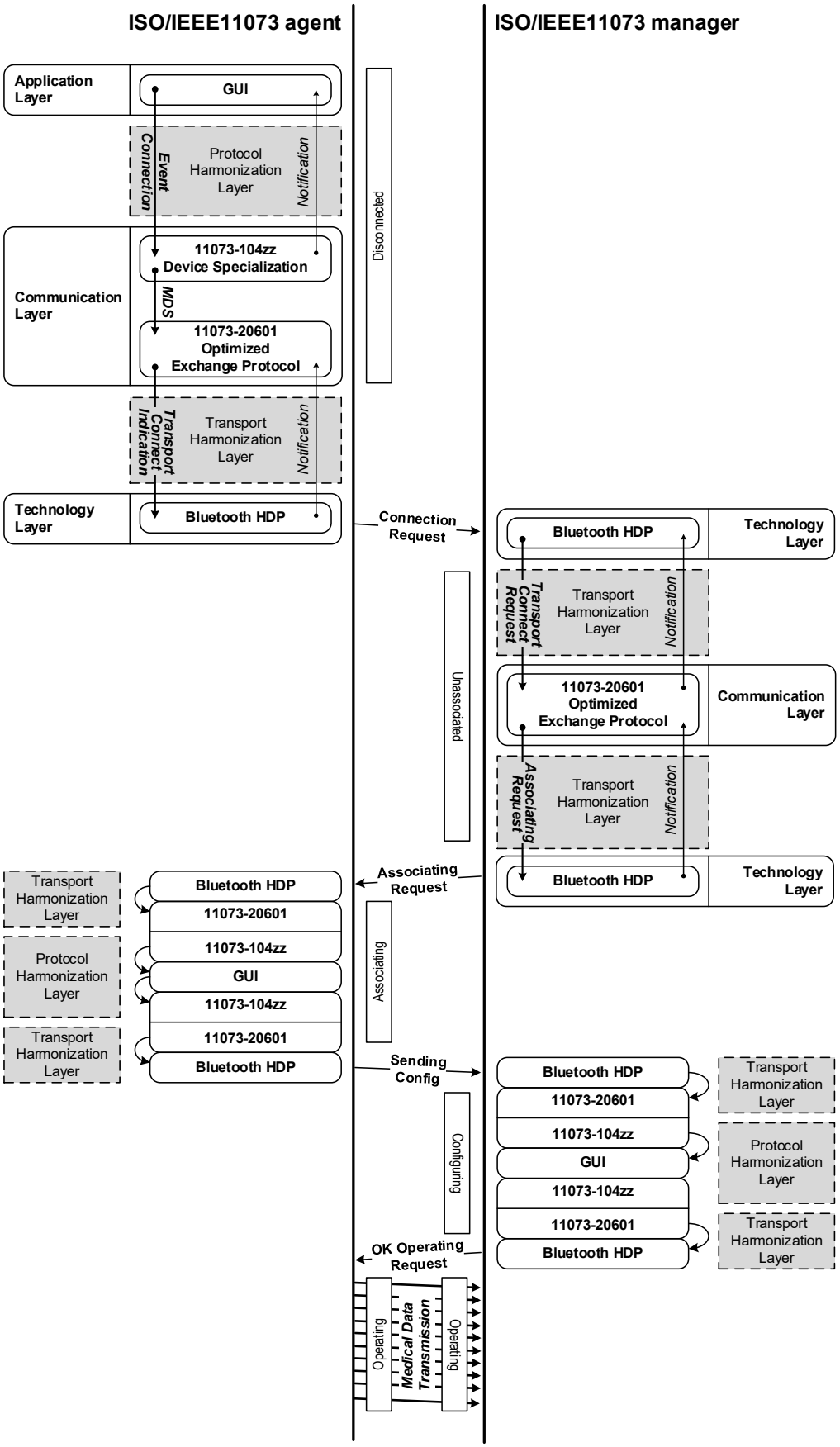

Fig 4. Connection procedure between an agent and a manager following the ISO/IEEE 11073-PHD standard over Bluetooth HDP

The proposed e-health solution was implemented in 26 health environments in several cities in Spain (Madrid, Barcelona, Sevilla, Zaragoza, etc.), consisting of 118 health professionals, 319 senior patients, and 18 technical professionals with this distribution:

- 13 residences for the elderly. The participants were:
  - 67 health professionals in medicine, nursing, therapeutic care, physiotherapy, and psychology, among other specialities (45 women and 22 men aged between 29 and 59 years).
  - 183 seniors (105 women and 79 men) aged between 62 and 87 years.
  - 9 technical professionals such as residence staff.
- 8 health centres. The participants were:
  - 34 health professionals of primary health specialities (21 women and 13 men aged between 35 and 61 years).
  - 74 seniors (43 men and 31 women) aged between 63 and 85 years.
  - 4 technical professionals of the health centres.
- 5 hospital services. The participants were:
  - 17 health professionals in internal medicine, chronic diseases, etc. (11 men and 6 women aged between 41 and 58 years).
  - 62 seniors (35 women and 27 men) aged between 65 and 83 years.
  - 5 technical professionals of the hospitals.

The evaluation was planned as a pilot study, where all of the participants were volunteers, who signed informed consent. All data of the participants and their interaction with the e-health solution were confidential and protected fulfilling the European Union EU 2016/679 General Data Protection Regulation (GDPR). The e-health solution contained all the technological elements detailed in this article (see Fig. 5): PCH Alliance-certified devices (AND UA-767PBT-Ci blood pressure monitor [17], AND UC-351PBT-Ci weighing scale [18] and NONIN 3150 WristOx2 pulse oximeter [19]) with wireless (Bluetooth HDP) technologies, multiuser identification using RFID technologies, and standard e-health services (as ISO/IEEE 11073 manager) implemented using tablet devices. When the e-health solution was installed in every health environment, a short training session (20 min) was performed, and all participants were using the service daily for 15 days.

In all these scenarios, the evaluation methodology was performed using a QUIS questionnaire to assess not only the subjective satisfaction of the users but specific aspects of the human-computer interaction. All participants responded to the QUIS questionnaire. QUIS is an instrument developed by the Human-Computer Interaction Lab at the University of Maryland and internationally validated as an evaluation tool [20]. Version 7.0 includes a demographic questionnaire, questions regarding the technical knowledge of the user, a measure of overall system satisfaction along a 6-point scale, and measures of specific interface factors on a 9-point scale. Furthermore, several *ad-hoc* questions were added to record specific information about the e-health solution using a 5-choice scale (more suitable for the elderly): "very much", "much", "indifferent", "little" and "very little":

- "*Having the e-health solution in your work routine, could you perform your daily activities in complete normalcy?*"
- *"Do you find the size and weight of the different elements of the e-health solution adequate?"*
- *"Do you find battery life adequate?"*
- *"Is it easy to correctly use medical devices?"*
- *"Is it easy to correctly use multiuser identification tags?"*
- *"If you have been moving with the e-health solution, do you find range coverage adequate?*"

... among other specific questions about medical devices, multiuser identification, etc.

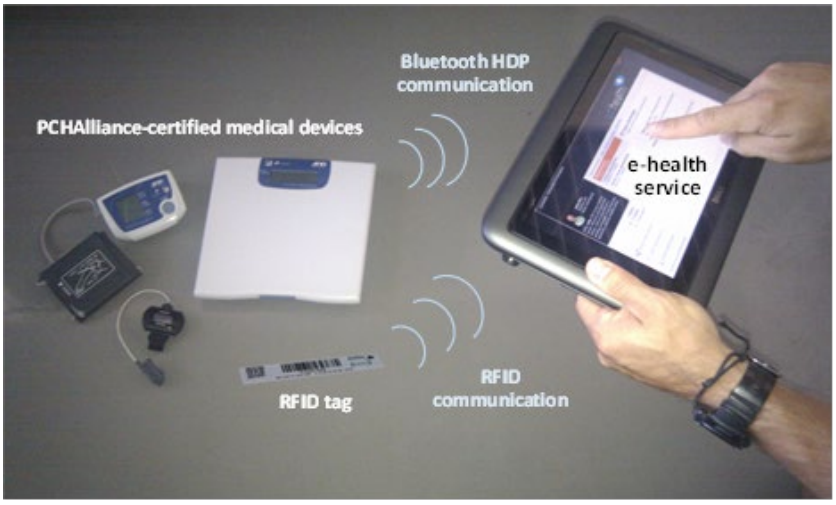

Fig 5. ISO/IEEE 11073-PHD e-health solution with PCHAlliance-certified devices over Bluetooth HDP and multiuser identification through RFID technologies

IV. RESULTS

From a technical point of view, the proposed ISO/IEEE 11073-PHD architecture has been implemented as the multiplatform environment (Windows / Linux / Mac OS), and their conformances have been validated using the official Toshiba Bluetooth stack, certified by PCH Alliance. For verification of the standard communication (following the connection procedure detailed in Fig. 4), all connection attempts were captured for two weeks in the 26 health environments of the pilot study. For each case (in rows), Table I shows the success ratio (%) for every first attempt, second attempt, and the following attempts. The communication works correctly (on overage) 97.9% of the time (95.1% on the first attempt and 3.0% on the second attempt) and only 1.9% (on overage) of the connections require more than 2 attempts. Because the results are equivalent regardless of health environments, hereafter, graphics are presented as average values of all health environments (indicating the particular deviations).

Regarding the verification of accuracy in the multiuser identification, following the ID transmission procedure detailed in Fig. 2, Table II shows different situations with one (1dev), two (2dev), three (3dev), or four (4dev) medical devices and one (1mng) or two (2mng) managers in the same coverage area. Before the pilot study, the daily routine showed that 13.3% of human errors were due to manual data acquisition, incorrect treatments, and inaccurate patient identification. The lower rows (with 1 manager) show that errors due to the incorrect selection of other devices previously connected (in the 'C' row) increase from 1.3% (2dev) to 1.9% (3dev). With only 1 device, there is no error because the previous device is always the same. Thus, errors due to no device being detected (in the 'A' row) are proportionally decreased to the number of devices. Adding another manager (2mng) reduces the errors that are caused by missing a manager (on average, from 1.0 ± 0.1 (1mng) to 0.7 ± 0.1 (2mng), in the 'B' row) but increases connection errors (on average, from 1.3 ± 0.3 (1mng) to 1.9 ± 0.5 (2mng), in the 'D' row) because of interference between managers. Adding more devices (with 2mng), connection errors (in the 'D' row) proportionally increase (regarding 1mng) by approximately 0.2%, and errors due to incorrect selection of previous devices (in the 'C' row) slightly increase from 0.9% (2dev) and 1.6% (3dev) to 2.1% (4dev). These results show that the method proposed in this paper does not have significant errors or malfunctions (in all cases, malfunction errors are around 0.5–0.6%, in the 'E' row), and the method improves the accuracy in the multiuser identification by reducing the error rate to 4.9% on average (less than 5%).

Table I. Success ratio (%) of standard communication

Connection	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13
1st attempt	95.6	96.0	95.6	95.3	95.1	94.1	94.3	95.8	94.8	95.2	95.3	95.2	95.7
2nd attempt	3.0	3.9	2.7	3.1	2.6	4.0	2.4	3.3	2.4	3.7	2.1	3.6	2.4
next attempts	1.4	0.1	1.7	1.6	2.3	1.9	3.3	0.9	2.8	1.1	2.6	1.2	1.9

(a) Residences for the elderly: R01 to R13

Connection	HC1	HC2	HC3	HC4	HC5	HC6	HC7	HC8	HS1	HS2	HS3	HS4	HS5
1st attempt	95.6	95.3	95.1	96.0	94.6	95.2	94.8	95.3	94.5	94.3	94.5	95.3	94.4
2nd attempt	2.2	2.8	3.1	3.3	2.3	3.3	3.0	2.3	3.1	3.7	3.4	3.1	4.0
next attempts	2.2	1.9	1.8	0.7	3.1	1.5	2.2	2.4	2.4	2.0	2.1	1.6	1.6

(b) Health Centres (HC1 to HC8) and Hospital Services (HS1 to HS5)

Table II. Success ratio (%) of multiuser identification

	mean	**1dev 1mng**	**2dev 1mng**	**3dev 1mng**	**1dev 2mng**	**2dev 2mng**	**3dev 2mng**	**4dev 2mng**
Success	**95.1%**	**95.8%**	**95.2%**	**95.1%**	**95.3%**	**95.2%**	**95.2%**	**94.3%**
Errors	**4.9%**	**4.2%**	**4.8%**	**4.9%**	**4.7%**	**4.8%**	**4.8%**	**5.7%**
A. no device	0.7%	1.3%	0.7%	0.4%	1.1%	0.6%	0.3%	0.8%
B. no manager	0.9%	0.9%	1.0%	1.1%	0.6%	0.7%	0.8%	1.0%
C. previous device	1.1%	0.0%	1.3%	1.9%	0.0%	0.9%	1.6%	2.1%
D. connection errors	1.6%	1.6%	1.2%	1.0%	2.4%	1.9%	1.4%	1.2%
E. malfunctions	0.6%	0.4%	0.6%	0.5%	0.6%	0.7%	0.7%	0.6%

A summary of usability and acceptance of users, following the first section of the QUIS questionnaire, is detailed in Table III. The general impression (terrible-wonderful axis) is really good (8.2 ± 0.7), practically all users rated the system higher or equal to 8 points. Results of ease (difficult-easy) of use and learning show that more than 75% of users find the solution easy to use (7.6 ± 0.8) and even easier to learn (7.9 ± 1.3). Regarding the questions about whether the solution is stimulating (or dull) and flexible (or rigid), answers show that both ratings are acceptable, 5.7 ± 1.6 and 6.1 ± 1.9, respectively. To analyse the power of the solution, questions were asked to rate the perceived speed and reliability, and the answers reveal an adequate power (7.1 ± 1.4). Finally, almost 70% of users were satisfied with the solution, independently of their age, sex, educational level, and technological knowledge.

To check the consistency of the questionnaires, Table IV details multiple results. More than 90% of users find the graphics and colours with much or very much adequacy. For the majority of users, the information format and the user identification seem "indifferent" and demonstrate the technology transparency as a positive point of the solution. Similarly, there is no clear preference between tablets and smartphones, although their preferences (2 of every 3 users) show interest in voice interfaces and no special interest in wearable medical sensors. Overall, the results confirm the usability.

Finally, the time savings in the daily routine of health professionals was measured. Table V shows the average times (in minutes) measured over two working weeks for the daily service of the participants, grouped into three categories (nursing, medicine, and caregiving) for the three proposed environments: residences for the elderly (RE), health centres (HC) and hospitals services (HS). In all cases, Table V compares the time of the daily routine in a traditional way (manual) versus using the proposed e-health solution (digital) without the multiuser identification (no ID) and including it (with ID). The results are significantly positive with a time savings of more than 50% in all groups and scenarios. Remarkably, nursing is the most favoured group with the use of the proposed technology (time savings of 62.4 ± 0.6). In addition, the hospital is a favoured scenario with time savings of 62.5 ± 1.3 (in nursing) and 56.7 ± 0.9 (in medicine). For medical professionals, digital identification does not represent a substantial time savings because the patient identification process is part of the medical action protocol. However, the multiuser identification significantly improves the time savings in all situations, with improvements (with ID vs. no ID) of 7.1 ± 0.4 (residences), 6.6 ± 0.7 (hospitals), and 5.6 ± 0.3 (health centres).

Table III. Summary of usability results

Terrible – Wonderful (general)	**8.23**
Difficult – Easy (to use)	7.61
Frustrating – Satisfying	6.82
Inadequate – Adequate power	7.15
Rigid – Flexible	6.17
Dull – Stimulating	5.78
Difficult – Easy (to learn)	7.94

Table IV. Detail of usability results

Question	Percentage (%) of answers					
	VM	M	I	L	VL	NA
Adequacy of the graphics and colours	**50.6**	42.8	2.1	1.6	1.4	1.5
Adequacy of the information format	12.4	9.3	**48.6**	7.2	2.5	20.0
Importance of the user identification	17.3	8.6	**51.7**	6.1	3.2	13.1
Election of tablet vs. smartphone	13.5	12.4	**37.3**	14.8	17.3	4.7
Need of voice interface (not only touch)	16.8	21.2	**29.4**	22.3	7.6	2.7
Interest in wearable medical sensors	5.2	8.1	19.2	27.4	**31.7**	8.4

VM = Very Much, M = Much; I = Indifferent; L = Little, VL = Very Little, NA = Not answered

Table V. Time saving (in minutes) in the daily routine of health professionals

	Nursing			**Medicine**			**Caregiving**		
	RE	**HC**	**HS**	**RE**	**HC**	**HS**	**RE**	**HC**	**HS**
manual	21.0	17.0	14.0	16.0	13.0	9.0	32.0	30.0	24.0
digital (no ID)	9.8	8.0	7.0	8.0	6.5	4.8	19.4	17.3	15.3
digital (with ID)	5.7	5.0	3.5	6.0	4.0	3.0	12.3	11.7	8.7

V. DISCUSSION

One of the main reasons why e-health solutions are not more widely used in residences, health centres, or hospitals is that each device uses different communication protocols, so different software or hosting is needed to process the information from varying devices. This makes the system so expensive and time consuming that its implementation for a large range of users is financially and logistically impractical. Since ISO/IEEE 11073 is becoming the recommended standard for more entities, such as the Food and Drug Administration (FDA), network infrastructures with multiuser identification is the next step in e-health implementations for a high number of users. Because there is still a long period before standards are widely implemented in health environments, several key points are required to further advance the standardization process.

One point is patient identification. This paper analysed two ways for identifying patients. First, when a vital sign is measured, and the information is sent safely, attached with the Patient ID. Second, when RFID identification is used for correctly linking the patient with the prescribed drugs or treatment. There is still a third, interesting and cheap way, consisting of smartphones with NFC using an app that reads the RFID code, and it checks the drugs to be administered. Possibly, it may be cheaper and faster to create apps for smartphones than to develop devices for reading the RFID tags and sending the information for comparison over a server. This app would allow the user to send patient data identification with a measurement that the healthcare professional could introduce manually on the screen of the device. Probably, it could be a small application compared with the numerous possibilities of automated e-health systems discussed in this paper. However, it could be useful because it is a cheap and easy method to help nursing and medicine services become familiarized with the advantages that e-health systems offer. Furthermore, the use of e-health solutions within multiuser identification solutions enables the implementation of advanced services and data analysis that would not otherwise be possible. For example, the use of RFID tags for patients, machines, and drugs significantly reduces the chance of confusion in the data and makes information quickly available, which is critical for treatment administration.

Other point is integration to electronic patient records. E-health community have spent many years working on the seamless integration of standards, for example between ISO/IEEE 11073 and ISO/EN 13606 [21], to further advance towards end-to-end interoperable e-health solutions. In the new technological contexts oriented to digital health, a key issue to ensure interoperable continuity of care is by harmonizing medical data acquired in any patient environment with any Health Care Information System (HCIS). To address this integration task there are several challenges, such as: preserve the consistency among data, information and knowledge; and implement open standards and middleware components that permit transparent interoperability and improve the usability of e-health among health care professionals in concerned.

VI. CONCLUSIONS

The wireless communication technologies and the closed and commercial e-health proposals typically belong to a convoluted and segmented ecosystem. In an attempt to seamlessly handle this heterogeneity, open and interoperable initiatives are needed. To achieve such a goal, this paper aims to contribute with two approaches to be included in ISO/IEEE 11073 family of standards as a standardized procedure for multiuser identification that is implemented in a wireless standard-compliant e-health solution for elderly people.

This solution is based on the internationally recommended ISO/IEEE 11073 family of standards, with its Bluetooth HDP profile, and a design model that relies on modularized architecture and abstraction layers compatible with PCH Alliance-certified medical devices. This proposal contributes with an open interoperable alternative to the closed and commercial solutions and enables third-party developers to work collaboratively and extend the currently implemented features, owing to the design based on plugins, value-added services, and multiple transport technologies and protocols.

With almost 460 participants in the assessment process, results have demonstrated the technical validation of the standard communications, and the proposed multiuser identification method reduces the human error rate (from 13.3% to less than 5%). Furthermore, the usability evaluation is very positive: almost 70% of the users are satisfied with this solution, and time savings is more than 50% in all the groups (nursing, medicine, and caregiving) and environments (residences, health centres, and hospitals).

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