eSticky–An Advanced Remote Reminder System for People with Early Dementia

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Abstract. While the European population is aging, the number of people with dementia is dramatically rising. With this comes an increased need for products that help affected people to be more independent and able to live in their own home for as long as possible. ESticky addresses this need by providing a sophisticated reminder system that replaces the old-fashioned sticky-notes by electronic versions thereof, which can be programmed from near and far in a device-independent manner via the internet and using a standard web browser. For this purpose, a set of low-cost ePaper-displays are used, accompanied by a small and unobtrusive base station. The displays can be placed at several strategically useful places in a user's home, to enable users and/or care persons to place reminders that will, based on the user's daily routines, most probably be read. Active displays even enable the user to press a confirmation button to show that he or she has actually read the reminder. The system is developed using a user centred design approach, to take all stakeholders' wishes and needs into account, in order to come up with a system that is easy to use and provides good service to many people.

Keywords: Reminder system · Dementia · Older adults · Independence

1 Introduction

The number of people living with dementia worldwide in 2013 was estimated at 44 million. By 2030 this number is expected to reach 76 million and by 2050 rise up to 135 million [1]. It is also foreseen that by 2030 one in five people will be older than 65 years of age and almost half of the people that are older than 84 will have dementia [2, 3]. In Europe, data shows that the age-specific prevalence rates have been constant over time and this trend is expected to continue in the future [4].

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Alzheimer Europe's 2013: The prevalence of dementia in Europe report [5] estimated that the average EU population who were living with dementia at the time was 1.55%. The report further indicates the population for Italy being 1,272,317 (2.09% of the total population), for Austria 145,431 (1.73% of the total population), for Cyprus 11,250 (1.07% of the total population) and for Poland 501,092 (1.31% of the total population). The fact that this report shows that there are people living with dementia in the age band of 30–59 is worth noticing. Even though the number of affected population within this age band in comparison to older age bands is considerably less, it indicates that dementia can also be experienced by younger adults too.

Studies in many countries have attempted to quantify the financial cost of dementia. This has proven to be a challenging task but what is clearly agreed upon is that these costs are large and growing. In OECD member countries, which include Italy, Austria and Poland, a significant portion of health spending is linked with the direct costs of dementia (e.g. nursing home care). A cross-country variation does apply nonetheless [5]. In addition to the direct costs of dementia there are also significant indirect costs too; the outcome of the impact on families, carers and the wider community. As previously mentioned, it is difficult to quantify the full cost because measuring and estimating the indirect costs presents methodological challenges (e.g. quantifying with a monetary value the cost of informal care). Hence, different approaches are used in different studies leading to uncertainty on the resulting numbers. From a European perspective, it is noticeable that we account for about a third of the annual global costs [5].

Insufficient support from professionals and health care services to stimulate self-management abilities is often experienced in the early stages of the disease, while interventions for coping with dementia are rare. Moreover, medical treatment still remains as the main focus of such interventions. Rather, an approach that adopts a more holistic view of the person and their needs is required, as was also proposed in [6]. Most people with dementia would prefer to continue living in their own homes. This situation would have a positive impact on their quality of life while also keeping them closer to their families. Furthermore, it would benefit them financially too, since formal care at home can be expensive and in some cases not even possible [7]. Either way, the burden for both family and paid caregivers is heavy. As the elderly population increases and the number of younger adults' decreases it will become even more unviable to expect younger adults to assist older persons with their long-term care needs in general, including those due to dementia. Long-term care workforce shortage, caregiver burden and high costs of care have led to an increase of interest in the potential of Assistive Technology (AT) to substitute for, complement, or supplement paid and unpaid caregiving for people with dementia [8].

AT that supports people who are living with dementia varies greatly. Their goals are commonly cited as maintenance of independence and providing a sense of autonomy, relieving caregiver burden and contributing to better safety. From simple standalone devices to more complex integrated systems, by helping a person remain independent for as long as possible, it enables them to live longer in their own homes than would otherwise be possible. Everyday living, monitoring, safety, communication, as well as automated prompts and reminders are areas where AT can be especially helpful for persons with dementia.

Since the purpose of AT for memory impairment compensation is to offer reminders or prompts, dementia has thus been equated to memory impairment. It must be noted however that people living with dementia are not just forgetful, but their ability to recall information, recognise objects and create new memories are also affected. As a result, storing, retaining and recalling new knowledge is a problem. In turn, their ability in learning and remembering how to use AT devices is likewise impaired. Existing products that offer reminders seem to have neglected this aspect and hence their design does not consider the type and range of cognitive impairments found with persons in this population.

The eSticky project aims to design and develop small and novel eSticky displays that provide reminders and prompts to people living with dementia. The novelty of the product will lie in its design and its affordability, as well as in the combination of several reminders into an integrated, remotely configurable and extendable system. Resembling traditional sticky notes, the proposed eSticky displays will be affordable to the point that a person living with dementia can purchase multiple displays and stick them in different areas of his or her home. By having eSticky displays located in every room of the home, family members and/or caregivers can predetermine, based on the normal daily routine of the person living with dementia, in what area of the home it will be more effective to set a reminder on the respective eSticky display. Reminders and prompts can be set using the eSticky web portal. Let us assume that a person living with dementia has a doctor's appointment at 12:00. The evening before the day of the appointment a family member uses the web portal to (remotely) set a reminder for 08:00 (the next morning) on the eSticky display that is located in the kitchen and also sets a reminder for 11:00 on the eSticky display that is located in the TV room. These eSticky displays were purposefully chosen by the family member since he or she is aware of the daily routine of the person living with dementia. This routine usually entails that the person be in the kitchen between 07:45–08:15 for breakfast and watch favourite TV shows between 10:30–11:30.

The user-friendly and intuitive design of eSticky makes it accessible to people with disabilities and easy enough to use to enable people with beginning dementia to set their own reminders.

2 IoT Importance for Older Adults

The Internet of Things (IoT) can improve older adults' quality of life. Additional important benefits resulting from their use include decrease of strain on national health systems and decrease of system operational costs overall [9, 13]. As an aging society, the use of such technology should be pursued for improved lifestyle, independence and home health care and promotion [10, 11]. Coupled with the design and development of this technology solutions and services, one needs to consider the five basic programs proposed by the General Assembly of the United Nations in 1991 (UN, 1991) when care is offered to older adults: independence, participation, care, self-fulfilment, and dignity [12, 13].

The potential of the IoT paradigm in the context of assisted living for older and fragile adults is discussed in [22]. Considering the peculiar requirements of this user group,

the authors [22] evaluate the paradigm from functional and technological perspectives. In their review of the state-of-the-art, the authors [22] mention that research on matching users' needs, values, habits and lifestyles are evident in the literature, especially in the design of new IoT-based AAL systems [14–16]. One IoT platform that was implemented to take care of older adults at their home is presented in Pires et al. [17]. In their study [17], a smart TV was used to convey health-related information to the individual, using an unobtrusive method (i.e., as additional commercials). Others [18, 19] have focused on adopting user-centred design approaches for the design and development of an ehealth platform to assist older adults in smart cities. An IoT architecture was modified to also include an additional layer in [20] that would help address specific needs of people with diverse disabilities. Efforts have likewise been directed towards standardisation, focusing on effective user-centric IoT based AAL solutions [14]. Moreover, it was reported that more promotion is needed in this regard, since lack of standards is seen as a major challenge to the actual spread of IoT-based AAL systems in healthcare specifically. In [21] it is reported that in addition to efficiency and security, system flexibility and learnability are likewise key features of the user-centric IoT design that could significantly increase the level of system usability.

The study in [23] investigates the effectiveness of an electric calendar, showing the date and schedule automatically for older people, and to prove the characteristics of appropriate users. The participants were 27 older adults with or without dementia (9 men, 18 women, 72–94 years old). The study design was a cross-over randomized controlled trial, with 15 participants (55.6%) allocated to the first group to use the electric calendar, and 12 participants (44.4%) to the second intervention group. The outcome measures are daily behaviors and cognitive function assessed by the Mini-Mental State Examination and Neurobehavioral Cognitive Status Examination. Participants showed significant increase in total Mini-Mental State Examination score after intervention period, whereas there was no significant difference after no intervention. Daily activities related healthcare were improved. The participants with positive outcomes showed higher motivations and around 18 points in Mini-Mental State Examination. Most healthy older adults mentioned that electric calendars were useful, but unnecessary. Using the electric calendar was effective in improving global cognitive function and daily activities.

3 End User Aspects

The main target group of eSticky (potential end users) are people with age-related obliviousness, people with beginning stages of dementia and people with beginning Alzheimer's disease (only in an early or medium state), so-called primary users, who can live independently in their homes or professional institutions for older people without any special help. The stakeholders also include informal carers (e.g. family members, so-called secondary users) and formal carers – care service providers offering 24/7 assistance, retirement homes, nursery homes and their formal staff (healthcare professionals, i.e. tertiary users). eSticky will be used directly by older people with memory problems and their caregivers, families, etc. who will use it for the good of the primary users.

The main objectives of user involvement in the project are to:

1. Define the process and procedures for the recruitment and involvement of older adults.
2. Analyse the demand for assisted-living solutions based on data for the services operated by experts (i.e., end-user oriented consortium partners) to drive implementation.
3. Provide input about customer behaviour and attitude, purchasing processes, regulatory and other decision-making for validating the customer appreciation and evaluation of the solution, willingness to use it and willingness to pay for it (price sensitivity).
4. Identify security, safety and privacy issues for data collection and monitor compliance with the regulations.

In the initial phase, the project activity picked-up from the older adults and carers/families to analyse the demands and needs and the platform specification, to guarantee that these demands and needs are respected in the hardware configuration of the device and the adaptation of the software platform and services. For the evaluations that are being conducted in the project, a total of 40 older adults will participate, in two countries, i.e. in Austria and Poland. In a full user-centred design approach (UCD), end-user oriented partners will constantly monitor, discuss, evaluate and provide feedback based on the system development activities, so as to guarantee the proper implementation, integration and optimization of the platform.

To achieve it, the development of eSticky notes is user driven right from the beginning of the project. First, the methodology has consisted of studying existing results from requirements analysis conducted in other projects, where relevant and freely available. For this purpose the other assistive technology (AT) tools, devices and past Active and Assisted Living (AAL) projects from 2014–2018 were analysed pointing out the differences between various solutions and to confirm that there are a lot of prototypes and products for older adults, including people with memory problems, but none of them are similar to the eSticky solution. The end-user partners shared their research and analysis of AAL and AT, and personal experience in the usage of AAL. Moreover, they analysed trends in business models of these systems. The important aspect of planning user requirements was to define the process of recruiting users, policy for user involvement, taking into account local cooperation organisations (national associations, centres and non-governmental organisations), own contacts and communication channels of end-user partners in Austria and Poland, as well as inclusion and exclusion criteria of users, exit strategy, data collection methods, privacy design and ethical issues.

The next task has focused on choice and usage of investigative methods for user-centred design to fulfil the goal of a product engineered for its users including: ethnographic study, contextual inquiry, prototype testing, usability testing and other methods. Generative methods may also be used in the project including: card sorting, affinity diagramming and participatory design sessions. The goal of the user-centred design is to make products which have very high usability. This includes how convenient the product is in terms of its usage, manageability, effectiveness and how well the product is mapped to the user requirements. The end-user partners provided the review of standards for eSticky design (ISO norms, Universal design, Privacy by Design, World Wide Web Consortium (W3C) standards, Web Content Accessibility Guidelines (WCAG), Mobile

Web Best Practices, Design for All), review of business tools (like SWOT, PESTLE analysis, Business Model Canvas, Stakeholder analysis, User stories) and proposed different materials and forms for work with users.

An analysis of usable products similar to the product being designed in eSticky was also prepared, including the review of other electronic displays, watches and wristbands, sound players, automatic and electronic pillboxes, providing the conclusions and suggestions for further design process in the project.

Then, an initial user research was conducted to test the user interface (UI) mock-ups and to help generate the requirements focus groups with primary and secondary users to assess the prototype and field trials with primary users in the second testing phase. The results from the focus groups have generated input for the development of the prototype and will be continued to continuously improve the system, serving as a constant source of feedback.

Finally, the integrated prototype will be installed in the user's homes and field trials will be conducted in order to define further requirements for the development of the final product. The purpose of end-user involvement in the project is to create a solution that will meet potential users' needs and expectations. Nobody knows the requirements of people with dementia better than affected people themselves do (and their families and caregivers). Involving end users right from the beginning will allow eliminating basic mistakes when designing, testing and implementing eSticky notes.

1. In the exploratory and creative phases of the innovation process, the wishes and needs of the end-users serve as input to the development of the new solution and design of the business plan.
2. In development phases, the end-users provide the feedback loops validating and verifying the progress of the development work.
3. In business plan development, end-users provide input about customer behaviour and attitude, purchasing processes, regulatory and other decision-making. End-users are also crucial for validating the customer appreciation and evaluation of the solution, willingness to use it and willingness to pay for it (price sensitivity).

Since this qualitative approach towards user-involvement takes a significant amount of supervision, only a specified group of users can participate in the project. These are spread across our 2 user sites in Austria and Poland and user partners make sure that as many different user-profiles as possible will be included.

Since depending on users' condition some of them will have reduced cognitive capabilities, there are certain additional ethical issues that need to be taken care of. Legal and ethical issues will be especially considered for the testing and evaluation phases of the application with the end users. In these phases, data is obtained by monitoring the behaviour of the elderly people while at home, and this data will be processed and analysed. This will require the authorization by the end user and/or his family. The end-user partners have produced a detailed "Informed Consent" process (signed by either the users themselves or their legally assigned representatives) that guarantees transparency and include information such as a description of the project and its aims, a specification of the role of different end-users in the project, self-determination of the end-users (to be able to turn off systems or services at their own discretion), contact person in the

project (for ethical issues and related questions) and exit rights for individual end-users (withdrawal possible at any time, without a reason and costs).

Moreover, one very important issue is that the privacy of the elderly people must be respected. Therefore, user data will be (a) fairly and lawfully processed, (b) processed for limited purposes, (c) adequate, relevant and not excessive, (d) accurate, (e) not kept longer than necessary, (f) processed in accordance with the patient's rights, (g) secure and (h) not transferred without adequate protection.

It is worth underlining that the end-user partners have applied for ethical considerations by ethical committees in Poland and Austria to ensure compliance with national guidelines regarding Informed Consent and confidentiality. The consortium also acts in compliance with the EU's General Data Protection Regulation (GDPR) 2016/679 and respective national regulations in Austria and Poland, where these are more restrictive than the GDPR.

Another important goal of this project is that the system can be used by as many people of the target group as possible. Therefore the consortium follows the "Design for All" principle during all evaluation, design and implementation steps to fulfil this criterion.

The eSticky UI mock-ups were tested so far by older adults and their caregivers in two European countries, namely Austria and Poland. Due to the social distancing measures imposed amid the COVID-19 pandemic, each end-user site implemented the testing via small focus groups, one-to-one meetings or virtual meetings according to their resources and national restrictions in place at the time of the recruitment. In total, 27 persons (age range: 34–67, gender: 9 men and 18 women) of primary, secondary (some participants had both roles) and tertiary users (professional carers) evaluated the UI mock-ups. The majority of users were from urban areas, some of them from rural areas and had between little, medium and high IT literacy (but all users had at least a little experience with IT systems). The end-user partners received so far quite positive feedback and good opinions from the users in both countries, as well as the comments and suggestions for improvement of the system. Section 5 summarizes the UI mock-ups in detail and provides the conclusions from user feedback.

4 High-Level System Architecture

The high-level system architecture shows the relationships between the different sys-tem components (Fig. 1):

1. **Displays (passive)**: Passive displays simply show the reminder messages. The user has no possibility of interaction with a passive display. The base station sends messages to the displays (according to the database entries), which show these messages with the determined display parameters.
2. **Displays (active)**: Same as passive displays, only that the user can make simple interactions here, i.e. he or she can press a button to confirm. The user's answer will then be sent to the registration server and stored in the database. Relatives or carers can view this answer on demand via the web application. After confirmation by the user, the message is deleted on all displays.

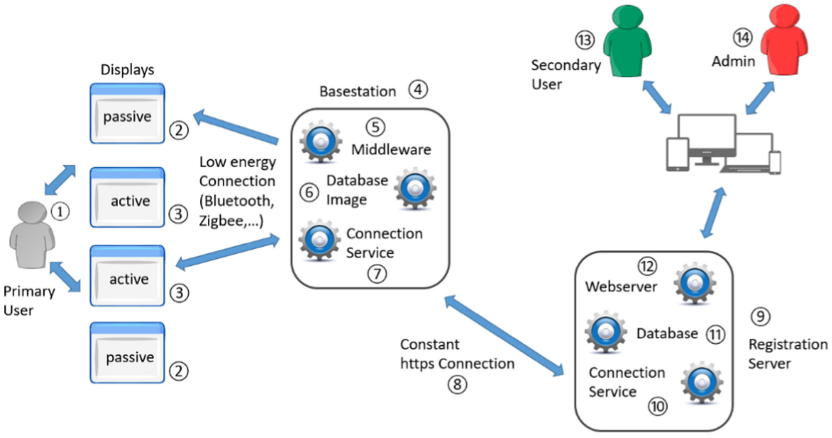

Fig. 1. High-level system architecture

3. **Base station**: The base station includes the middleware, an image of the database and a connection-service to interact with the registration-server. The base station has a pre-configured admin-user-account for service purposes.
4. **Middleware**: The middleware controls the displays. It uses an image of the database (located on the registration server). It registers new displays with a unique ID due an automatic pairing process.
5. **Database Image**: Image of the Database, which is located on the registration server.
6. **Connection Service**: Sets up and keeps alive an https-connection to the registration server.
7. **Constant https-Connection**: Connection between base station and registration server, used to get image of the database, get notifications, when the database has been updated and send users' confirmation messages to be stored in the database.
8. **Registration Server**: Contains a connection service, the database and a webserver.
9. **Connection Service**: Maintains the communication with the base stations.
10. **Database**: Stores all the messages and their schedule as well as the assignment to which displays every message will be sent. The users' confirmations will also be stored here.
11. **Webserver**: Delivers the web app that lets the secondary users configure the system (set user-friendly name for registered displays, user management, etc.), maintain the message schedule (incl. setting the message and its parameters) and view the primary users' confirmations. Special attention is paid to responsiveness, usability and accessibility (WCAG 2.1 AA) when implementing the GUI. When a secondary user changes something, it is stored in the database and the respective base station is notified via the connection service.
12. **Secondary User**: Relatives and carers (and also primary users, if their dementia still allows it) can communicate with the web application via different end devices (e.g. PC, tablet, smartphone). They can create new messages, parametrize messages (view), create schedules for the messages, select the displays on which the messages should appear and view the primary users' confirmations.

13. **Admin**: The admin configures all system relevant settings:

    - A user-friendly name for the registered display-IDs
    - User administration (user name, password, rights and roles).

5 UI Mock-Ups and Conclusions from User Feedback

With primary end user's needs in mind, a first set of UI mock-ups was designed by the technical and the design team. The goal was to design a UI, which is intuitive and guides an end user through the system configuration and message creation in an easy way. Although it was clear at the time of mock-up creation that further design steps were going to be needed, the mock-ups were created in a way that allowed the users to experience the planned basic structure and user guidance of the eSticky system, thus enabling them to give valuable feedback for further enhancement of the UI.

5.1 Description of UI Mock-Ups

When the system is started for the first time, the user chooses a language on a welcome page, before setting up the components. Once the user has given the base station a user-friendly name, he or she can login or register to the system depending if they already have an account or not. In the case of registration, users have to enter their first name, last name, email address and a chosen password. Afterwards the user, who is now the administrator of the base station, has to pair the displays with the system. Further, it is possible to add other supervisors to this base station by inviting them via their email address. Once this walkthrough has been completed, the login page appears. The users that have been invited via their email address get an email with a confirmation link, leading to the eSticky system to join the base station via login or registration.

After successful login, the message list is shown. The user can add a new message to the system via a "create"-button, which leads to a configuration page for a message. Here the user can enter the text for the message, the text colour, background colour, enter a start date as well as the repetition settings and decide if the message should be active or passive. If the message is active, only the active displays will be shown at the bottom of the page, where the user can choose on which displays the message is supposed to be shown later. If the message is passive, however, all displays will be shown, since active displays can serve both purposes. After submitting the message, the user will be linked to the message list again, where the message will be shown now and can be edited or deleted. When the user chooses to edit a message, the user will be linked to the same configuration page again, with the only difference that the fields are now prefilled. Furthermore, a preview of the message will be shown in this view, to give the user an idea of how the message will look like on the display.

As an alternative to the message list, the user can choose a calendar view in the main menu on the top of the page. In this view, the user can select a display and a week and then gets an overview of all the messages scheduled for that week, sorted by day and hour (see Fig. 2).

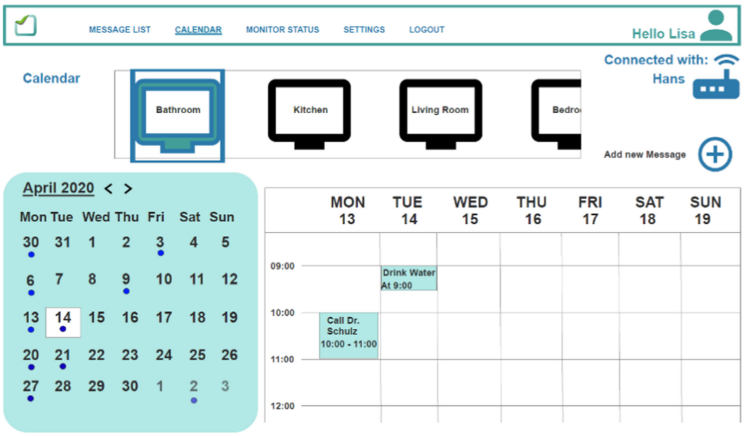

Fig. 2. Calendar view

Just like in the message list, messages can be added, edited and deleted here. The blue dots on the monthly calendar (left hand side) point out the days with at least one message already set for the display selected at the top.

The main menu item "monitor status" links to a page that shows all displays that are currently connected to the user's base station. This view includes the battery life, connection status and current message status of each display to give a quick overview of the connected components. This view also includes the possibility to edit or add a display. When a user decides to edit a display, he or she gets the same view as in the beginning when the initial display pairing took place.

A settings-view can also be shown if selected in the navigation. This page shows the whole information about the accounts that are registered for this base station. Editing an account is also possible here. The displays are also shown again on this page, split into active and passive and with a warning to check the display status in case this is necessary (i.e. low battery).

When a user logs out, the login page is shown again. When a user, who is already registered on the eSticky system for more than one base station, logs in, a page is shown after login where the user can choose to which base station he or she wants to connect. This is mainly relevant for professional careers, who might want to administer eSticky messages for several primary users.

5.2 Evaluation of User Feedback on Mock-Ups

The UI mock-ups were shown and explained to 27 users in Poland and Austria and quantitative as well as qualitative feedback was gathered and evaluated. Then conclusions were drawn on what changes have to be applied to the UI in order to meet user's needs and wishes. Some suggestions were outside the scope or possibilities of the project, like e.g. the wish to be able to use own photos on the displays, instead of icons (the envisaged low-power and low-cost e-paper displays do not provide enough colours and good enough quality for displaying photos). However, many of the user's suggestions

will be taken up and implemented in the actual system prototype. In addition, a detailed manual will come with the system to clarify things that cannot be made implicitly clear in the UI. The following list gives an outline of the most important changes planned:

- The pairing process has been considered too complicated by many users. Therefore, either the displays will be shipped readily paired, or, in the ideal case, a possibility will be found how to do without pairing.
- Buttons need to have a consistent look and feel throughout the system and must always provide textual descriptions along with icons. Also the positioning of buttons needs to be adapted in some views.
- An explanation of what the "active" and "passive" message types (and display types) mean will be given directly in the interface.
- An icon-overview will be added instead of the search field.
- Most users had troubles understanding the many options for message repetition and activating and deactivating those options. Since providing so many possibilities is not possible without a certain extent of complexity, a decision has been taken, in the light of usability, to reduce the amount of options for message repetition, only allowing daily, weekly, monthly and yearly repetitions, as well as a choice of specific weekdays.
- In the calendar view the distinction between active and passive messages will be made clearer by adding an "A" in the corner of every active message. A confirmed message will be marked by green colour and a check mark, while a "!" and red colour signal that the message has expired without being confirmed.
- Horizontal scrolling will be avoided at all times.
- Generally, text size (compared to icon size) was an issue for some users. Text will be larger in the next version of the UI.
- Users asked for light signals and sounds to attract the user's attention. There is an ongoing discussion about adding sound and LEDs to the displays. The main issue here is the power consumption, which must not interfere too much with long battery lifetime. Therefore, the final decision on this issue is still pending. It depends on the outcome of further tests.
- To allow messages of a certain length, but also to allow large messages for people with vision impairments, different font sizes for the message text will be possible in future.

6 Middleware and Connectivity

The aim of the middleware is to forward the appropriate messages to the corresponding displays, according to a predefined schedule. The middleware runs on the base station that is situated at the home of the primary user. It connects to the webserver to acquire message updates for the particular primary user, as well as the messages' schedule. The middleware consists of 3 modules: the reasoner, the scheduler and the sender. In addition, it also interacts with a local MySQL database (DB) where it stores the messages as they arrive from the webserver in order to send them to the displays at the appropriate time for each message. In addition, the local DB also serves as a means to support the system for several hours in case of internet connection failure, as the messages will be retrieved from there and sent to the displays according to their initial (prior to internet connection failure) schedule.

6.1 Components

In the following paragraphs we describe the components that compose the middleware. Figure 3 shows the system workflow.

Reasoner
The Reasoner Component retrieves the user-scheduled messages from the webserver and stores them in the middleware's local DB. A set of appropriate REST calls are issued to receive new messages, as well as updates for existing messages. Other information retrieved include details about how the messages should appear on the display of choice (i.e., the "designs" of the messages, see Fig. 3). All retrieved data are stored into the middleware's local DB on the base station. The messages will be sent to the displays at the appropriate point in time, decided by the Scheduler Component based on the messages schedule. There is a distinction between "complex" and "simple" messages, where complex messages are "iterative", meaning that they appear more than once on a display. Simple messages define a single appearance on the display.

Scheduler
One of the major roles of the base station is to decide when and where messages need to be sent. This task is being handled by the scheduler which is responsible for figuring out what messages are in line to be displayed, which monitors will display them and when these messages should be sent. The scheduler accomplishes this task by regularly checking the DB table containing the messages as inserted by the reasoner beforehand. If any messages are to be displayed in a specific time span, then the scheduler will retrieve them and place them in a queue. The messages in the queue will be sent to the appropriate displays and will be handled by a different module, namely the sender. Once a message is placed in the queue, the scheduler marks the message as "in queue" and moves on to the next messages.

The sender is the module responsible for sending the messages in the queue. It is a simple and fast module that is able to read the messages, connect to the corresponding display and send the messages, logging at the same time any errors.

Having two separate modules for the scheduler and sender is considered a preferred approach, as opposed to having a single module doing all, as this process is very sensitive when it comes to punctuality through long time periods and needs to be able to recover from any unexpected issues/failures that may occur. Having two different modules ensures that, in case the sender fails to send a message to a display for any reason and stalls (e.g. network or connectivity problems), the scheduler will continue functioning as normal, ensuring that no other messages are lost due to issues. Additionally, if these modules were to be combined in one, a possible delay would become a possibility as well. As the sending procedure may be time consuming compared to other functionalities of the system after the continuous use of the system through time, a delay could accumulate which may result in missed messages. This possibility is eliminated by the separation of the two modules.

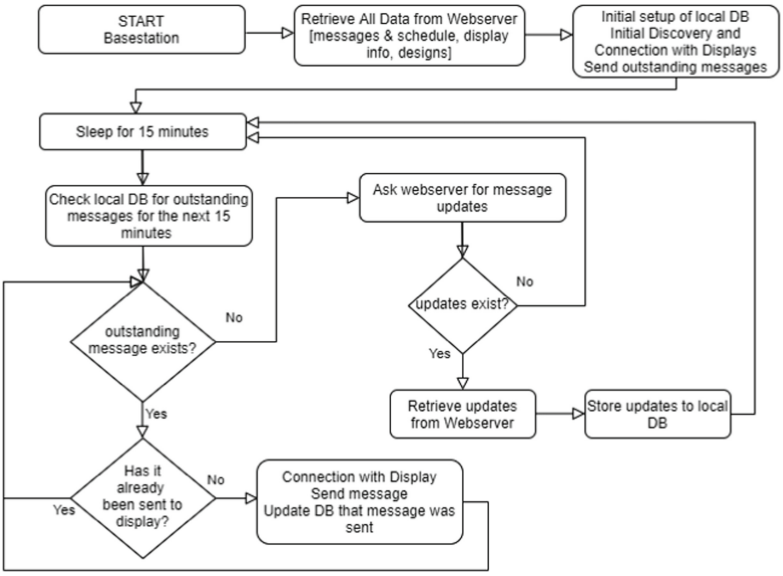

Fig. 3. The Middleware's workflow

7 Alternative Displays Solutions

An important requirement of the project in terms of the hardware components was to find an appropriate solution to facilitate the displays that will be placed in the local environment, i.e. the end user's house. Prior to defining the final design, that is based on the ESP32 microcontroller, the consortium was also considering two alternative solutions from the market. Both solutions satisfied the specifications of the project and provided pre-programmed displays that can be easily set up in the end user's house. The specifications for the displays included among other, long battery life to avoid recharging in time intervals that are less than 6 months. That would allow for a technician or a family member/healthcare professional to undertake this task. The first solution was rejected due to the fact that it required an extra device, a hub that was responsible for connecting with the displays and sending them the messages to be displayed. This process is facilitated by the base station. In addition, some displays did not support the decided communication protocol, while those that did, were extremely energy consuming. About the second solution, while it did not require any extra devices and all of the displays supported the communication protocol, it did not provide enough support in terms of maintenance, configuration and programming of the displays.

8 Conclusions

The development of the eSticky system as it is going on at the moment has been described in this paper. The background has been given and the user involvement thoroughly discussed. After an outline of the high-level system architecture, the work that has happened

on user interfaces has been described, as well as the conclusions drawn from user feedback to the UI mock-ups. The middleware was clearly described in its functionality and technical decisions in terms of hardware outlined.

In conclusion, the user feedback so far has been good and promising for future system uptake, provided that some adaptations are made to the UI, which are already in progress. The system is quite safe towards internet connection failure, saving its status from before the failure on the local database. The final system shall be very easy to use and will enable users to remind themselves or be reminded in a convenient way that is fit to ensure longer independence for the elderly end users.

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