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Distributed Architecture for an Elderly Accompaniment Service based on IoT Devices, AI, and Cloud Services

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Abstract— As the population ages, we face a substantial increase in health and care demands. This requires large investments from public administrations and associations that are currently overstretched. Indeed, the material and human resources required to offer quality and sustainable care are lacking. The private sector is not offering a clear solution either as it is unable to offer generally affordable personalised attention. This paper proposes a distributed architecture that supports an accompaniment service for the elderly and dependents (*SAM Service*). It is based on the creation of a technological platform of cloud services, together with an accompanying device. The service uses smart devices, natural language and a specialised social network that connects the elderly with their families and with their social and health carers. SAM Service will help to mitigate the complicated issue of care as it will allow public bodies, associations, or companies to offer a 24/7 quality accompaniment service that is both affordable and sustainable. Given the complexity of this type of systems, the main contribution of this work consists of the proposal of a set of architectural patterns that will facilitate the deployment of the service under different technologies, actors and development scenarios.

Index Terms— **Accompaniment for the elderly; dependent; IoT; Cloud Service; e-Health; Quality of Life**

I. INTRODUCTION

THE number of senior adults had already reached 101 million at the start of 2018. The projection is that this figure will rise to 149 million by 2050. The growth of the very old population (over 85), which will more than double, attaining 31.8 million in 2050, as opposed to the population of 13.8 million at the beginning of the study in 2018. For their part, centenarians will reach half a million in 2050, i.e., a fivefold increase compared to 2018. By 2050, there would be less than two people of working age per individual aged over 65.

This longevity comes with increasing health and care service demands. Chronic diseases accentuate the problem: they affect 80% of people aged over 65 years and account for 86% of deaths across Europe [1].

The accompaniment of the elderly complements the care of the elderly and dependents. Beyond physical health, accompaniment improves their quality of life, maximising their independence and preventing situations of potential risk. The accompaniment concerns daily activities, and it requires total dedication and trust. The most common accompaniment activities include offering company day and night, helping with shopping and visits to the doctor, reading a book or news, monitoring the taking of medication, or ensuring that daily routines are followed. Accompaniment is a necessary personal and social support for the emotional health of this population segment [2-4].

Yet this desirable service has become prohibitively expensive for most households, for family associations and even for governmental and non-governmental organisations [5-6]. The reasons are the sheer amount and range of tasks involved, the sector of the population addressed, and the sensitivity of the issue, as well as the amount of both material and human resources necessary to achieve the required care.

The general objective of this study was to improve the quality of life of our elderly citizens through sustainable IT services, and more specifically, through the creation of an Accompaniment Service for the Elderly and Dependents (*SAM Service*). The proposed service is based on a network that interconnects these people with their families and their health staff (*SAM Network*), offering different accompaniment services, mainly through an IoT device (*SAM Device*). These devices perform accompaniment tasks based on a personal assistant that will attend them twenty-four hours a day, communicating via natural language, while also acting as the interface of the whole accompaniment service.

This work is mainly motivated by the problems and shortcomings that the research group has been detecting over the more than eight years that it has been working together with the social services of different populations.

The specific objective of this article was to advance an architectural framework that defines and organises all the distributed IT system components that are necessary to create and deploy such a complex technological platform. It was designed to easily integrate different technologies as well as manufacturers and provides different deployment scenarios (from the most compact, based on a stand-alone application located on an IoT voice assistant device, to an entire deployment of cloud services and microservices, with proprietary and third-party components). The ultimate goal was to achieve a scalable, reliable and sustainable service over time.

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The rest of the work has been structured as follows: Section 2 presents a state-of-the-art overview. This latter analysis led to the proposed solution, detailed in Section 3. Section 4 presents the platform's high-level architecture needed to support the SAM Service. Section 5 describes the implementation of the system's components by setting out the technical architectures which specify the necessary technological elements. Section 6 presents a case study illustrating different deployment architectures that ensure the project's implementation. The main conclusions and the future lines of action are detailed in Section 7.

II. STATE OF THE ART

A range of studies exists in the literature on the viability of using computer systems for communications between patients, family members and health personnel. Others works have defended how telecare can reduce the care costs of the elderly or even improve the care they are given. All of this has laid the basis to different investigations to focus on proposals for telecare on for the elderly [7-8].

An innovative programme to finance European programmes called Ambient Assisted Living (AAL) was launched in Europe in 2008. It was followed by the Joint Active and Assisted Living Programme (AAL-2). These programmes are part of the European Union's Research and Innovation framework programme called Horizon2020. The AAL concept refers to technical solutions that help people with disabilities or the elderly to lead a more independent life or that permit people to live autonomously in old age. The goal is to stay connected, healthy, active, and happy in old age. Although AAL-2 maintains the same priorities as its predecessor, it does so with a particular focus on the Societal Challenges - Health, Demographic Change and Wellbeing, as well as the Digital Agenda for Europe.

Over 200 ICT-based projects for the elderly were presented between AAL and AAL-2. The participants involved have contributed to creating a critical mass of researchers in Europe.

Most proposals are based on cloud applications, with mobile device interfaces that bring social workers, doctors and even relatives closer to the elderly. Nevertheless, these solutions do not usually involve the elderly themselves or do not lead to them feeling truly accompanied [9].

A major requirement of our study was to propose interfaces as friendly and adjusted as possible. It is worth noting that natural language processing (NLP) technologies have been evolving since the 1960s, from Pattern-Matching with small rule-sets, to the wide range of techniques and algorithms available today: Speech-To-Text (STT), Automatic Speech Recognition (ASR), Natural Language Understanding (NLU), Natural Language Generation (NLG), Text-To-Speech (TTS). These technologies have flourished in recent years, as illustrated by the numerous open-source initiatives that have emerged [6].

The interest in them is not limited to the academic world: commercial initiatives based on voice assistants have proliferated [10]. They have triggered great interest in different fields of research due to their potential as an interface of interaction with the elderly and disabled [6, 11-12]. Moreover, the technology has now reached an acceptable degree of maturity.

Although commercial platforms function very well and can be easily used in projects wishing to incorporate NLP (even gratuitously), in practice, they still present many restrictions [13-14]. Regarding accompaniment, the main restrictions are as follow: the voice and conversation models are not specifically designed or adapted to the characteristics and needs of the elderly; they do not facilitate integration with other IoT systems and devices; and information privacy problems remain to be solved, since conversations must go through third-party servers, where they are stored to improve and refine dialogue models and voice models.

It may seem, a priori, that this type of technology is likely to become a problem for elder users, especially due to their natural rejection of innovations [15]. Studies conducted on this population segment show that far from spurning voice assistants, the senior population has ended up accepting them. Thanks to the human ability to anthropomorphise any object, they even value them [16].

It is essential that the services and devices designed for the elderly explicitly envisage such determining characteristics, restrictions, and idiosyncrasies of this sensitive segment of the population [9, 14].

The current state of the art sheds lights on the essential role of health and care services for an increasingly aging population. More specifically, studies have uncovered not only the need to accompany the elderly and dependents, but also the potential of IT to provide these services with sufficient quality and at an acceptable cost for citizens [17].

The analysis revealed that most solutions —including the technologies and the legal and regulatory frameworks on which they are based— are still scarce, poor and scattered. Table I(a) presents a brief comparison between the different functionalities required by the system and how they are approached from research projects (**Research**), open technology (**Open**) proposals and commercial (**Commercial**) proposals.

Table I(b) summarizes the main conclusions of the study.

The accompaniment service for the elderly and dependents (*SAM Service*) must be viable and economically profitable for the different interests, financing and exploitation models [18], whether the project is led by a family association, a local corporation, or a great healthcare company. Each one of them will have different interests, will require and prioritize different services and functionalities, will have certain resources, must be accountable with different indicators and will serve very different population volumes. However, in all cases, the proposed accompaniment service must be functionally and economically viable.

TABLE I
SYNTHESIS OF THE STATE OF THE ART.

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(a) Impact of the functionality for different proposals

Functionality	Research	Open	Commercial
Data privacy	High	Medium	Low
Ease of Integration	Low	High	Medium
Communication: elderly, family, and health	High	Medium	Low
Thought for Seniors	High	Low	Low
Viable architectures for different scenarios	Low	Medium	High
Mature Voice Models for Seniors	Medium	Low	Low
Global approaches and solutions	Low	Low	Medium
Functional requirements	High	Medium	Low
Nonfunctional requirements	Low	Medium	High

(b) Main conclusions of the state of the art

Item	Summary of the situation
IT suitability as a solution	Numerous proposals guarantee that IT are a great help in the field of social assistance and support for the elderly.
Existence of mature technologies	There is already enough mature technology to address major projects: Voice user interfaces, AI, IoT devices and personal assistants, cloud services.
Suitability of open proposals	Numerous open proposals and research projects can be found, but with significant limitations: the proposals allow to create very tight prototypes for a use case and for a set of very specific technologies and scenarios.
Suitability of commercial proposals	There are very interesting commercial proposals that allow a wide range of customization. However, these proposals are designed for a middle segment of the population that leaves aside the needs and characteristics of the elderly. Also, the customization possibilities do not allow to solve this problem, they even prevent the deployment of crucial functionalities.
Integration of proposals and manufacturers	Even though there is a lot of mature technology in many of the necessary fields, and that in some cases the integration of different technologies is proposed, in general there are no proposals focused on facilitating this important aspect and, in practice, the existing proposals are limited to very specific integrations, for very specific technologies, manufacturers, versions, business models and development scenarios.
Proposals based on architectural patterns	Within this scope and for the problem of creating a support service for the elderly based on intelligent assistants based on voice and supported by cloud services, there is no study that proposes a set of architectural patterns that allows integrating solutions both open as third party; that can be adjusted to the needs of different providers: family associations, public or private organizations; that can be adjusted to different business and financing models; and that facilitates its deployment in the face of different needs and scenarios.

The objective of this work is not only to provide a realistic and valid proposal for the accompaniment service, its specific objective is to provide a set of architectural patterns that facilitate, on the one hand, the integration of multiple technologies and manufacturers necessary to achieve a system so complex, but, on the other hand, that it facilitates the deployment of the system in the face of the large volume of possible existing development scenarios that, moreover, will change.

III. PROBLEM DEFINITION AND PROPOSED APPROACH

The main problem identified in this work was the huge cost of feeling accompanied 24/7 in terms of human capital and resources. Our proposal consisted of creating an *Accompaniment Service for the Elderly* (*SAM Service)* that rested on a technological platform allowing to improve the experience of users, provide a meeting space for the elderly, family, and health workers, and lower the costs of the service to make it affordable for institutions and families.

The present study focused on the different architectural frameworks as well as high-level, technical and deployment architectures that would be adapted to a system with these characteristics. It would also permit the use of existing technologies and facilitate the deployment of solutions adjusted to the needs of different use cases.

In the proposed solution, the concept of *Service* was highly ambitious. It embraced much more than the design and development of a given platform or technology. The notion of *Service* here structured all the necessary elements: agencies, institutions, regulations, material and human resources, and IT infrastructures.

The *SAM Service* is based on the creation of a technological platform of specialised cloud services (*SAM Core),* along with the use of IoT devices. The aim was to provide a tracking and accompaniment service to the elderly and people at risk that was less invasive and as natural as possible (*SAM Device).*

The true potential of a *SAM Service* lies in its underlying innovative concept: beyond the provision of a service to the elderly only, it is designed to extend the service to the environment, specifically to families and all the social and health workers who participate in their care (*SAM Network*).

An intelligent virtual assistant (*SAM Device)* is responsible for the most routine tasks which require countless hours of dedication. This device is conceived to be integrated into the person's daily life as an extra companion, family member or assistant. The device would be aware of their needs and communicate with them through a natural language interface, via voice and conversation models that are specifically designed for the elderly. This also entails incorporating a natural language service into the project *(SAM Voice Service)* that allows users to communicate with their voice only.

The proposal is thus a technological platform conceived as an IT service *(SAM Core),* together with a set of digital assistants (*SAM Device)* for the elderly and the dependent, based on natural language (*SAM Voice Service),* and a specialised social network (SAM Network) that supports the communication. Such a solution could help public social services and specialised companies to provide this key accompaniment service to the elderly and dependents effectively and, above all, sustainably, in terms of public budgets and existing resources.

The proposed service *(SAM Service)* requires an IT infrastructure (*SAM IT Infrastructure).* This infrastructure is provided by an *IT platform* composed of a series of large components or subsystems.

Due to the complexity of the proposed system, the countless actors and stakeholders involved in both functional and operational aspects, the many technologies involved, and the various application scenarios, it is essential to provide an overall and integrative view connecting all these elements. For this reason, an architectural vision —covering the wide range of components, from conceptual and deployment aspects to technical ones— can represent an appropriate instrument to ensure the success of this type of initiative.

IV. GUIDELINES FOR GRAPHICS PREPARATION AND SUBMISSION

SAM Service is based on an IT infrastructure on which the *Elderly Accompaniment Service* is offered. This infrastructure refers to a cluster of models, services, physical devices and software applications that provide technological and methodological support to the social assistance strategy,

facilitating a flexible and effective creation of value-added services.
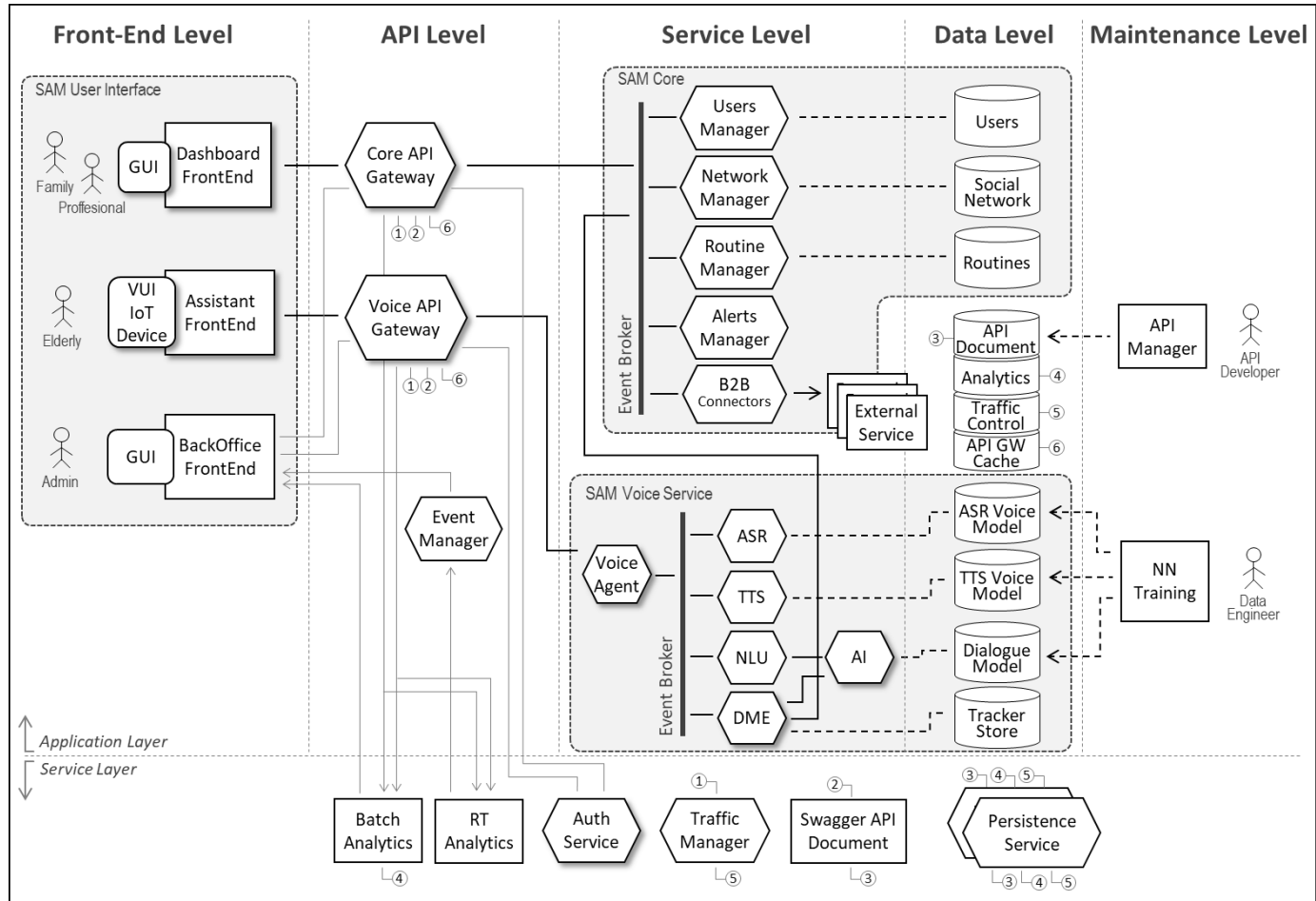
Fig. 1. The SAM Service high-level conceptual architecture.

These services favour communication between users, their families and the professionals who care for them. In the same way, these infrastructures have a powerful impact on the action strategies and define how the services will be provided. They can even determine the most appropriate work structure.

An architecture based on services and microservices (fig. 1) was proposed with the aim of making this IT infrastructure as versatile as possible. The aim was that it would be able to incorporate multiple technologies from multiple manufacturers, and to adjust and readjust the technological resources so that they be always adapted to the changing situation, both technologies and the accompanying service [19].

We sought to reach a balance in the number of designated services so that they would be as functionally independent as possible, but without generating too many microservices as this would make any future maintenance highly complex.

The resulting high-level architecture is shown in fig. 1. An architectural style based on n-level architectures was applied. It structures the elements into levels and layers. The elements are fundamentally defined as services, following an architectural pattern based on *Service Oriented Architectures* (SOA) and *Microservices* [19].

The **Front-End Level** defines the elements necessary to interact with end users, grouped under the *SAM User Interface* concept and organised by the *architectural pattern Model, Controller View* (MVC). Three types of interfaces were identified.

The **Assistant Front-End** interface is the user interface for the elderly, based on voice (VUI) provided by an *IoT Device* (**SAM Device).** This device is especially designed to accompany the elderly, although it can also be very useful for family members wishing to access SAM services through the voice interface. A conceptual block diagram of the device architecture is shown in fig. 2.a.

Fig. 2.b presents a diagram illustrating the interaction flow between a user and a *SAM Device*, with the device's main states and transitions.

The **Front-End Dashboard** interface is directed towards healthcare professionals and family members. It is based on a graphical user interface (GUI) designed as a *Single Page Application* (SPA) accessible from any device that has a Web browser. It is the system's current interface. Figure 6 illustrates some screenshots of this interface.

(a) SAM Device high-level hardware architecture.

(b) Flowchart of the interaction with the *SAM Device*.

(c) Prototype based on Raspberry Pi together with two microphones, 4 LEDs, speaker, temperature and humidity sensor, and relay. Source: ReSpeaker documentation.

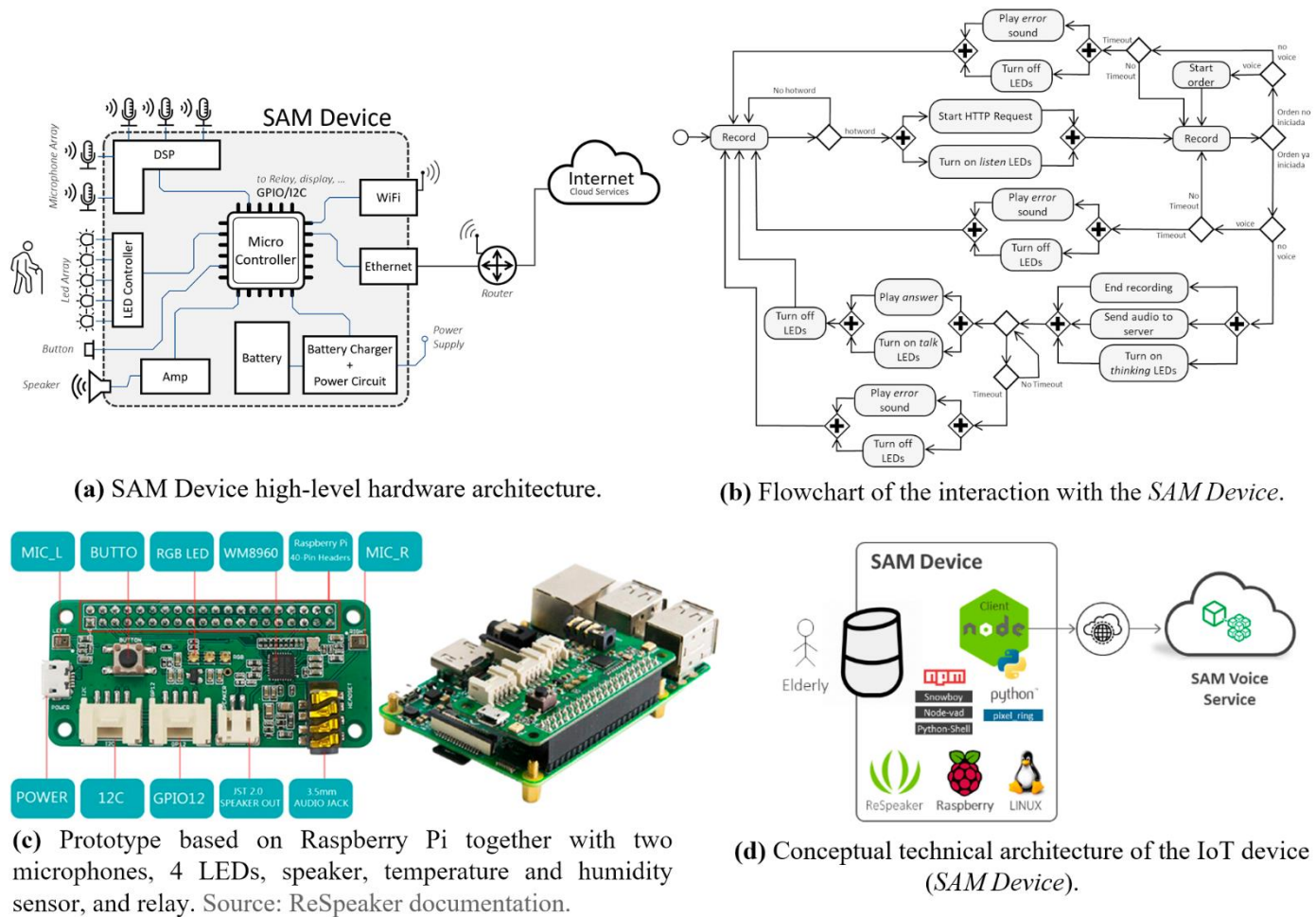**(d)** Conceptual technical architecture of the IoT device (*SAM Device*).

Fig. 2. SAM Device components.

The **Front-End BackOffice** allows the technical administrators of the service to access the functionalities of the system's management, configuration, alerts and analysis. They can also manage the traffic (relying on the *RT Analytics, Batch Analytics* and *Traffic Manager* services located in the *Service Layer)* and generate alerts in real time.

The **API Level** (fig. 1) contains the services that act as an *Application Programming Interface* (API) for the rest of the services and microservices provided by the platform, centralising the exposure of all the *endpoints* defined in the *backend,* including access control, which will be finally provided by the *Auth* Service located in the *Service Layer*, based on an *OAuth* strategy.

Two major services *(Core API Gateway* and *Voice API Gateway)* act as an entry point to the *SAM Core* and the *SAM Voice Service*, respectively. Both are located at the *Service Level.*

Traffic control information is also processed and stored through the *Traffic Service Manager.* In the same way, all traffic information is managed by the Traffic Manager. The latter provides an automatic scaling system to manage the volume of traffic received.

To facilitate and streamline the management of end-points, a *Swagger API Document Service* was defined. It is in the *Service*

Layer that manages the necessary documentation of the platform's services. It is linked to the Maintenance Level through the API *Manager.*

The **Service Level** acts as *Software as a Service* (SaaS) providing all the functionality required by the *SAM Service.* This level is the *core* of the platform and is composed of two large modules: the *SAM Core* and the *SAM Voice Service.*
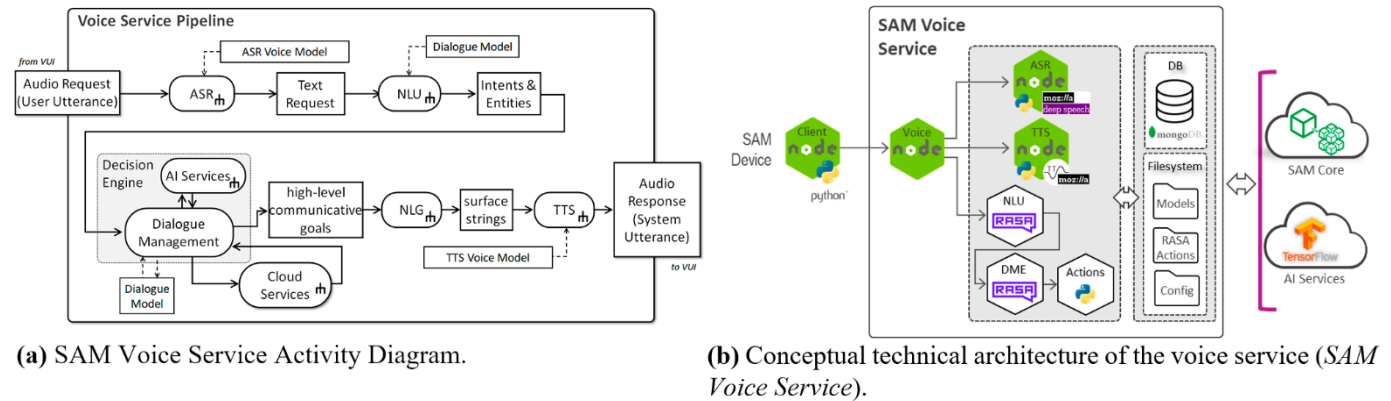
The **SAM Core** is composed of a series of services that offer the basic *SAM Service* functionality (fig. 1): *Users Manager, Network Manager, Routine Manger, Alerts Manager.* All these services are interconnected with the Gateway and with each other through an *Event Broker* that manages the messages. It is at this level that different connectors can be defined (through the *B2B Connectors)* allowing the integration of the *SAM Service* with other systems, and the interaction with other third-party application and service platforms.

The **SAM Voice Service** is based on a microservices architecture (fig. 1) in which the following components were defined: the orchestrator (*Voice Agent),* the *Automatic Speech Recognition* (ASR) service, the *Natural Language Understanding* service, the *Dialogue Management Engine* (DME), the *AI* Services, the *Text-To-Speech* (TTS) service. All communication between the *Voice Agent* and the *SAM Voice Service* Internal Services tales place by passing messages

through a private *Event Broker.*

(a) SAM Voice Service Activity Diagram.

(b) Conceptual technical architecture of the voice service (*SAM Voice Service*).

Fig. 3. SAM Voice Service Diagrams.

The activity diagram in fig. 3.a shows the orchestration performed by the *Voice Agent.*

The databases related to the *SAM Voice Service* are: the *Voice Model*; the *Dialogue Model* (responsible for identifying a conversation's *intents* and *entities*, as well as helping with decision-making); and the *Tracker Store* that allows saving all conversations in order both to perform a forensic analysis, if required, and to re-feed the *Dialogue Management Engine* (DME) to improve its behaviour

The databases that facilitate the management and administration of the entire system are also located at this level: the *API Documents, Analytics, Traffic Control,* API *GW Cache*

V. IMPLEMENTATION

A. Hardware prototypes of the IoT device (SAM Device)

Three distinct hardware devices were built: one based on the *ReSpeaker Core v2 board*; another based on a *Raspberry Pi* along with a *ReSpeaker 4-Mic Array board*; and a final *Raspberry*-based prototype and a *ReSpeaker 2-Mic Array board*. All prototypes incorporate the hardware components defined in the conceptual architecture (fig. 2.b). Fig. 2.c shows an example of one of the prototypes assembled with a Raspberry Pi and a range of microphones and LEDs. All the built-in components and the whole design followed open hardware principles. In this way, it is easy to replicate, maintain and modify the proposed hardware device, even if the specific components described here are not available.

With respect to the device software, we followed the technical architecture defined in fig. 2.d. As shown in this diagram, the core of the SAM device is composed of a NodeJS-based client, running on a Linux version, which uses Python to access AI functionalities, such as the identification of the wake word or the detection of silences

B. Voice Services

The voice service (**SAM Voice Service)** is a *backend* component in this project and is in the service and data levels (Service *Level* and *Data Level).* Its purpose is to provide support for the voice assistant, performing artificial intelligence (AI) tasks that do not fit into the IoT device, either due to a high

computational cost or because of the business logic involved.

Fig. 3.b presents the voice service's conceptual technical architecture. It shows a diagram of the services that will intervene, the technology on which the implementation will be based, and how they relate to each other and to the rest of the external elements.

VI. DEPLOYMENT ARCHITECTURE AND PERFORMANCE SCENARIOS

A. Architecture design

The present section describes two system deployment architectures: a minimum deployment as well as a high availability deployment are presented. A specific development scenario was also developed for each architecture.

We avoided incorporating other essential services, such as *auth services*, management and *backOffice* services, etc. because they follow commonly used deployment diagrams. They would also have complicated the diagrams and overshadowed the important elements of the project.

Fig. 4.a shows the basic deployment architecture. The proposal offers the minimum functionality needed by the voice service and determines how its components will be distributed in the final deployment.

The elements were encapsulated in a *Docker* container that facilitates the deployment and separation of each service's workspaces, significantly improving scalability compared to a traditional infrastructure.

Based on this architecture, fig. 4.b illustrates a basic development scenario. It was very useful during the phases of development and concept testing.

The service must be viable and sustainable regardless of the number of users, whether a few users or thousands —in the case that is successful and that it ultimately needs to support thousands of individuals. Likewise, it must be sufficiently flexible to adapt to variable situations in which there may be many or few users at given moments. It does not, however, ensure scalable performance and resource consumption. To address this, a high-availability deployment architecture based on clusters and load balancers is proposed (fig. 4.c).

(a) Basic deployment architecture and the technologies.

(b) Minimum deployment scenario.

(c) High availability deployment architecture.

(d) High availability performance scenario.

Architecture Selection Parameters	Deployment Architecture		
	Stand-Alone	Basic Deployment	High availability
Flexibility regarding local and global changes	0	0.5	1
Integral service	0	1	1
Access to third party platforms	0	0.5	1
Services update	0	0.5	1
Efficiency	0	0.5	1
Scalability	0	0.5	1
Adaptability	0	0.5	1
Security	1	0	0.5
Reliability	0	0.5	1
Fault tolerance	0	0.5	1
Reconfigurability	0	0.5	1
Short term implementation	1	0.5	0
Quick return on investment	0	0.5	1

Architecture Selection Parameters	Deployment Architecture		
	Stand-Alone	Basic Deployment	High availability
Implementation costs	0.5	0.5	1
Usage costs	0	0.5	1
Management and maintenance costs	0	0.5	1
Software modifiability and extensibility	0	0.5	1
Communication costs	0	1	1
Network traffic volume	0	1	1
Need for specialised IT staff	0	0.5	1
Communications Service Unit	0	0.5	1
Redundancy	0	0.5	1
Number of accessible services	0	1	1
Concurrency of users and services	0	1	0.5
Geographic coverage	0	0.5	1
Local independence	1	0.5	0

0: Low impact; 1: High impact

(e) Comparison of the main performance scenarios for the proposed deployment architectures based on the defined parameters.
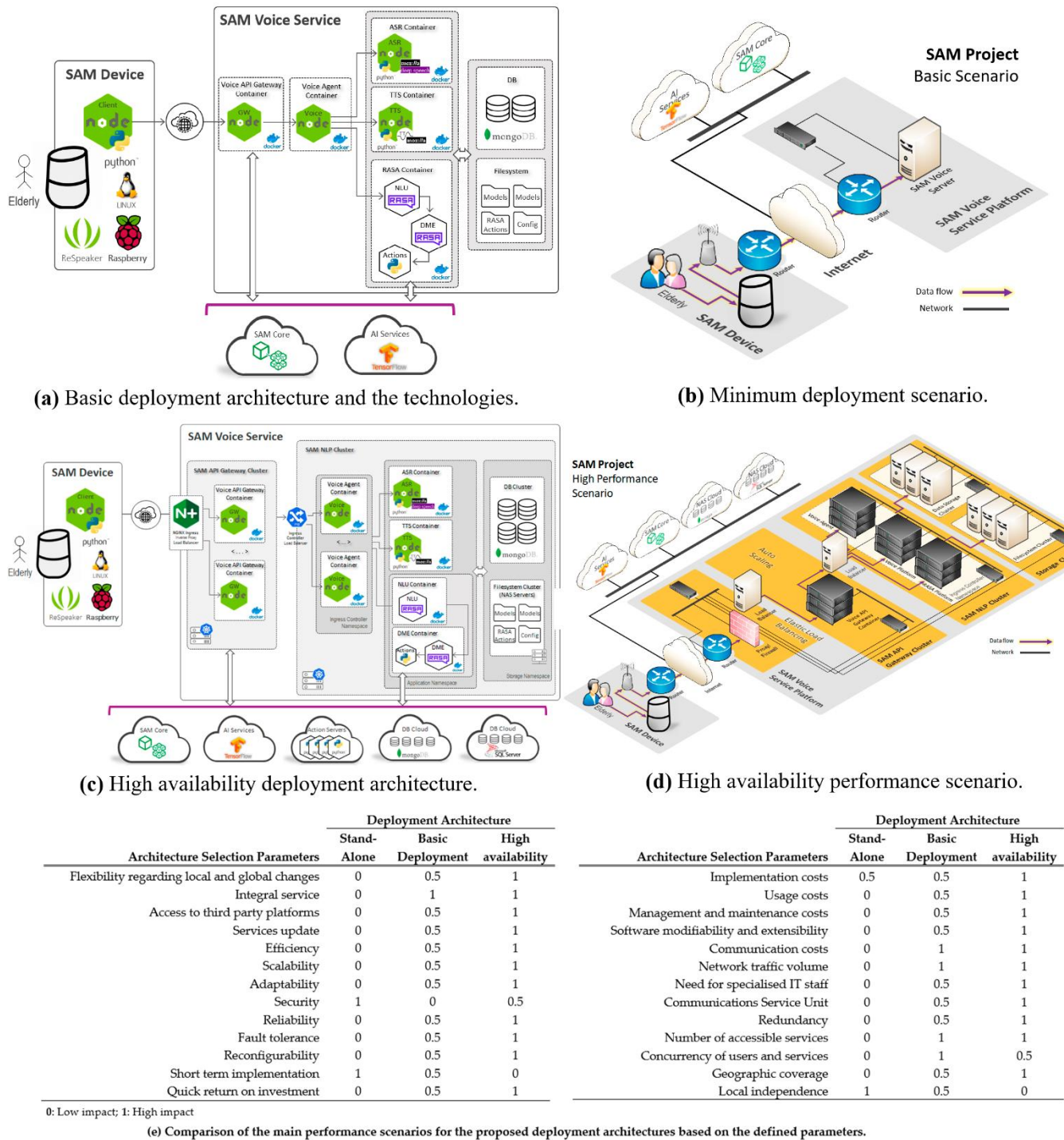
Fig. 14. Deployment architectures and performance scenarios.

Now, the service can be deployed both on a few servers only, based on scalable server *clusters* for each microservice and storage networks for file systems and databases. The scalability can be applied both to the entire system and to any of its individual components, thus acting only at points where deficiencies in the service are detected or, on the contrary, are oversized.

The purpose of these *clusters,* combined with the *containers,* is to expand the resources dedicated to the voice service, by allowing the machine to launch, if needed, more instances of the services. The *load balancer* distributes requests to less crowded instances.

To implement the *clusters* and orchestrate the containers, *Kubernetes* were used, together with *Nginx*. They act as a reverse *proxy* that redirect the incoming server requests to the required resource, centralising access and concealing the services distribution logic to ensure a more transparent usage for end users.

Finally, considering the high availability architecture presented above, a second scenario was created as an example (fig. 4.d). It is directed towards high availability and the ease of scaling that is required in a true production environment. This high availability scenario is broadly based on clusters of servers and storage networks, as well as load balancers, obtaining a valid environment for production that offers high levels of security capacity, scalability, elasticity and resilience.

B. Architecture comparison

Following the idea raised in [20], a series of parameters were defined that characterise the different development scenarios for the accompaniment service (Fig. 14.e). This strategy forces an emphasis on non-functional requirements. In this way the problems of ignoring them in the specification phase and the consequences of having to take them into account in more advanced phases can be avoided.

Each *parameter* was manually evaluated by assigning a value between 0 (*low impact*) and 1 (*high impact*) for three different deployment configurations: from a *stand-alone deployment*, based solely on the distribution of the assistant devices, to a *high availability deployment*.

These patterns are clearly a mere reference for decision-making, since each deployment will be substantially conditioned not only by the desired functionalities or the means and resources available, but also by the physical or structural restrictions of each community or country. For example, reliable or high-bandwidth communication networks may not be available in some countries or in some areas.

That a proposal has many 0 or 1 does not make it better or worse. The decision will depend on the non-functional requirements that have been established for each deployment. In fact, in practice, the most adjusted option (with lower values) that adapts to the established requirements will always be sought.

Moreover, each parameter's relative value may vary greatly depending on the system's desired characteristics or type of deployment. For example, it does not make much sense to analyse the integration with other platforms in a high availability deployment, just as it would not be relevant to reconfigure the system in a stand-alone deployment. In these cases, these parameters should either not be considered, or they should be attributed a low weight.

Based on all the above, the proposed deployment plan must follow a model that envisages each parameter's suitability and contemplates the problem as a whole. It would also be advisable to explore not only the scenario to be implemented but also the various possible alternatives in the short or medium term to better understand and adjust the relative value of each parameter

IIV. CONCLUSIONS

In this paper, after studying the problem of demographic change and active aging, it is concluded that new technological solutions were necessary to alleviate the effects of old age — essentially vulnerability and dependence— on the elderly and their careers.

Although there are different approaches to the problem, they are insufficient or are functional prototypes that are difficult to adapt to the multiple and changing scenarios because the non-functional requirements have not been considered in the design stage. We set ourselves the goal of creating an accompaniment service for the elderly based on a cloud infrastructure and a physical device capable of assisting and accompanying the elderly by communicating with them through voice and natural language.

This goal was achieved in the following way: by designing a set of distributed architectures; by creating the necessary software and hardware systems; by implementing three hardware prototypes of IoT devices (SAM Device) that interact through voice, together with a platform (the SAM Voice Service) capable of offering cloud services for voice and natural language processing, and for the accompaniment of the elderly (SAM Core); and lastly, by creating a voice model and a conversation model especially adapted to the elderly. Both the device, protocols and conversation models were developed from a gender perspective, involving a separate study and providing specific solutions where necessary.

This type of system is based on very complex IT services. They involve countless technologies and manufacturers and can support solutions offering highly diverse functionalities. For this reason, the present work proposed a series of conceptual, technical and deployment architectures, that support the implementation of versions adjusted to the needs and resources proper to each project. These deployments are also scalable, reliable and sustainable over time.

Currently, a fully functional support system for the elderly has been achieved, which is being tested together with the social services of different municipalities, and for different groups. All the material and source code of the work is freely available and can be found in the public repositories detailed throughout the document.

Family members and professionals cannot be replaced by technologies. Our proposal, however, can greatly help institutions, associations and socio-health professionals to offer sustainable services that improve the independence and quality of life of all those involved.

In the short and medium term, we continue to work on different projects that address more specific aspects of the system, such as voice interfaces, voice and conversation models, new emotion models, accompanying physical devices, or cloud services. However, in the long term, given the complexity of the system and the variety of scenarios that must be faced, our interest continues to focus on improving the architectural patterns and delving into the techniques to help decision-making on the management of most suitable network configurations for each project

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