

Privacy by design in systems for assisted living, personalized care and well-being: a stakeholder analysis

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Abstract

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The concept of privacy-by-design within a system for assisted living, personalized care and well-being is crucial to protect users from misuse of the data collected about their health. Especially if the information is collected through audio-video devices, the question is even more delicate due to the nature of this data. In fact, in addition to guaranteeing a high level of privacy, it is necessary to reassure end-users about the correct use of these streams. The evolution of data analysis techniques began to take on an important role and increasingly defined characteristics in recent years. In this article, with reference to European projects in the AHA/AAL domain, we will see a differentiation of the concept of privacy-by-design according to different dimensions (Technical, Contextual, Business) and to the Stakeholders involved. The analysis is intended to cover technical aspects, legislative and policies-related aspects also regarding the point of view of the municipalities and aspects related to the acceptance and, therefore, to the perception of the safety of these technologies by the final end-users.

Contribution to the field

This manuscript analyzes the privacy-by-design requirements of a system for assisted living, personalized care and well-being, with particular regard to platforms that provide for the processing of audio and video signals. This analysis was carried out trying to understand how the different categories of stakeholders involved in the realization of a project influence or are influenced by the privacy requirements. The introduction of the Contextual and of the Technical domains' analysis wants to show how some proposals push more on the technological advancement and others on aspects that instead refer to the contextual domain, highlighting that contextual aspects in a project, with particular reference to H2020 projects, are fundamental to technological innovation to be accepted and spread in a stable manner. The knowledge of these aspects for each stakeholder category and how they can become hindrance factors for the entire project converge in a SWOT analysis concerning the possible impact of the various categories of stakeholders from the point of view of who intends to develop and deploy a AHA/AAL platform, possibly including audio/video data. In particular, we aim to identify the critical features connected to the selection and involvement of relevant stakeholders.

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In review

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10 **Abstract**

11 Privacy by design within a system for assisted living, personalised care and well-being is crucial to
12 protect users from misuse of the data collected about their health. Especially if the information is
13 collected through audio-video devices, the question is even more delicate due to the nature of this
14 data. In addition to guaranteeing a high level of privacy, it is necessary to reassure end-users about
15 the correct use of these streams. The evolution of data analysis techniques began to take on an
16 important role and increasingly defined characteristics in recent years. The purpose of this paper is
17 twofold: on the one hand, it presents a state-of-the-art about privacy in European AHA/AAL projects,
18 with a focus on those related to audio and video processing. On the other hand, it proposes a
19 methodology, developed in the context of the European project PlatfromUptake.eu, to identify
20 clusters of stakeholders and application dimensions (technical, contextual and business), define their
21 characteristics and show how privacy constraints affect them. From this study, we then generated a
22 SWOT analysis in which we aim to identify the critical features connected to the selection and
23 involvement of relevant stakeholders for the success of a project. Applying this type of methodology
24 to the initial stages of a project allows understanding of which privacy issues could be related to the
25 various stakeholder groups and which problems can then affect the correct development of the
26 project. The idea is, therefore, to suggest a privacy-by-design approach according to the categories
27 of stakeholders and project dimensions. The analysis will cover technical aspects, legislative and
28 policies-related aspects also regarding the point of view of the municipalities and aspects related to
29 the acceptance and, therefore, to the perception of the safety of these technologies by the final end-
30 users.

31 **1 Introduction**

32 Due to the demographic changes among European countries, health and social care have become
33 crucial challenges for many world nations. The general increase of older people compared to the total
34 population affects the current and future economic context. The scientific community has contributed
35 to tackling the problem by studying and proposing solutions and technologies under the so-
36 called *Active and Assisted Living (AAL)* (Siegel, Dorner, 2017) and *Active Healthy Ageing (AHA)*

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37 (Sixsmith et al., 2014). AAL and AHA aim to propose tools and technologies to improve the ageing
38 process and well-being of older people, with particular regard to those in situations of fragility. The
39 broad concept of Active and Healthy Ageing was proposed by the World Health Organisation
40 (WHO) as the process of optimising opportunities for health to enhance the quality of life as people
41 age. It applies to both individuals and population groups. (Bousquet J, Kuh D, et. al 2015). The
42 definition of Active Assisted Living (AAL) comes from the AAL Programme (AAL Europe
43 Programme Website), a joint funding activity of partner states of the AAL Association, with the
44 financial support of the European Commission, based on Article 185 of the Treaty on the Functioning
45 of the European Union (TFEU). AAL aims to improve older adults' autonomy, participation in social
46 life, skills, and employability by providing innovative Information and Communication Technologies
47 (ICT)/digital-based solutions. These solutions, whether products, systems or services, aim to enhance
48 the older adults' quality of life, improve the long-term sustainability of health and care systems, and
49 strengthen the industrial base in Europe and internationally. AAL and AHA paradigms typically use
50 systems based on sensors of various types, wearable or contactless, capable of collecting a large
51 number of data to be processed. The analysis of audio-video signals, thanks to the constant growth in
52 performance of signal analysis techniques and related hardware, is increasingly used in AHA / AAL
53 projects. These technologies permit gathering users and environmental information without being
54 invasive directly on the body and provide contactless monitoring capabilities. The new European-
55 level initiative Goodbrothers Cost Action (Goodbrothers, 2022) aims to increase awareness of the
56 ethical, legal, and privacy issues associated with audio-based and video-based monitoring.
57 Goodbrothers proposes privacy-aware working solutions for assisted living by creating an
58 interdisciplinary community of researchers and industrial partners from different fields (computing,
59 engineering, healthcare, law, sociology) and other stakeholders (users, policy makers, public
60 services), stimulating new research and innovation. Today, audio and video-based applications can
61 recognise the general conditions of the individuals (e.g., various activities, behaviour, emotional
62 state, fall detection, food intake monitoring, etc.), providing their vital parameters in real-time (e.g.,
63 heart rate, respiratory rate) (Cicirelli et al., 2021). Video cameras and microphones belong to the
64 category of contactless sensors, non-invasive from a technical point of view; nonetheless, their nature
65 makes them difficult to be accepted by end users also for issues related to the perception of privacy.
66 The risk of using these devices is to create a misused surveillance system that might impact users'
67 lives. From a technical point of view, an approach based on privacy by design is essential to
68 guarantee the security of data and its processing (Mittelstadt, 2017).

69
70 In this paper, section 2 contains a state-of-the-art about Privacy by design and Privacy by Default,
71 which have acquired more and more importance following the introduction of the GDPR. We will see
72 in detail the requirements imposed by the introduction of the GDPR, concerning European projects,
73 with specific reference to health and audio and video analysis. In section 3, we will introduce a
74 methodology to correctly define the different stakeholder groups typically part of an AHA/AAL
75 project. We will analyse their specific characteristics or needs by mapping them to the Technical,
76 Contextual and Business dimensions, allowing us to face the technical, ethical, and regulatory
77 constraints and issues separately and in the best possible way. In section 4, we will see an analysis of
78 the state of the art of various European projects, in which audio/video analysis plays a fundamental
79 role, grouping them accordingly to the previously defined dimensions. Finally, in section five, we
80 will expose, through a SWOT analysis, a set of best practices helpful in introducing the correct
81 identification of stakeholders and application dimensions.

82 2 Privacy and GDPR, a state-of-the-art

83 *Privacy by design* is a catchword used for the first time in 2000 in a title of a workshop named
84 "Workshop on Freedom and Privacy by design" held at the "Computers, Freedom & Privacy 2000"
85 conference (FP2000, 2000). Even if the term was coined around 20 years ago, its meaning could not
86 be precisely identified. The two words *Privacy* and *Design* are abstract concepts that can assume
87 different meanings strictly related to the context scope where they are used (Van Rest, Boonstra et
88 al., 2014). Burgoon et al. (Burgoon, Parrott et al., 1989) propose this definition of Privacy: "Privacy
89 is the ability to control and limit physical, social, psychological and informational access to the self
90 or one's group". This definition makes us see Privacy as a right, freedom, a capacity, a claim and an
91 ability. *Design*, instead, expresses the intention to establish a set of rules starting from the initial
92 phases of the life cycle of a system. Matching these concepts together, *Privacy by design* refers to
93 finding a meeting point between the formal and legal concept of privacy and the limits of the current
94 information technologies. The design process, in fact, is critical for that privacy and data protection
95 design patterns are applied starting from the project's beginning phases, according to the EU
96 legislation, ensuring privacy and gaining personal control over individuals' information.

97
98 The General Data Protection Regulation GDPR (EU) 2016/679 defines the guidelines for the
99 Processing of Data and their free movement to guarantee the Protection of Information about Natural
100 Persons. The GDPR obligation is addressed to all companies that use, for some reason, information
101 of Natural Persons and not to legal persons (other companies). In addition to harmonising and
102 updating privacy regulations throughout the EU, GDPR aims to redefine companies' approaches in
103 terms of data protection, mainly because of the continuous and increasingly frequent cyber-attacks
104 that companies of all sizes and sectors have been subjected.

105
106 This is GDPR Art.25 recommendation for Privacy by Design (GDPR, 2018):

107 *"Taking into account the state of the art, the cost of implementation and the nature, scope, context*
108 *and purposes of processing as well as the risks of varying likelihood and severity for rights and*
109 *freedoms of natural persons posed by the processing, the controller shall, both at the time of the*
110 *determination of the means for processing and at the time of the processing itself, implement*
111 *appropriate technical and organisational measures, such as pseudonymisation, which are designed*
112 *to implement data-protection principles, such as data minimisation, in an effective manner and to*
113 *integrate the necessary safeguards into the processing in order to meet the requirements of this*
114 *Regulation and protect the rights of data subjects."*

115 **2.1 Privacy by Default**

116 Implementing privacy by default requirements means that once the product or service has been
117 deployed to end users, the stricter privacy requirements are already applied automatically. This must
118 be done considering that all sensitive user data must be saved only for the time strictly necessary for
119 their use and no unnecessary data must be requested. Violation of these rules results in a lack of
120 privacy requirements.

121
122 This is GDPR art.25 recommendation for Privacy by Default (GDPR, 2018):

123 *"The controller shall implement appropriate technical and organisational measures for ensuring*
124 *that, by default, only personal data which are necessary for each specific purpose of the processing*
125 *are processed. That obligation applies to the amount of personal data collected, the extent of their*
126 *processing, the period of their storage and their accessibility. In particular, such measures shall*
127 *ensure that by default personal data are not made accessible without the individual's intervention to*
128 *an indefinite number of natural persons."*

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129 2.2 Controllers and Processors

130 Reading the GDPR is important to understand the meaning of the terms Controller and Processor, as
131 they are responsible for the application of the privacy and data protection rules and how the services
132 provided by third-party producers must be introduced within a system or project.

133 2.2.1 Controllers

134 GDPR definition of controller is the following (GDPR,2018):

135 *"controller means the natural or legal person, public authority, agency or other body which, alone or*
136 *jointly with others, determines the purposes and means of the processing of personal data; where the*
137 *purposes and means of such processing are determined by Union or Member State law, the*
138 *controller or the specific criteria for its nomination may be provided for by Union or Member State*
139 *law*

140 The Controllers, physically representable by a single individual worker or by a company or legal
141 entity of various kinds, are the persons responsible for the treatment and processing of sensitive data,
142 therefore they coordinate all the activities that concern them. A Controller may be subject to a legal
143 obligation to process personal data, section 6 of the Data Protection Act 2018 states that anyone who
144 is under such an obligation and only processes data to comply with it will be a controller.

145 2.2.2 Processors

146 GDPR definition of Processor is the following (GDPR,2018):

147 *"Processor means a natural or legal person, public authority, agency or other body which processes*
148 *personal data on behalf of the controller"*

149 From this definition it is clear how the Processors follow the instructions of the Controllers
150 associated with them without having the authority to take important decisions without authorisation,
151 unless the presence of laws that allow it, as specified in the GDPR Article 29. As in the case of
152 Controllers, a Processor can be represented by a single individual worker or by a company or legal
153 entity of various types.

155 2.2.3 Third-party organisations

156 Privacy-by-design and Privacy-by-default can also affect third-party organisations: in fact, during the
157 creation of a product, for reasons such as the use of an external product or particular knowledge in
158 certain fields, it may be necessary that an external resource, which can be a company or even a single
159 developer, is included in the process.

160
161 *GDPR also talks about this possibility (GDPR, 2018):*

162 *'When developing, designing, selecting and using applications, services and products that are based*
163 *on the processing of personal data or process personal data to fulfil their task, producers of the*
164 *products, services and applications should be encouraged to take into account the right to data*
165 *protection when developing and designing such products, services and applications and, with regard*
166 *to the state of the art, to make sure that controllers and processors are able to fulfil their data*
167 *protection obligations.'*

168 2.3 Pre-GDPR legal framework

169 In 1992 the integration process to the single European market reached its climax with the Maastricht
170 Treaty and the European Community's creation. However, with a single market, there was also the
171 need to have a European framework law protecting personal data. To this end, the European
172 framework law on the protection of personal data aimed to harmonise rules at the national level as
173 well to avoid polarisation: on the one hand, states with regulations that are too lax in attracting
174 companies and investors and, on the other hand, states with rules that are too strict to prevent data
175 from circulating. The EC adopted Directive 46 in 1995, now replaced by the GDPR. At that time,
176 data protection was in its infancy. Little was known about it. It was not possible to adopt a uniform
177 standard binding on all States. It was decided to issue a directive to set the objectives but leave room
178 for national legislators. Directives and regulations are two of the most important legal acts of the
179 European Community. However, they are two very different things with essential implications for
180 States: a directive defines objects but leaves each country to adopt national rules to adopt the
181 directive, while regulations are EU laws that are binding in all countries of the EU in a uniform way.

182 **2.4 GDPR and health**

183 Although the GDPR has not completely changed the discipline of personal data protection in the
184 health care area, has nevertheless dictated some innovations. The need for its emanation derives from
185 the progressive evolution of the concept of privacy in the light of the continuous changes induced by
186 technological and IT progress. In a delicate matter such as that of the processing of health data, the
187 European legislator has paid particular attention to protect the right to data protection, which has
188 been elevated to the fundamental right of each individual. As is known, the GDPR is applied directly
189 in the EU member states, which have intervened with internal regulatory acts only to repeal any
190 national regulations in contrast with the new discipline and integrate some aspects left to the state's
191 discretion legislator.

192 Among the significant changes introduced by the regulation, the obligation to keep records of
193 processing activities must be noted, which contain all information relating to the processing of
194 personal data carried out by the Data Controllers or, on their behalf, by the Data Processors.

196 Another important novelty is the introduction of the figure of the Data Protection Officer (DPO).
197 This expert has the task of supervising and facilitating compliance with the regulations on personal
198 data protection. DPO consultation is mandatory for all public health authorities belonging to the
199 National Health Service and for private structures that carry out large-scale data processing; it is not,
200 on the other hand, mandatory for individual health professionals who work as a freelance individual.

202 In these cases, the processing of health data is considered lawful:

- 203 • preventive medicine, diagnosis, social or health assistance or social services with treatment
204 purposes;
- 205 • protection from threats affecting the public health sector, both in the management of services
206 and medical devices
- 207 • to allow advances in scientific or historical research or for statistical purposes

209 In all other cases, health data processing requires the consent of the interested party, preceded by
210 appropriate information. Among the information that must be provided to the interested party, the
211 retention time of health data deserves to be reported.

213 Talking about Audio and Video recordings, with the introduction of the GDPR, the regulations for
214 declarations of consent have become more stringent: tacit consent is no longer valid but must be
215 given in an informed and unambiguous manner. Before the GDPR, the regulations could vary from

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216 country to country depending on the various legislations. In Germany, for example, registration
217 without consent was considered to be punishable by law. In the UK, concerning the Data Protection
218 Act of 1998 (DPA), this activity was classified as data processing, and it was only necessary to
219 inform end-users of the activities being carried out without the need for explicit consent.

220 **3 Stakeholders and dimensions mapping**

221 The aspects introduced by the GDPR, data processing and informed consent, are stringent underlying
222 the application of a privacy by design approach. In this article, we want to focus on other aspects, on
223 people, to contextualise their roles and responsibilities. The level of complexity of large-scale
224 projects, with particular reference to EU-funded projects, is very high, and countless factors must be
225 best orchestrated to achieve the pre-established goals. At the basis of the realisation of a project of
226 this type, once all goals have been defined, it is necessary to identify all the stakeholders involved
227 and proceed to arrange them into homogeneous groups. In this phase, it is necessary to pay attention
228 to the end-users of the system: the appropriate use of audio/video acquisition and processing
229 technologies mainly involves issues related to privacy, use of data and perception of safety by end-
230 users, which perhaps represents the most difficult obstacle to face for this stakeholder group. This is
231 true especially in the context of AAL/AHA projects, where this group, consisting of older adults, is
232 still not very accustomed to using and understanding technology. To apply the concepts of privacy by
233 default and privacy by design, as desired by the GDPR from the initial stages, it is essential to
234 correctly identify the categories of stakeholders, keeping in mind that, for each of them, the problems
235 relating to these concepts will be different and will need to be addressed in a specific way.

236 Much attention has been given to identifying stakeholders within the work carried out in the European
237 project PlatformUptake.eu project (Carboni, Russo et al, 2021). PlatformUptake.eu aims to provide a
238 state of the art regarding open service platforms in the AAL/AHA domains and proposes a valuable
239 methodology and tools to measure the impact and uptake both for existing platforms and for the
240 development of new ones. From PlatformUptake.eu comes the following definition of platform/open
241 platform, that will be used in this paper:

242 *"A platform is a software system that allows the many-to-many substitutability between applications,*
243 *services and devices from multiple vendors via common APIs for the benefit of individual users*
244 *whatever their role is (older person, carer, social worker, care worker, governmental representative,*
245 *technology developer etc.). It is an open digital ecosystem that connects the individual users to health*
246 *or social care provisions, to lifestyle and prevention applications and home technology to support their*
247 *independent living, healthy lifestyles and participation in society. An open platform tries to maximise*
248 *adherence to the principles of: Open Source, Open Standards-Based, Federatable, Shared Common*
249 *Information Models, Vendor and Technology Neutral, Support Open Data, Provide Open APIs, Open*
250 *Usage and Open Adaptation. A Platform is defined as an operating environment under which various*
251 *applications, agents and intelligent services are designed, implemented, tested, released and*
252 *maintained."*

253 Paragraphs 3.1 and 3.2 definitions come from the work done by the authors in PlatformUptake.eu,
254 which was based mainly on these resources:

- 255 • MAST | The Model for the Assessment of Telemedicine - built following six perspectives of
256 assessment ((1) health problem and characteristics of the application, (2) safety; (3) clinical
257 effectiveness; (4) patient perspectives; (5) economic aspects; (6) organisational aspects; and
258 (7) socio-cultural, ethical and legal aspects).
- 259 • OPEA: Open Platform Ecosystem Assessment Framework - is a three-dimensional model.
260 The first axis includes the value network of the AAL platform provider, AAL application
261 provider, Health Service or Social Service provider, the informal carers, assisted persons and
262 society. The second axis marks the assessment domains of the evaluation: assistance problem
263 and characteristics of the open platform & applications, technical aspects, user perceptions,
264 outcomes, economic aspects, organisational aspects, and contextual aspects. The third axis
265 relates to the three levels of assessing the AAL ecosystem: the platform, application, and
266 service level.
- 267 • GLocal Evaluation Framework - is the ACTIVAGE reference evaluation framework for AHA
268 Large Scale European pilots.
- 269 • Market Intelligence - also known as business intelligence, it provides several methods to
270 analyse the platforms' maturity and business models:
- 271 • Business Model Canvas, to analyse existing providers' business models.
- 272 • ADL Matrix, for understanding how an industry's maturity and competitive position affects
273 strategy, in terms of industry maturity (from embryonic to aging) and competitive position
274 (from dominant to weak).

275 3.1 Stakeholders groups

276 The main stakeholders groups identified in the AHA/AAL domain are:

- 277 • Primary end-users: older persons who benefit from the services provided by the platform
- 278 • Secondary end-users: healthcare organisations, home care/community supports, residential
279 care homes, professional caregivers, informal caregivers, volunteers
- 280 • AAL/AHA solutions developers/providers: hardware manufacturers, software/app developers
- 281 • Authorities and facilitators: public authorities, social security system, insurance companies,
282 policymakers
- 283 • Open platform providers: EU-funded platforms, Commercial open platforms

284 The rest of this section will describe the different stakeholder groups and the various dimensions.

285 Finally, we will try to show how they relate to each other.

286 3.1.1 Primary end-user

287 In the AAL/AHA domain, the primary end-user is the individual intended as the main beneficiary of
288 a service or a set of services the considered platform provides. The Primary end-user directly benefits
289 from these services with an increase of his quality of life. These people can typically benefit from
290 these services directly, for example, by purchasing them from an Open Platform Provider (typically
291 Commercial) or through Secondary end-users (typically from an organisation such as a healthcare
292 facility or similar). This last scenario is quite typical of EU-funded projects, especially during the test
293 phases, where the Secondary end-users are also project partners and take care of the selection of the
294 Primary end-users.

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295 3.1.2 Secondary end-users

296 The secondary end-users group comprises care organisations or institutions who contribute to
297 organising, paying or enabling applications and services the platform provides, like healthcare
298 providers, social and well-being organisations, etc. Also, the various types of Caregivers are included
299 in this cluster, which contains two subgroups of stakeholders, one represented by the caregiver's
300 family and the other by care organisations. In this document, we refer to the subgroup of care
301 organisations, implicitly considering caregivers as a service they offer. This reflects the typical
302 organisation of a European project in the AHA / AAL domain, in which care organisations recruit
303 caregivers.

304 3.1.3 AAL/AHA solution developers/providers and Open Platform Providers

305 The AAL/AHA solution developers/providers group refers to the team of individuals that follow and
306 implement the entire life cycle of the applications, or more generally, of the products, deriving from a
307 given platform. This group includes platform developers, who create and maintain the platform's
308 product services and applications, and third-party developers, those who develop standalone
309 applications or products using available APIs and SDK. The developer's role in an EU Funded
310 Platform is typically very different compared to a commercial one. In the case of an EU Funded
311 Platform, most of the people involved from a scientific and technical point of view are researchers.
312 They are an active part of the consortium that submitted the project application to the European
313 community. They, therefore, are aware, even if not always to an in-depth level, of most aspects of the
314 platform, including economic or managerial ones. When we talk about commercial realities,
315 developers are typically employees and often, for security reasons, only aware of the specifics of the
316 sub-projects they work for.

317 3.1.4 Authorities and facilitators

318 Authorities and facilitators group includes the public sector service organisers, public authorities,
319 social security systems, insurance companies, municipalities, and policymakers: in general, it can be
320 seen as a larger scale version (regional, national, or international) of the Secondary end-users cluster.
321 The type of problems involved is very complex aspects also linked to laws, infrastructures, or
322 characteristics such as readiness or the impact they have on a large scale. The main goal is to help
323 citizens to allow them to live an independent life for as long as possible. The first step is the
324 collaboration between the various Health and Care departments and external partners, aiming to
325 research, develop, test and implement AHA/AAL solutions. It is essential to provide citizens with
326 increased self-reliability and independent living, improving working conditions, increasing efficiency
327 and improving the municipality's economy. Companies play a crucial role in all this, and therefore
328 the state must support them with funds for innovation but also other activities such as periodic
329 exhibits to give visibility to even the smallest companies.

330 Regarding digital technology's needs and requirements, the two main aspects were "how to relate"
331 and "how to connect". "How to relate" implies a work that prepares municipalities for each platform
332 type. Here the main aspects are: the understanding of policies and policy coordination, collaboration
333 on care processes, without which the whole system becomes unstable, information must be
334 understood and defined in its structure and content, while on the application side, it is crucial to
335 connect the systems, infrastructures, in compliance with laws and safety standards. "How to connect"
336 is more about values, citizens having a say, and digital rights and good employership acquire
337 fundamental importance, as does the fact that the profits deriving from the use of these platforms
338 must then be redistributed to society.

339 **3.2 Dimensions**

340 In addition to categorising stakeholders, it is essential to identify the application dimensions (or
341 domains) concerning the stakeholder groups. The three specified dimensions are the Technical,
342 Contextual and Business dimensions.

343 **3.2.1 Technical dimension**

344 This dimension describes and characterises the functionalities and services of a platform, taking into
345 account these fundamental aspects of an IoT system:

- 346 • device management capabilities: how the devices connected to the services provided by the
347 platform are monitored;
- 348 • integration/interoperability: how access to the data and functionality of the services can be
349 made or provided from an API point of view;
- 350 • information security: identify and classify possible data vulnerabilities to prevent possible
351 threats;
- 352 • types of protocols: types of protocols used, both for the processing and for the transmission of
353 data;
- 354 • data analytics: all activities aimed at providing interactive, real-time, predictive or batch
355 analytics;
- 356 • visualisation capabilities: all activities related to the creation and customisation of GUIs that
357 show the results of the analysis and allow interaction with them;

358 **3.2.2 Contextual dimension**

359 The contextual dimension is wide and related to all those non-technological aspects of fundamental
360 importance for the realisation of a platform. The main points can be summarised in:

- 361 • legal and administrative context: regards all legal and administrative issues related to the
362 development and introduction of an AHA / AAL platform;
- 363 • ethics and privacy: regards all aspects relating to the processing of data, their type and how it
364 is reflected on the rights of the end-users;
- 365 • data sharing and governance: consider the various models (e.g. Citizenship, Economic,
366 Collective, Third-party) and data management;
- 367 • Intellectual Property Register (IPR): concerns various trademarks, patents, copyrights, open
368 or closed access information and services that are exploited in the development or use of a
369 platform;

370 **3.2.3 Business dimension**

371 In this dimension, financial and exploitation aspects are taken into account. It studies the specific
372 business model and includes complex factors of a non-scientific nature that will not be covered in
373 this document.

374 **3.3 The analysis and the challenges**

375 For this document, only the two technical and contextual dimensions will be considered, as the
376 business dimension, though exciting and complex, is beyond the scope of the article. The use of
377 audio and video processing technologies brings a series of aspects reflected directly on the technical
378 and contextual dimensions and across the various types of stakeholders identified previously. Above

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379 this, all aspects of privacy and data protection imposed by the GDPR and other possible regulations
380 or limitations that may be more stringent (health, legislative, technical, etc.) must be considered.

381 In this analysis, we will identify with A, B, C, and D the four stakeholder groups defined previously;
382 therefore, we will have:

- 383 - Group A: Primary end-users
- 384 - Group B: Secondary end-users
- 385 - Group C: AAL/AHA Solution developer/provider and Open Platform Providers
- 386 - Group D: Authorities and Facilitators

387 Regarding Information Security (IS), it is important to define its meaning and its difference from the
388 term Cyber-Security. The National Institute of Standards and Technology defines Information
389 Security as:

390 *"The protection of information and information systems from unauthorised access, use, disclosure,*
391 *interruption, modification or destruction, in order to provide confidentiality, integrity and*
392 *availability"*

393 In a nutshell, it is about protecting the data of companies, individuals and institutions, whose
394 confidentiality must be respected, integrity maintained and availability guaranteed under regulations.
395 The three objectives, in English "confidentiality", "integrity" and "availability", are known by the
396 acronym CIA (Perrin, 2008):

- 397 - Confidentiality: data are not accessible to unauthorised parties
- 398 - Integrity: data are kept intact and not subject to unauthorised changes
- 399 - Availability: data are always available to the user who needs this data

400 Over time, various researchers have reworked the original 'CIA Triad' several times (Parker
401 2010,2015). Still, it represents the most precise and recognised way of summarising objectives in the
402 IS field. Physical places where data are stored are computers, mobile devices, hard disks, servers and,
403 in recent times, cloud environments have been added. Keeping a large amount of information safe is
404 the main objective for those who want to address the issue of information security. In-depth skills in
405 IT security are not required but more in managing data. The defence mechanisms used are many and
406 require specific technologies such as control systems that verify the access of users who want to
407 consult or use them. Another aspect to be taken care of is prevention, starting from the document
408 storage phase and, subsequently, in critical moments such as the transfer from one device to another.
409 The most valuable contents, such as credentials and passwords, must always be kept secret and
410 protected from unauthorised access. Cyber security deals specifically with how companies and
411 organisations protect their programs and resources of a purely digital nature.

412 Unlike what we found for information security, we move into a much more technical field, in which
413 you need to know in depth all the cyber threats you may encounter. Cyber security professionals
414 must be able to counter hacker attacks and the appearance of malware. Therefore, it is deduced that
415 while cyber-security is a problem strictly related to the technical dimension, information security is
416 instead an aspect that borders on the contextual dimension, affecting all defined stakeholder
417 categories. The concept of Information Security Awareness (ISA) therefore, becomes fundamental
418 due to the increase in possible dangerous behaviour of people and the growth of networks and related
419 applications (Parsons, Calic et al., 2017)(Shaw, Chen et al., 2009). Vroom and Von Solms (Vroom,

420 Von Solms, 2004) point out that 48 per cent of security breaches are accidental or related to poor
 421 knowledge of IS policies, mainly caused by human errors. Literature shows that the human attitude,
 422 intrinsically and especially in people with little technical knowledge, can reveal vulnerabilities and,
 423 therefore, cyber attacks (Von Solms, Niekerk, 2013)(Stanciu, Tinca, 2016). The fact that these
 424 behaviours are challenging for an organisation to control leads to the conclusion that ISA training is
 425 strongly recommended as an integral part of a company's security policies.

426 With the increase in the digital transfer of personal data, privacy of the same is a fundamental aspect
 427 to be considered when developing services or applications. According to the literature (Pattakou, A.;
 428 Mavroeidi, A, 2018), privacy requirements are:

- 429 - Anonymity: the inability to recognise a user by third parties or other users
- 430 - Pseudonymity: fictitious names are used to ensure anonymity
- 431 - Unlinkability: the relationships between the subjects and their actions cannot be reconstructed
 432 by third parties
- 433 - Undetectability: a third party cannot detect the existence of a component
- 434 - Unobservability: actions between subjects are hidden

435 Especially after the introduction of GDPR, it is critically important that users know what data they
 436 are providing, to what processes and for what kind of use, primarily because the use of applications
 437 to support daily life is constantly growing. Security awareness training programs, strictly linked to
 438 ISA training, aim to facilitate the acquisition and, above all, understand the safety rules to minimise
 439 the risk of people harming themselves or the systems they use (Wilson, Hash, 2003).

440 A simple analysis can start by identifying the primary activities relating to the two domains taken
 441 into consideration and mapping them to the corresponding stakeholders. We will first analyse the
 442 technical dimension and then the contextual dimension.

443 **3.3.1 Technical Dimension mapping**

444 As far as the technical dimension is concerned, the first group of stakeholders to be considered is
 445 group C, which is responsible for the development intended as the realisation of the
 446 hardware/software product that will expose the system's functions. The main challenges for this
 447 group of stakeholders are compliance with all the regulations imposed by the GDPR on the treatment
 448 and processing of personal and non-personal data, along with the privacy rules and attention to cyber
 449 security defined in the contextual phase. As regards group A, it is good practice that there is no
 450 relationship between it and the technical dimension, which must be as transparent to the end user as
 451 possible, especially if the focus is placed on an application where audio/video acquisition and
 452 processing is carried out. The aspects relating to ISA are different and of fundamental importance, as
 453 we will see in the next paragraph. Group B and D can have a technical support role regarding the
 454 systems' experimentation, testing and feedback phases, in particular group B, as it has a close
 455 relationship with group A. The other activities mainly concern the contextual dimension.

456 Knowing notions and being aware of privacy laws is not sufficient for technicians' and software
 457 developers to build and set up GDPR compliant products to avoid violations. The observance of
 458 some practical guidelines able to combine theoretical aspects with experimental procedures
 459 can protect and maintain client and employee personal information and data:

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- 460 • The collection of data should be kept encrypted and anonymised. For example, alter names,
461 addresses and other confidential information but taking care to make them however usable for
462 applications and analytics engines.
- 463 • The observance of some practical guidelines that combine theoretical aspects with practical
464 procedures can protect and maintain client and employee personal information and data.
- 465 • Cloud hosting as an alternative to maintain a physical data centre, especially for smaller
466 firms, can simplify the management of the space for storing and elaborating data, outsourcing
467 security and compliance controls. However, the choice of an appropriate cloud system is
468 crucial. Data stored in a Cloud can potentially be physically placed in any location around the
469 globe that could be subjected to different privacy laws and security standards, leading to
470 unintentional violations.
- 471 • The annual execution of vulnerability assessments using third-party penetration tests and
472 regular vulnerability scans can help identify the system's vulnerabilities even for hackers'
473 newest attack techniques.
- 474 • Develop and maintain written information security policy for access control, change
475 management and data integrity.
- 476 • Adopt secure endpoints (firewalls, password and device management, malware and
477 ransomware protection, VPNs, etc.), especially for companies that base their business online
478 in a global market.
- 479 • The creation of access management to prevent:
 - 480 ○ unauthorised user's access to the system in a way and data;
 - 481 ○ the verification of access rights to all information resources and to the use of the
482 system.

483 When using Internet of Things (IoT) technologies exploited for AHA and AAL purposes, privacy
484 management must consider specific aspects proper of networks, devices, interfaces, mobile
485 applications, etc. Some basic requirements for IoT include:

- 486 • Identify devices before establishing their connectivity to avoid exchanging data with
487 unauthorised devices.
- 488 • All connected sub-systems must be able to interoperate with the main framework controlling
489 things to ensure complete infrastructure control.
- 490 • Use specific procedures and tools to provide correct and precise functionality of the
491 components of the network.
- 492 • Adopted solutions must comply with Data Protection and IS policies, so that data can be
493 treated with confidentiality, authenticity and integrity (Clincy V., 2019)).

494 3.3.2 Contextual Dimension mapping

495 Analysing the contextual dimension is complex and critical in terms of achieving a project's
496 objectives. As previously introduced, the aspects to consider are the legal and administrative context,
497 ethics and privacy, data sharing and governance and IPR. In this paper, we will analyse the first three
498 aspects and their repercussions on the activities of the various stakeholders. As regards the legal and
499 administrative context, the impact of the GDPR on groups B, C and D must be considered. While for
500 group C the primary regulation to be taken into consideration is the one imposed by the GDPR,
501 which also affects ethics and privacy and data sharing, with regard to groups B and D it will also be
502 necessary to take into account other aspects: group B, speaking about AHA/AAL, will undoubtedly

503 be subject to health regulations that could fall on the group C, as further technological limitations or
 504 related to the processing of data could be placed, but also on group A, in a passive manner. Group D
 505 has the same characteristics but presents a more complex scenario as, referring to a municipality, the
 506 possible regulations, also according to the specific region of belonging, go beyond the boundaries of
 507 this research. Data sharing and ethics and privacy, as seen above, are conditioned by the GDPR for
 508 groups B, C and D but above all by the rules of IS and the need to satisfy the requirements defined as
 509 the CIA triad, i.e. Confidentiality, Integrity and Availability, and the five privacy requirements:
 510 Anonymity, Pseudonymity, Unlinkability, Undetectability and Unobservability. These concepts,
 511 more familiar to the members of Group C, as naturally connected to technical issues, instead have a
 512 contextual counterpart of great importance that can be addressed by introducing the concept of
 513 Information Security Awareness within the consortium in favour of all stakeholders groups. Among
 514 all these, it is important to dedicate space in this discussion to group A: one of the main problems of
 515 research is to consider its point of view while losing the fundamental one of the users (Abdul
 516 Rahman, Muharman, 2015). The user perspective is conceived as understanding, and if this is valid
 517 for all categories of stakeholders, for group A it assumes critical importance because often, the
 518 success of a project depends on the level of acceptance, involvement and understanding by end-users.

519 Regarding acceptance and understanding, the ISA is of great importance: in AHA/AAL systems
 520 based on audio and video, the perception of privacy violation by the subjects captured is frequent and
 521 only through a real awareness of how data is protected, transmitted and processed, it is possible to try
 522 to overcome these human limits. The involvement of end-users is also an aspect that is often
 523 overshadowed. There are various approaches, for example, their participation in the development
 524 phases of a project (Hani, De Marcellis, 2016) or gamification-type approaches. In the health domain,
 525 gamification can be fundamental, educating users to carry out activities aimed at protecting or
 526 monitoring their health more enjoyably, thus reducing the concerns related to it. (King, Greaves,
 527 2013). Gamification is applied in various sectors and always intends to educate, for example
 528 gamified services help users not to forget to take medicines or to carry out daily exercises. This
 529 approach towards services that use audio and video recordings can help ensure a better perception in
 530 accepting this type of technology in everyday life: it is educational, maintains users' interest and
 531 supports the protection of health. In addition, this method has been studied in relation to the security
 532 domain, specifically ISA (Wu, Tien et al., 2021). A gamification-type approach increases user
 533 engagement, but they must be informed of all the privacy aspects that the use of a system of this type
 534 entails, such as the type of data used and who has access to it. In this case, developing the software
 535 with the previously identified privacy requirements is essential (Aikaterini-Georgia, Angeliki et al.,
 536 2019). About user involvement, it has proved to be beneficial at many levels, like improved patient
 537 safety, user satisfaction, the reduction in development costs, limiting redesign and increased
 538 likelihood of commercial success (Grocott, Weir et al., 2007).

539 **4 H2020 Projects and audio/video analysis**

540 The goal of this section is to show a state of the art on the most recent AHA/AAL projects in which
 541 audio/video analysis has an important role, but also to show that the classification of stakeholders and
 542 dimensions presented in this article can be helpful in the phases of creating a project. The GDPR
 543 provides guidelines to follow for the protection and processing of data, however, it considers the
 544 technical aspect more than the contextual one. As we will see in this section, in most projects, there is
 545 no univocal classification neither for stakeholder groups nor for application dimensions, their
 546 existence is often implicit in the nature of a project, but in most cases, it is not dealt with explicitly.

547 **4.1 H2020 projects related to audio/video processing in the AHA/AAL domain**

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548 Through a research carried out mainly with the documentation available on the Cordis Europa portal
 549 (Cordis Europa, 2022), 25 different projects have been identified, starting from 2013, many of which
 550 are currently underway. Their first classification was carried out trying to understand, for each, the
 551 contextual or technical dimension of reference (Table 1). Projects focused on the contextual
 552 dimension aim to improve aspects such as the uptake, the relationship between the stakeholders
 553 involved, the improvement and unification of infrastructures and services, etc. In summary, all those
 554 aspects fundamental to technological innovation must be accepted and spread in a stable manner. On
 555 the other hand, projects focused on the technical dimension aim to create or introduce new and
 556 innovative technologies in AHA/AAL research. Every project listed contains both a contextual and a
 557 technical dimension. Typically, the ones that focus on the latter need to strengthen the contextual
 558 dimension side to create a technology that can be maintained and used over time, even after the end
 559 of the projects.

560

561 **Figure 1 Projects classification in the Contextual and Technical dimensions**

Projects in the Contextual Dimension	Projects in the Technical Dimension
<p>Platformuptake.eu (Assessing the State of the Art and Supporting an Evidence-Based Uptake and Evolution of Open Service Platforms in the Active and Healthy Ageing Domain, 2020-2022)</p>	<p>Activage (ACTivating InnoVative IoT smart living environments for AGEing well, 2017-2020)</p>
<p>Shapes (Smart and Healthy Ageing through People Engaging in Supportive Systems, 2019-2023)</p>	<p>Smart Bear (Smart Big Data Platform to Offer Evidence-based Personalised Support for Healthy and Independent Living at Home, 2019-2024)</p>
<p>We4aha (Widening the support for large scale uptake of Digital Innovation for Active and Healthy Ageing, 2017-2020)</p>	<p>Anatomus (Personalised multimedia digital consultation to revolutionise the doctor-patient consultation process, 2019)</p>
<p>Mecasa-ai (Inclusive innovation bringing the digitalising world to the changing care needs and preferences of Europe's ageing population, 2020)</p>	<p>Phara-on (Pilots for Healthy and Active Ageing, 2019-2023)</p>

<p>Acrossing (Advanced TeChnologies and PlatfoRm fOr Smarter ASsisted LivING, 2016-2019)</p>	<p>Rise-well (Critical solutions for elderly well-being, 2020-2024)</p>
<p>Smartwork (Smart Age-friendly Living and Working Environment, 2019-2022)</p>	<p>See Far (Smart glasses for multifacEted visual loss mitigation and chronic disEase prevention indicator for healthier, saFer, and more productive workplAce foR ageing population, 2018-2022)</p>
<p>Homes4life (Certified smart and integrated living environments for ageing well, 2018-2021)</p>	<p>HOLOBALANCE (HOLOgrams for personalised virtual coaching and motivation in an ageing population with BALANCE disorders, 2017-2020)</p>
<p>Ageingatwork (Smart, Personalised and Adaptive ICT Solutions for Active, Healthy and Productive Ageing with enhanced Workability, 2019-2022)</p>	<p>Eyesynth (Audio-Visual System for the Blind Allowing Visually Impaired to See Through Hearing, 2017-2019)</p>
<p>Ehcobutler (ehcoBUTLER. A global ecosystem for the independent and healty living of elder people with mild cognitive impairments, 2015-2022)</p>	<p>Radio (Robots in assisted living environments: Unobtrusive, efficient, reliable and modular solutions for independent ageing, 2015-2018)</p>
<p>Gatekeeper (Smart living homes - whole interventions demonstrator for people at health and social risks, 2019-2023)</p>	<p>Grow me up (2015-2018)</p>
	<p>Enrich-me (Enabling Robot and assisted living environment for Independent Care and Health Monitoring of the Elderly, 2015-2018)</p>

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	Seizsafe (Patient-self-adaptive system for detection, recording and alert to caregivers of night-time seizures, linked to private cloud platform for patient tracking and big data exploitation, 2016-2019)
	IN LIFE (INdependent LIVING support Functions for the Elderly, 2015-2018)
	my-AHA (My Active and Healthy Aging, 2016-2020)
	Semeoticons (SEMEiotic Oriented Technology for Individual's CardiOmetabolic risk self-assessmeNt and Self-monitoring, 2013-2016)

562 Our analysis focused on recognising 17 characteristics for each of the projects. The table in Figure 1
 563 shows the results obtained by analysing the aims, methodologies and results of 25 European research
 564 projects.

565 These characteristics are defined as follows:

- 566 • Years: the beginning and ending years of the project;
- 567 • Focus AHA: the project is mainly focused on AHA aspects;
- 568 • Focus AAL: the project is mainly focused on AAL aspects;
- 569 • Contextual dimension: the project belongs to the contextual dimension;
- 570 • Technical dimension: the project belongs to the technical dimension;
- 571 • Focus privacy: the project implements strategies related to privacy/security aspects. We use
 572 "(x)" when the project does not satisfy GDPR directives (i.e. the project is antecedent to the
 573 implementation of GDPR rules), "x" when the project satisfies them.
- 574 • Smart devices: during the project, have been used or developed smart devices (e.g. smart
 575 home appliances);
- 576 • Use of robot: during the project, has been used or developed a robot;
- 577 • Use AI/ML: during the project, have been used Artificial Intelligence / Machine Learning
 578 algorithms;
- 579 • Focus synergy: the project aims to create synergies and connections among final users;
- 580 • Focus Training: the project aims to train final users (e.g. the creation of courses of study);

- 581 • Focus certifications: the project aims to create models for the certification of methodologies,
 582 products and solutions.
 583 • Focus monitoring: the project aims to monitor users' activities and health status;
 584 • Focus device: the project aims to create a new customised device to monitor, assist, and
 585 support final users in their activities.
 586 • Home environment: the project is strictly related to the home environment;
 587 • Other environment: the project is related to other environments (e.g. work environment)
 588 • Beneficiaries: the users that have been recognised as the beneficiaries of the project's output.
 589 They are categorised into four groups as previously defined in the paper.

590

591

Figure 2 European projects in the AHA/AAL domain

Project Name	Years	Focus AHA	Focus AAL	Cont. dim.	Tech. dim.	Focus privacy	Smart devices	Use of Robot	Use AI/ML	Focus Synergy	Focus Training	Focus Certifi.	Focus Monit.	Focus device	Home env	Other env.	Benef.
Semeoticons	2012-2016		x		x		x						x	x	x		Group A
Ehcobutler	2015-2022		x	x		(x)	x						x		x		Group A Group B
Grow me up	2015-2018		x		x	(x)	x	x	x				x	x	x		Group A
In Life	2015-2018		x		x	(x)	x						x		x		Group A
Radio	2015-2018		x		x	(x)	x	x	x				x	x	x		Group A Group B
Enrich-me	2015-2018		x		x	x	x	x					x	x	x		Group A
Acrossing	2016-2019	x		x							x				x		Group B
my-AHA	2016-2020		x	x	x	x	x		x				x				Group A
Seizsafe	2016-2019		x		x								x	x	x		Group A Group B
Eyesynth	2017-2019		x		x				x						x	x	Group A
HoloBalance	2017-2020		x		x	x	x		x				x		x		Group A Group B
ActivAge	2017-2020		x		x		x	x	x				x		x		Group A Group B Group C Group D
We4aha	2017-2020	x		x						x							Group C Group D Group C Group D
Homes4Life	2018-2021		x	x								x					Group C Group D Group C Group D
See Far	2018-2022		x		x	x			x				x		x	x	Group A
Ageingatwork	2019-2022		x	x		x	x		x				x		x	x	Group A
Anatomus	2019		x		x	x									x		Group A Group B Group A Group B Group C Group A
GateKeeper	2019-2023	x		x		x				x							Group A Group B Group C Group A
Mecasa-ai	2020	x		x		x			x	x							Group A Group B Group A Group A Group B Group C Group D Group A
Phara-on	2019-2023		x		x	x	x	x	x				x		x		Group A Group B Group C Group D Group A Group B Group A Group B Group A Group B Group C Group D Group A
Smart Bear	2019-2024		x		x		x		x				x		x		Group A Group B Group A Group B Group A Group B Group A Group B Group A Group B Group C Group D Group A
Shapes	2019-2023		x	x		x	x		x				x		x		Group A Group B Group A Group B Group A Group B Group A Group B Group A Group B Group C Group D Group A
SmartWork	2019-2022		x	x		x	x		x				x			x	Group A Group B Group A Group B Group A Group B Group A Group B Group A Group B Group C Group D Group A
PlatformUptake.eu	2020-2022	x		x						x							Group B Group C Group D Group A Group B Group A Group B Group A Group B Group C Group D Group A
Rise-well	2020-2024		x		x	x	x						x				Group A Group B Group A Group B Group A Group B Group A Group B Group A Group B Group C Group D Group A

592

593

594 4.2 The analysis

595 Using the table shown in the previous paragraph, we tried to provide a graphical representation of
 596 what emerged, visible in Fig. 2. This figure has been organised into 3 columns: in the central column
 597 there are, in chronological order and taking into account the year of introduction of the GDPR, the
 598 projects examined; in the left column we have collected the intrinsic characteristics (focus on AHA
 599 or AAL, focus on technical or contextual dimension, focus on privacy); the right column shows the
 600 aims or outputs of the project (the beneficiaries, the application context and the type of application).

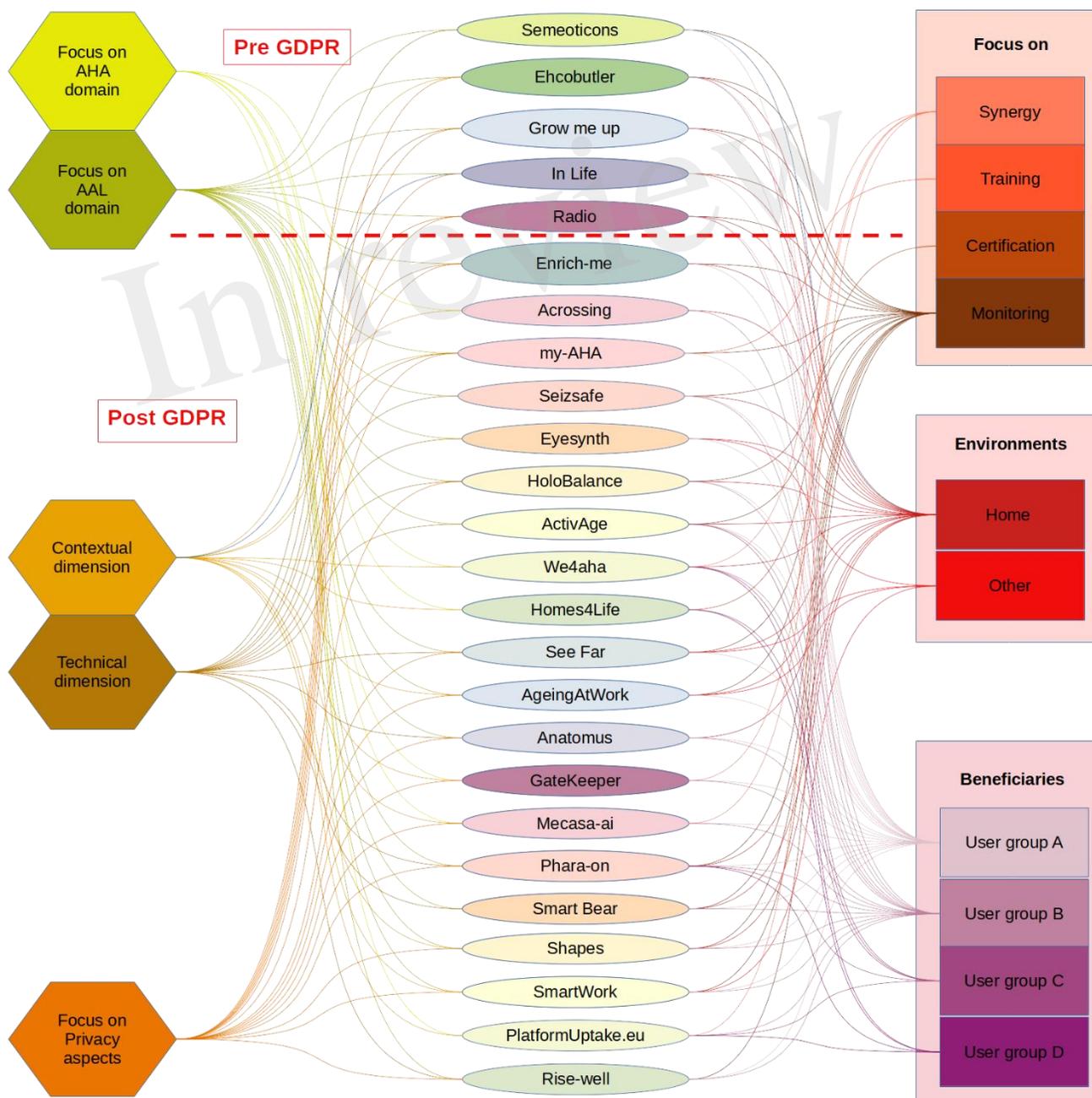
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601 Looking at the left column, we can see that most of the projects are focused on AAL, since most
 602 involve using or developing assistive technologies. The distribution of projects oriented to the
 603 technical or contextual dimensions is reasonably balanced with a slight predominance of the former.
 604 This information agrees with the previous indication on the majority of AAL-type projects. Since a
 605 project always has a contextual dimension, it is essential to know that the project's success also
 606 depends on the attention paid to the management of contextual activities. Concerning privacy, there
 607 are no significant differences between the phase before the introduction of the GDPR and the
 608 subsequent one.

609

610

Figure 3 Graphic representation of the characteristic of the projects



611

612 This is partly because the projects are all relatively recent, and each declares appropriate management
 613 of sensitive data and the consent of primary end-users. From a contextual point of view, the activities
 614 are typically limited to the compilation of informed consent without defining formal information
 615 strategies (e.g. ISA training). From the technical point of view, regarding the list of requirements
 616 specified in paragraph 3.1.1, the majority pay attention mainly to the correct data management.

617 Looking at the right column, we can see how most projects focus on home monitoring and have
 618 stakeholders from groups A and B as primary beneficiaries. The projects listed therefore propose
 619 different solutions oriented to the same context. It should be noted that their time windows often
 620 overlap, but no synergy between them is highlighted. This prevents the birth or affirmation of
 621 standards in the AHA/AAL sector, which unfortunately, to date and despite the multitude of projects
 622 and related investments by the European community, do not yet exist. All these different solutions
 623 can generate distrust by the Primary end-users and therefore compromise the entire test and data
 624 processing phase of a project. It is noted that the definition of stakeholders is often a consequence of
 625 the project's aims, hence the attention paid to groups A and B but little to groups B and C, often not
 626 even mentioned.

627 The privacy-by-design approach proposed in this article aims to suggest a unique definition of the
 628 four stakeholder groups, their characteristics and their relationships to ensure consistent and correct
 629 data management that is not limited to meeting the written criteria. Each individual must be aware of
 630 their role and importance within a project to ensure its success.

631 The stakeholder groups defined in this article and the two dimensions, technical and contextual, must
 632 be modelled and defined according to the project to be carried out. In the next section, a SWOT
 633 analysis will be presented, to show Strengths, Weaknesses, Opportunity and Threats for each
 634 stakeholder group and providing guidelines that helps in their definition and in identifying their
 635 purpose and boundaries to ensure not only correct data management but also correct data generation.

636 **5 Impact on success: a SWOT analysis**

637 SWOT (Strengths, Weaknesses, Opportunities, and Threats) is a useful technique for keeping track of
 638 a project's strengths and weaknesses and for analysing and reviewing any opportunities and threats that
 639 may appear during its life cycle (Leigh, 2009).

640 Conducting a SWOT analysis can bring significant benefits to a project, such as reducing risks,
 641 improving planning and generally increasing the chances of success. More precisely, the four main
 642 points of a SWOT analysis can be defined as follows:

- 643 • Strengths. Refers to factors internal to the project that should favor its success.
- 644 • Weaknesses. Refers to factors internal to the project that could make the project fail.
- 645 • Opportunities. Refers to factors that are external to the project that could make the project
 646 successful.
- 647 • Threats. Refers to factors external to the project that can significantly impede its success.
 648 Threats, like Opportunities, are just possibilities, but identifying them allows for alternative
 649 plans to be exploited in the unfortunate case they occur.

650 In this section we aim to conduct a SWOT analysis concerning the possible impact of the various
 651 categories of stakeholders from the point of view of who intends to develop and deploy a

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652 AHA/AAL platform, possibly including audio/video data. In particular, we aim to identify the
653 critical features connected to the selection and involvement of relevant stakeholders.

654 The starting point is the relationships between the Contextual and Technical dimensions and the
655 four stakeholder groups that have been provided in the previous section, intending to highlight the
656 criticality and potential of each of them to achieve the project objectives, with particular regard to
657 the issues of health and audio/video analysis. Through the proposed SWOT analysis, in this section,
658 we will try to summarise the concepts seen previously to make available at a glance the strengths,
659 weaknesses, opportunities and threats of each stakeholder group towards achieving the project
660 objectives. In this analysis, the stakeholder groups covered will be Primary end-users, AHA / AAL
661 solution developers providers, open platform providers, secondary end-users, and authorities and
662 facilitators. We opted to combine the latter two groups in this analysis. Indeed, considering a health
663 facility concerning secondary end-users, at the level of SWOT analysis, the scenario is similar,
664 albeit on a smaller scale, compared to that of a municipality if we consider the Authorities and
665 facilitators group. Notice that we conducted the analysis on the basis of the information collected
666 by questionnaires (coming from PlatformUptake.eu's activities) and after extensive discussions
667 with members of the three identified groups. The conducted SWOT analysis does not pretend to be
668 exhaustive. Still, it aims to underline and summarise the key elements most relevant to the
669 community as they emerged from our considerations. To this end, we provide the SWOT analysis
670 in Tables 2, 3 and 4 respectively for primary end users, secondary end users (combined with
671 authorities and facilitators) and finally for platform developers.

672 For primary end-users, strengths and weaknesses correlate to the capabilities in interacting with an
673 ICT platform and the issues of different nature that might impede such familiarity with
674 technologies. In principle, every AAL/AHA service should be designed to be accessible to
675 everyone, e.g. by spousing universal design principles. However, the suggestion is to carefully
676 balance the primary end-users group to be included, selecting for the first test phase a limited
677 number of testers having a good relationship with ICT tools. At the same time, in subsequent stages,
678 the groups can be enlarged, considering users exhibiting weaknesses or other frailties.
679 Opportunities depend and are proportional to the size of the groups of primary end-users involved,
680 granting real data sets for validation of platforms and community building. Threats exist and should
681 be appropriately mitigated. For instance, the risk of losing interest might be counteracted by
682 introducing gamification approaches described earlier in this paper.

683

684

Table 1. SWOT for primary end-users

		Usually Positive	Usually Negative
		Strengths	Weaknesses
Internal	<ul style="list-style-type: none"> • Knowledge of expected platform requirements in order to focus on relevant features of AAL/AHA platforms • A good relationship with ICT tools and general technologies • Benefitted from ISA training 	<ul style="list-style-type: none"> • Distrust of technology • Congenital or acquired difficulty (physical or cognitive) that prevents the use of technology 	

	Opportunities	Threats
External	<ul style="list-style-type: none"> Provision of high-quality realistic data to better tune platform services and improve research in AAL/AHA Creation of a community of users by direct engagement of their peers and word of mouth 	<ul style="list-style-type: none"> Risk of losing interest Possibility to provide erroneous data, whether deliberately or not Risk of dropping out (voluntarily or not)

685

686 The SWOT analysis for secondary end-users reports similar considerations, although at a different
687 scale. For instance, the adaption of the platform can be favoured inside associations of secondary end-
688 users (e.g. associations of municipalities in a region or, again, groups of nursing homes). It is vital to
689 notice that selecting proper secondary end-users can bring into the deployment of the platform
690 knowledge about the "market pull". This is an essential point in revising business plans and in focusing
691 the platform on those services which are helpful and sustainable. Proper validation of sustainability is
692 a possible by-product achievable as an opportunity by running pilots with secondary end-users.
693 Viceversa, weakness should be sought in potential organisational inefficiencies and scarce inclination
694 to change, possibly due to the fear of additional workloads or the management of different procedures.

695

Table 2. SWOT for secondary end-users, together with authorities and facilitators

	Usually Positive	Usually Negative
	Strengths	Weaknesses
Internal	<ul style="list-style-type: none"> Capability to represent the "market pull" in AAL/AHA platforms Skills in providing ISA training to linked primary users of AAL/AHA platforms Previous skills on AAL/AHA topics Possession of an active and lively network of primary end-users 	<ul style="list-style-type: none"> Inefficiencies in the internal process Lack of flexibility in reorganising the management of care with the related primary users Distrust of changes Possible perception of an increased workload during the introduction of services provided by the AAL/AHA platform
	Opportunities	Threats

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External	<ul style="list-style-type: none"> • Creation of a community of secondary end-users by networking or clustering activities (e.g. by participation in associations) • Collection of data with high reference value concerning the sustainability in using the AAL/AHA platform • Creation of new highly professional profiles inside the institutions 	<ul style="list-style-type: none"> • Search for primary end-users for the test phases is approximate, and the profiles chosen are not suitable • The relationship established with the network not very profitable • Possible distrust of the primary end-users towards authorities might jeopardise the positive effects introduced by the AAL/AHA platform
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696

697 Finally, for platform developers, internal characteristics are linked to developers' personal
 698 capabilities and sensibilities and to features that cannot be taken for granted by default even in this
 699 group of stakeholders, e.g. ISA training. In response to the users' requirements and the market pull, it
 700 is expected that developers can act proactively by providing a technological push. External issues are
 701 linked to the general job market and to the difficulty of carrying out a project at a steady pace.
 702 However, the possibility offered by the job market favours cross-fertilisation and can help bring
 703 leading-edge technologies in the AAL/AHA domain.

704

705

Table 3. SWOT for platform developers

		Usually Positive	Usually Negative
		Strengths	Weaknesses
Internal	<ul style="list-style-type: none"> • Capability to bring the "technological push" into AAL/AHA platforms providing innovative service in a more ample response to users' requirements and market pull • Good predisposition toward open-source platforms and integration of services • Sensibility versus privacy by design and privacy by default paradigms 	<ul style="list-style-type: none"> • Possibility of having scarce ISA training • Difficulties in understanding users' needs and the number of actors and complex interactions needed in a AAL/AHA platform • Scarc flexibility in customising the platform to adequate to slightly different sets of groups 	
		Opportunities	Threats

External	<ul style="list-style-type: none"> • Development of high skilled professional figures for the generation and maintenance of AAL/AHA platform • Cross-fertilisation with platforms in other domains, including home automation, artificial intelligence and audio/video services 	<ul style="list-style-type: none"> • Loss of interest in the development due to the possible scarce impact of the platform in its beginning stages • Possibility of losing key persons during critical, crucial implementation steps due to the job market • Difficulty in hiring adequate resources
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706

707 **6 Conclusions**

708 This article analysed the privacy-by-design requirements of a system for assisted living, personalised
709 care and well-being, particularly reviewing projects that provide audio and video signal processing.
710 This analysis was carried out to understand how the different categories of stakeholders involved in
711 the realisation of a project influence or are influenced by the privacy requirements. The study of these
712 requirements started from the description of the regulation imposed by the GDPR. Subsequently, the
713 categories of stakeholders and the dimensions were introduced and related to each other to show their
714 importance in a privacy-by-design approach. Afterwards, we conducted a review of recent European
715 AHA/AAL projects in the audio/video domain. This section represents a state of the art, but also an
716 opportunity to highlight how the concept of technical and contextual dimensions is important and
717 often not consciously addressed, as well as the correct stakeholders recognition. The article concludes
718 with a SWOT analysis carried out on the main categories of stakeholders identified, which can be
719 helpful to face the setup of a project or the analysis of one in progress in a conscious way, so that the
720 regulations imposed by privacy-by-design and GDPR do not become risk factors that compromise
721 the success of the activities.

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In review

Figure 1.JPEG

Project Name	Years	Focus AHA	Focus AAL	Cont. dim.	Tech. dim.	Focus privacy	Smart devices	Use of Robot	Use AI/ML	Focus Synergy	Focus Training	Focus Certifi.	Focus Monit.	Focus device	Home env	Other env.	Benef.
Semeoticons	2012-2016		x		x		x						x	x	x		Group A
Ehcobutler	2015-2022		x	x		(x)	x						x		x		Group A Group B
Grow me up	2015-2018		x		x	(x)	x	x	x				x	x	x		Group A
In Life	2015-2018		x		x	(x)	x						x		x		Group A
Radio	2015-2018		x		x	(x)	x	x	x				x	x	x		Group A Group B
Enrich-me	2015-2018		x		x	x	x	x					x	x	x		Group A
Acrossing	2016-2019	x		x							x				x		Group B
my-AHA	2016-2020		x	x	x	x	x		x				x				Group A
Seizsafe	2016-2019		x		x								x	x	x		Group A Group B
Eyesynth	2017-2019		x		x				x						x	x	Group A
HoloBalance	2017-2020		x		x	x	x		x				x		x		Group A Group B
ActivAge	2017-2020		x		x		x	x	x				x		x		Group A Group B Group C
We4aha	2017-2020	x		x						x							Group B Group C Group D
Homes4Life	2018-2021	x		x								x					Group C Group D
See Far	2018-2022	x			x	x			x				x		x	x	Group A
Ageingatwork	2019-2022		x	x		x	x		x				x		x	x	Group A
Anatomus	2019		x		x	x									x		Group A Group B
GateKeeper	2019-2023	x		x		x				x							Group A Group B Group C
Mecasa-ai	2020	x		x		x			x	x							Group A Group B
Phara-on	2019-2023		x		x	x	x	x	x				x		x		Group A Group B Group C Group D
Smart Bear	2019-2024		x		x		x		x				x		x		Group A Group B
Shapes	2019-2023		x	x		x	x		x				x		x		Group A Group B
SmartWork	2019-2022		x	x		x	x		x				x			x	Group A Group B
PlatformUptake.eu	2020-2022	x		x						x							Group B Group C Group D
Rise-well	2020-2024		x		x	x	x						x				Group A Group B

Figure 2.JPEG

