

# DELIVERABLE 3.1A

## DESIGN OF OVERALL SYSTEM ARCHITECTURE & SECURITY AND PRIVACY SPECIFICATIONS

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## List of Abbreviations

ABBREVIATION	FULL	DESCRIPTION
WP	Work Package	Category of tasks which details the description of work
AAL	Ambient Assisted Living / Active and Assisted Living	Research Framework and European program for developing technological solutions for elderly care
IoT	Internet of things	inter-networking of devices which enable the collection and exchange data.
MCU	Main Control Unit	The Vizier main control unit at the home setting

## 1 Introduction

This deliverable provides a global overview of the Vizier platform, describing all the software and hardware components that are being developed within the framework of the Vizier project and how these components collaborate together to achieve the social companion-based system intended to keep the elderly user mentally, physically and socially active. Furthermore, this document describes the hardware setup of the framework and the communication protocols between the various software and hardware components as well as the security measurement taken to ensure the users privacy.

Chapter 2 describes the overall architecture, chapter 3 discusses the components of the Vizier platform and the communication protocols between these components, chapter 4 describes the hardware configuration of the Vizier system and chapter 5 discusses the privacy and security of the system

This deliverable is mainly related to D3.3 (Overall system integration and evaluation) where the integration of the of the various components covered in this deliverable are integrated. Furthermore, D3.1 is associated with all the deliverables of WP2 and WP3 which develop the components that are mentioned in this deliverable.

## 2 Technical Requirements

By technical requirements we mean what the Vizier system should do, how it should behave and what output or response it should give to the users.

The following tables present the respective specifications. “Description” in these tables describes the technical requirement, whereas “Related user needs” refers to the respective user needs from WP1 and particularly the use case scenarios in D1.2. For each of the collected requirements, there are system specifications to concretise their definition and help with implementation.

### 2.1 General requirements

#### R1.1: Speech based interface towards

<b>Description:</b>	The system must provide an easy natural language based interface for accessing Vizier functionalities
<b>Related user needs:</b>	All
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S1.1.1: The system must support speech recognition technology to understand the user input</li> <li>• S1.1.2: The system must understand the user natural language generated by speech recognition</li> <li>• S1.1.3: The system must react by speech using the text-to-speech technology</li> </ul>

#### R1.2: Intuitive graphical interface

<b>Description:</b>	The system must provide an easy graphical interface for accessing Vizier functionalities
<b>Related user needs:</b>	All
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S1.2.1: The system must offer the user an elderly intuitive user interface through its tablet</li> <li>• S1.2.2: The user interface must consider older users suffering from light cognitive and physical disabilities</li> </ul>

#### R1.3 Intelligent decision making

<b>Description:</b>	The system must possess intelligent decision making capabilities to provide the correct services at the correct moment
<b>Related user needs:</b>	All
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S1.3.1: The system should process the user recognised voice and react on the user appropriately</li> <li>• S1.3.2: The system must be able to process input from various modalities (speech, IoT, Smarthome devices, online services) and generate appropriate responses</li> </ul>

#### R1.4 Motivation and behaviour change

<b>Description:</b>	The system must apply various strategies to motive the user and change her/his behaviour to the better
<b>Related user needs:</b>	Vizier congratulates the user with her/his physical, mental or social achievements

<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S1.4.1: The system must track the user’s physical, mental and social status and intervene if there is a negative trend</li> <li>• S1.4.2: The system should apply long-term behaviour change strategies to help the user in improving her/his life</li> </ul>
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## 2.2 Management of daily life requirements

### R2.1: Alarm functionality

<b>Description:</b>	The system must provide alarm functionality with sound based waking up strategies as well as light based wake up strategies (incl automatic curtain opening / closing, dependent on the weather forecast) or by favourite music
<b>Related user needs:</b>	<ul style="list-style-type: none"> <li>• Waking up with alarm</li> <li>• Waking up with no alarm but with the sun of the day</li> </ul>
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S2.1.1: The system should perform the alarm functionality to wake up the user</li> <li>• S2.1.2: The system should integrate with existing smart home / IoT appliances that complement the user wake up functionality (light, curtain, etc)</li> </ul>

### R2.2: Home Automation

<b>Description:</b>	The system must provide functionality for controlling home automation
<b>Related user needs:</b>	All
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S2.2.1: The system must integrate various home automation appliances</li> <li>• S2.2.2: The system must provide a user interface to control home automation appliances</li> <li>• S2.2.3: The system must provide speech based commands to control home automation appliances</li> </ul>

### R2.3: List and reminders

<b>Description:</b>	Vizier provides lists and reminders to the user
<b>Related user needs:</b>	Forgot something when shopping, etc
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S2.3.1: The system should remind the user of events</li> <li>• S2.3.2: The system should provide an interface for managing the events and reminders</li> </ul>

## 2.3 Mental wellness requirements

### R3.1: Memory Training

<b>Description:</b>	The system must providing a strategy for remembering people’s names, or learning new names and shopping lists
<b>Related user needs:</b>	<ul style="list-style-type: none"> <li>• forgets people’s names</li> <li>• forgets something when shopping</li> </ul>
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S3.1.1: The system must help user train their remembering capabilities</li> <li>• S3.1.2: The system must give the users an easy way to store information and to acquire this information when needed</li> </ul>



### R3.2: Relaxation exercises

<b>Description:</b>	The system must provide relaxation exercises
<b>Related user needs:</b>	<ul style="list-style-type: none"> <li>worried about her memory difficulties and how she is going to age</li> </ul>
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>S3.2.1: The system must provide relaxation videos and instructions to help the user</li> </ul>

## 2.4 Physical wellness requirement

### R4.1: Physical Activity

<b>Description:</b>	The fitness activity tracker with goal setting and feedback
<b>Related user needs:</b>	<ul style="list-style-type: none"> <li>Enjoys doing physical activity</li> </ul>
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>S4.1.1: The system must track the user’s physical status and intervene if there is a negative trend</li> <li>S4.1.2: The system must provide an interface for the user to see their physical status and goals</li> </ul>

## 2.5 Social wellness requirements

### R5.1: Agenda

<b>Description:</b>	The system must provide agenda function to note as well as to find new activities in the calendar
<b>Related user needs:</b>	<ul style="list-style-type: none"> <li>Sense of belonging to a group</li> <li>meeting with new people as well as good friends</li> </ul>
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>S5.1.1: The system must manage the agenda of the user</li> <li>S5.1.2: The system must manage invitations and send invitations in an intuitive way</li> <li>S5.1.3: The system must suggest activities to the users when needed</li> </ul>

### R5.2: Social media interaction

<b>Description:</b>	The system must provide functionalities to track relatives on social media and to communicate with them
<b>Related user needs:</b>	<ul style="list-style-type: none"> <li>Sense of belonging to a group</li> </ul>
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>S5.2.1: The system must track the user’s social status and intervene if there is a negative trend</li> <li>S5.2.2: The system must provide an interface for the user to see their social status and goals</li> </ul>

### R5.3 Sharing events

<b>Description:</b>	The system must provide functionalities for sharing through social media (tips on knitting and other craftwork, Via a simple app, Julie can share pictures and designs of knitware (on Pinterest, ...))
<b>Related user needs:</b>	<ul style="list-style-type: none"> <li>enjoys sharing her knowledge</li> <li>social moment</li> <li>sense of purpose</li> </ul>
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>S5.3.1: The system must have an easy interface for sharing data via popular online services</li> </ul>

#### R5.4: Social activities

<b>Description:</b>	The system must provide functionality to find and join existing social activities or to create new ones. (e.g, network of 'walking groups', messages and invites to local walking events, info on music concerts nearby, ticket purchasing online, easy scheduling in agenda, invite friends, search a date)
<b>Related user needs:</b>	<ul style="list-style-type: none"> <li>• Enjoys the opportunity meeting with neighbors and talking with them</li> <li>• listening to music</li> <li>• enjoys social and cultural activities</li> </ul>
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S5.4.1 The system should have an easy interface for managing the agenda</li> </ul>

## 2.6 Safety & wellbeing requirements

#### R6.1: Easy contact

<b>Description:</b>	Easy contact function (phone / mail / messages)
<b>Related user needs:</b>	<ul style="list-style-type: none"> <li>• talks about an alarm to use in case she were assaulted in the street</li> <li>• the user urgently requires medical help</li> </ul>
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S6.1.1: The system must facilitate communication through various media (phone / mail / social media)</li> <li>• S6.1.2: The system should provide the user with an easy interface that integrate various communication media</li> </ul>

## 2.7 Healthy living requirements

#### R7.1: Medications

<b>Description:</b>	The system must follow up the user medication and remind the user when needed.
<b>Related user needs:</b>	
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S7.1.1: The system must be able to set up medication reminders and remind the user at the correct moment</li> </ul>

#### R7.2 Access to medical staff and family

<b>Description:</b>	The system must provide access to medical staff to enters working points in the Vizier system, that will follow up daily on these.
<b>Related user needs:</b>	
<b>System specifications:</b>	<ul style="list-style-type: none"> <li>• S7.2.1: The system should be integrated with existing care system that facilitate data transfer between the users and the cares</li> </ul>

## 3 Overall Architecture of the Vizier Platform

### 3.1 General Architecture

The architecture of the Vizier framework (Figure 1) consists of various software and hardware components, which can be divided into several groups of components. The core component of the Vizier system is its “Main Control Unit” (MCU) which runs at the home environment and communicates with all the local devices and the remote services. The MCU is represented by a social companion device in the home environment that enables voice based interaction and can be a device or a virtual human. Another way for the user to interact with the system is through the tablet-based graphical user interface which is designed to offer the user an intuitive approach to access the system. Through the Vizier Cloud Server, the MCU accesses and manipulate data of various vizier services which can be internal or external services.

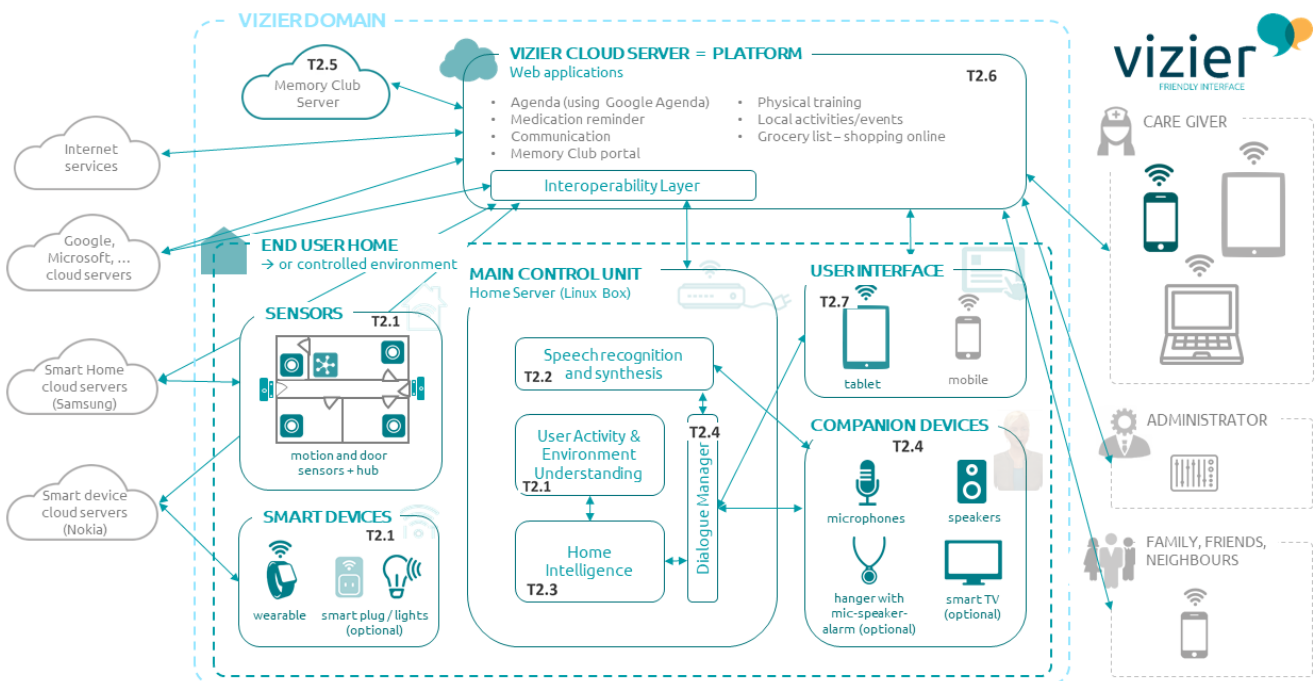


FIGURE 1 ARCHITECTURE OVERVIEW

### 3.2 The Main Control Unit (MCU)

The Main Control Unit (Home Server) is based on a Raspberry Pi 3 running full Rasbian (Linux variant) OS. The home intelligence logic runs on the home server and uses the southbound APIs to control the home automation system. The southbound APIs relate to:

- Biometric data
- SmartHome control / data

The MCU also runs all the dialogue management components that facilitate the natural voice based interaction with the user and is responsible of the main decision making functionality where various inputs are analysed based on predefined workflows and decisions are taken with the goal of supporting the user in her/his daily life.

### 3.3 Vizier Cloud Server

The Vizier Cloud Server (Platform) is developed on Amazon AWS with a MySQL database server and node.js for the API. This server will store the persistent data from the vizier platform. User access is regulated by LDAP access controls. There will be two types of access token (session tokens for user access, longer-lived tokens for home-server access). There are a number of different types of users of the Vizier Platform, home\_server, resident, care\_coordinator, family\_member, care\_assistant, administrator, medical practitioner, community care nurse. The interoperability layer is mostly based on the platform server.

### 3.4 Companion Devices

As defined in D1.3, the **Companion Devices** for version 1 is represented as 1) a wearable communication that can be attached to the user as a small pin or a necklace (Figure 2), 2) a regular speaker (Figure 3), 3) an expressive speaker (Figure 4) and 4) as an animated virtual human (Figure 5). One implementation for each category will be achieved for version 1 to investigate the best way to represent a social companion in AAL solutions.



FIGURE 2 SOCIAL COMPANION AS A WEARABLE COMMUNICATOR (A SMALL PIN OR NECKLACE)



FIGURE 3 SOCIAL COMPANION AS A REGULAR SPEAKER

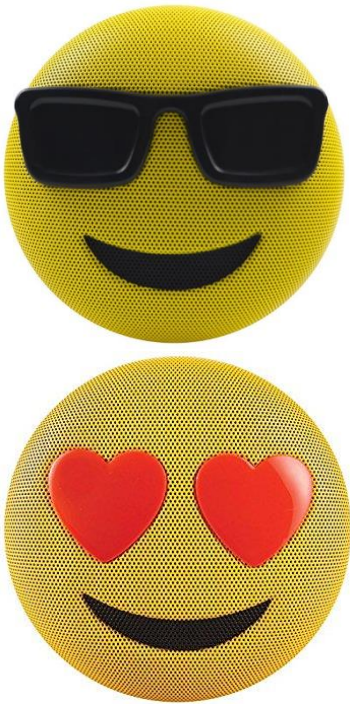


FIGURE 4 SOCIAL COMPANION AS AN EXPRESSIVE SPEAKER



FIGURE 5 SOCIAL COMPANION AS AN ANIMATED VIRTUAL AVATAR

### 3.5 External APIs

The external APIs that are linked to the Vizier Architecture are:

- Google/Microsoft API suite for lists, calendar, etc
- Shopping API (e.g. Tesco)

## 4 Communication

### 4.1 Client-Server Communication Using RESTful APIs

Communication between the MCU and the vizier cloud server occurs based on RESTful Open APIs with support of JSON as a data transfer format. The Open APIs are built using the open source tool Swagger<sup>1</sup> and offer a generic interface for accessing various IoT and SmartHome appliances. Swagger is a well-established toolset that offers an easy approach to generate code, to generate test cases and to generate documentation. The idea is to develop generic APIs that give the MCU access to various online services and smart devices and at the same time protect the MCU from device specific complexities.

### 4.2 Local Network Communication Using RabbitMQ

The RabbitMQ framework is used for communication between the Home Control Unit software components. It consists of the following distinct parts:

- A service that handles communication
- A client library which implements communication functionality for each software component

The RabbitMQ service (<https://www.rabbitmq.com/>) is a message broker that is used to host the communication between various RabbitMQ clients (Vizier software components in our case). The server uses AMQP (Advanced Message Queuing Protocol), which is a wire level protocol and built on top of TCP/IP, to communicate with other AMQP enabled applications. AMQP is an open standard for passing messages between applications implemented by RabbitMQ, which is the distributed message broker of choice for the Vizier, since it is open source, fast, scalable, highly configurable (e.g. guarantee message delivery) and platform independent.

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<sup>1</sup> <https://swagger.io/>

### 4.2.1 Client library

For a client to be able to communicate with other RabbitMQ enabled clients, it has to use the RabbitMQ client library. The library includes functionality to send/receive data. The client library implements the RabbitMQ protocol on top of AMQP. See figure for a decomposition of the RabbitMQ protocol stack.

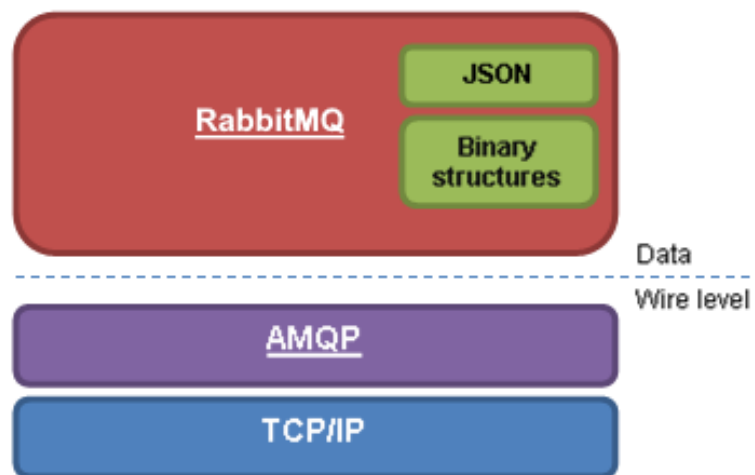


FIGURE 6 DECOMPOSITION OF THE RABBITMQ PROTOCOL STACK

### 4.2.2 RabbitMQ Events for Local Applications

Table 1 presents the message definition for communication between Vizier’s Home Control Unit, defining the exchange name used, the type of data that is being exchanged and a brief description of the message. All the messages are sent using the “Fanout” message type.

TABLE 1 A LIST OF THE RABBITMQ MESSAGES CURRENTLY DEFINED IN THE SYSTEM

Exchange	From	To	Data	Description
CapturedSpeechStream	Necklace	Speech Recognition	Binary	Captured audio stream
CapturedSpeech	Speech Detection	Speech Recognition	Binary	Captured audio stream
SpeechDictionary	Dialogue Manager	Speech Recognition	JSON	Natural language utterances dictionary
SpeechRecognitionResults	Speech Recognition	Dialogue Manager	JSON	Detected utterances and alternatives
CompanionOutput	Dialogue Manager	Speech Synthesis	JSON	Text output and behaviour tags
SynthesizedSpeech	Speech Synthesis	Companion	Binary	Raw audio of the synthesized speech
SynthesizedSpeechMeta	Speech Synthesis	Companion	JSON	Meta data containing speech visemes and behaviour data
UICommand	Dialogue Manager	Tablet App	JSON	UI command
UIStatus	Tablet App	Dialogue Manager	JSON	UI status

## 5 Security & Privacy

### 5.1 Security & Privacy of the Local System

Security and privacy are two important aspects in the Vizier project and are amongst the key objectives in the design of the Vizier architecture. The Vizier system has been designed in a manner that most information related to the user is sent encrypted between the client system and the online server. Personal data that can be used to identify the user is avoided from the communication channels between the client and the server. On the client side, the tablet and the MCU are protected by a well-configured firewall to prevent unauthorised access from outside. When needed, sensitive information is sent encrypted between the tablet (client) and internet component with a strong respect for security and privacy of the end user.

### 5.2 Security & Privacy of the Cloud system

Personal data, related only to the socialization and profile aspect of the elderly person, are the core resource that the cloud services are built on. For this reason, security and privacy are important for the cloud system, as it is crucial for the users to feel that the system does not allow unwanted privacy intrusions and to ensure that their personal data is respected.

The most prominent aspect is that only authorized users (i.e., users that are authenticated by the Vizier platform) may access and use sensitive data of the users. Based on this concept, Vizier Cloud security services allows access to data never directly but only through a strict API with an advanced authentication mechanism. Additionally, only users with the appropriate with specific roles, responsibilities and access rights can have predefined limited access to the user's data.



## 6 Conclusion

In this deliverable, we presented the overall architecture of the Vizier system and the privacy and security aspects of the platform. We described extensively the software architecture of Vizier and described all Vizier's software components in detail. Further, the hardware configuration of the Vizier system is also described in detail as well as the privacy and security specification.