INTELLIGENT KNOWLEDGE-AS-A-SERVICE

D1.8 iKaaS Final Technological Roadmap

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Abstract: This final version of the iKaaS technological roadmap outlines the status of the project key technical work items at the end of the project.

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Contents

1. Introduction

This final version of the iKaaS technological roadmap outlines the final status of the project key technical work items. More specifically, an overview of the iKaaS platform prototype environment is provided. Similarly, an overview of the iKaaS use cases and cross border applications is provided with reference to the corresponding prototypes. The document also provides an overview of the contributions of the European and Japanese partners in terms of the implemented components of the iKaaS architecture.

2. iKaaS platform prototype

This section provides an overview of the current iKaaS prototype in terms of the deployment environment and the components implemented as well as the roadmap followed towards its finalization.

2.1. iKaaS final prototype

As introduced in D4.3 [1], iKaaS has developed a toolbox of components that has been made publicly available and will allow third parties and stakeholders to setup iKaaS platform instantiations that support the services developed and tested in the context of the project. Therefore, the iKaaS toolbox includes components that collect, process data and perform decision making as part of a service (Virtual Entities and Data Processing) but also components that enable the setup of service chains themselves and their runtime manipulation (Service Manager, Resource Catalogue) as well as Applications for interfacing with the users of the services and components dealing with security and privacy of data (Security Gateway, Policy DB). In addition, as many iKaaS components are generic in nature it is also possible for third parties to introduce their own components, as long as they follow the iKaaS choice in cloud technologies and API specification, and integrate them in an iKaaS platform instantiation to offer extended services. It is also possible for third parties to pick and use even individual components of the toolbox, in cases they support standalone-desired features that the third parties are missing in their solutions portfolio. The detailed description of the iKaaS prototype software components can be found in D4.3 [1], D4.4 [2] and D4.5 [3].

2.2. Description of the deployment environment

The iKaaS Global Cloud is deployed in the SIRIS experimentation platform [4], which consists of an Infrastructure as a Service (IaaS) layer installed on a Data Centre provided by Create-Net. The IaaS layer of SIRIS is provided by OpenStack. OpenStack software controls the distribution of computing, storage, and networking resources. The user applications and tasks are run inside separate Virtual Machines (VMs). To enable specific testing of functionality for the iKaaS environment, a layer has been added on top of this IaaS, the CaaS (Container as a service) layer. This second layer is provided by Kubernetes. Kubernetes manages containerized applications across a cluster of nodes. This becomes useful to manage containers, such as Docker containers. These containers provide lightweight and ultra-fast virtualization for applications. The containers themselves are running inside the VMs.

The local cloud deployment environments essentially correspond to what has been implemented in the different iKaaS use case pilots and prototypes (see also Section 3). Both implemented global and local cloud components have been packed into Docker images. Minikube has been exploited for local cloud deployments. Minikube runs a single-node Kubernetes cluster [5] thus allowing the use of Kubernetes even on machines with limited physical resources and making it suitable for local cloud deployments. Further details can be found in D5.4 [6].

2.3. Roadmap

In accordance with the project time plan and the key milestones defined (see also D1.7 [7]) the iKaaS prototype modules development and integration has been completed and these have been exploited for use case validation. Corresponding results are reported in D5.4 [6]. The iKaaS developed functionalities must be by default packaged in a virtualized form. iKaaS has opted for a container-based approach, namely Docker. In addition, Kubernetes and Minikube have been exploited as a Docker container manager [8], [6].

3. Use Case pilots and prototypes

This section outlines the use case prototype implementations and pilots.

3.1. Service of environmental health in Madrid

3.1.1. Description of pilot

As a big city, Madrid is facing challenges related to air quality that must be addressed accordingly. Hence, the functionality of environmental health information in the city of Madrid use case focuses on pollutants and pollen airbornes, and how to improve the current mechanisms to detect and measure them, and thereafter, to improve the accuracy of the information to be provided to citizens, in order to reduce related health effects, especially in allergic and sensitive population, and therefore to improve the quality of life of citizens through a better understanding of the environment.

The Madrid objectives for the project included:

- To increase the current number of environmental city sensors introducing new mobile sensors in the on-board system of public buses.
- To develop a local platform that integrates all environmental devices and sensors.
- To collect and store all historical data and real-time values in a local cloud.
- To ensure data quality through reputation based system for sensors and predictive algorithms to avoid data lost.
- To define a protocol for data interchange into the Madrid city for mobility, traffic and environmental data.
- To create an open API connector for exchanging those data.
- To improve the related environmental health information system.

At the same time iKaaS capabilities provide a tool to derive new behaviour patterns of pollution and airborne pollen in the city. The combination of IoT and Big Data technologies in iKaaS are leveraged to provide on the fly information regarding the current environmental situation of the city which is produced on the basis of the experience learnt and real-time collected data, while the cloud architecture of the platform provides an infrastructure able to share; beyond data or processing capabilities; data, applications, services and the result of the analysis of data (knowledge) among all stakeholders and places involved in the project. A more detailed description of the use case can be found in D5.2 [9].

The functionality of environmental health information system articulated through Madrid use case iKaaS Platform, consists of two scenarios representing functionalities of the platform (A, Notice service and B, Warning Service). Use case specific KPIs are presented also in D5.2 [9].

3.1.2.Roadmap

The implementation of Madrid Use Case has been in line with the roadmap set out in D5.2 [9] and D.6.4 [10] and has been completed according to plan. At the latter stages of the project work in the scope of this use case mainly focused on the integration of the predictive model and the complete development of the functionalities for the testing of the citizen's information systems (including two scenario levels (notice and warning services). During Y3 Madrid partners have finalized the installation of the environmental and pollen mobile and static sensors that are used in the Madrid use case. Also, some fine-tuning work has been done regarding the user's web portal and app, which are the interfaces that interact with end users.

However, different setbacks have caused the originally scheduled testing phase to be delayed as it was intended to start by mid June 2017. Among others, and fundamentally, the delay in the delivery of the mobile sensors by the suppliers, which has also consequently delayed their installation and calibration. In addition to that, there have been also some unexpected delays with the reporting readings from some of the aforementioned sensors and with the integration of the dynamic information into the predictive model. This fact meant that the pollination and high atmospheric pollution seasons (mainly winter and spring) were over before being able to carry out effective tests in real conditions. Finally, the registration SDK took more time than expected to be ready. Thus, the integration with the AAL prototype (end user interface) was consequently delayed as well.

On this regard, the testing phase started on September 9th, 2017 and it is currently ongoing. The functionalities developed under the iKaaS project are being tested using selected population. Environmental health information is a very sensitive topic; therefore, such services must be strictly proven and certified before being officially used by public authorities. iKaaS, as a pilot project, is verifying all the functionalities of the Madrid Environmental Health service in order to ensure its reliability before being offered to Madrid citizens at large. KPIs will be reported as an amendment as it has not been possible to include them on time in D5.4 [6]. Exploitation of the outcomes from the Environmental Health Service is detailed in D6.6 [11].

3.2. Town management service in Tago-Nishi

3.2.1.Description of pilot

The town management case aimed to demonstrate how the iKaaS platform could be exploited to provide useful support tools for town management organization personnel to help their daily activities on the town management tasks. The application for this use case provides useful data for energy management with facilities for renewable energy in the town. It also provides useful information to the personnel to conduct search for dangerous points in a town to improve quality of life of the town residents.

The "Weather Prediction for Energy Management" scenario (defined in D5.2 [9]) addresses a function for weather prediction to induce the situation of very local area in the town in near future for effective and accurate energy management. In particular, we use open data in public for weather situation and weather-related data obtained from sensors installed in the town. From these data with iKaaS components, we generate knowledge on the relationship between the data and we can predict the weather situation in the very specific point and energy usage/generation status in the town.

The "VR Walkthrough for Urban Design" scenario (also defined in D5.2 [9]) addresses a walkthrough function in VR environment for urban design. A personalized situation or context in Tago-Nishi is represented as a VR environment by specifying weather condition, time of the day, season, user profile, etc. The function controls the level of visualization based on the privacy policy defined for each city object in town, and presents possibly dangerous or inconvenient places or contexts in a user-friendly and realistic manner using VR or AR representation. The obtained results are exploited for defining guidelines for safer city design. The function is designed to use a variety of data from iKaaS platform, such as environment data, geospatial data, town asset and ownership data, etc.

Experiments were performed to measure the response time to use the iKaaS platform from the town management application. In addition, the system performance of Query/Store Functions of the iKaaS Platform was evaluated by measuring the response time when a variety of queries are issued. The system performance was also evaluated by measuring the response time between the query issuing time and the time of reflection in the VR environment. The final evaluation of the platform in the scope of this use case was carried out in accordance with the KPIs defined in D5.2 [6]. Details on the implementation, experimental results in performance, and results of questionnaire survey on usefulness of this system are available in D5.4 [6].

3.2.2. Roadmap

The actual exploitation of the outcomes from the Town management use case is detailed in D6.6 [11]. As for the functions of town management system, we will improve accuracy of predictions for local weather and energy management by introducing several sophisticated algorithms or learning mechanisms such as deep learning as knowledge in iKaaS platform. Regarding the urban design support, we will add other actual functions for town facility improvement such as brightness control of the streetlight to reduce light damage, etc. We have been focussing on support system for town management company personnel in this project, but to expand these functions as community services, we will continue to discover and develop services for safe and secure life for residents by using the iKaaS platform.

3.3. Health Support service in Tago-Nishi

3.3.1. Description of pilot

The Health Support Service in Tago-Nishi is a service which utilizes indoor environment sensors and wearable activity meters to provide the following services: a) Identification of staying-at-home elderly residents; b)Identification of physically inactive elderly residents; and c) Alert to break sedentary behaviour. The purpose of the use case, "Health Support Service in Tago-Nishi,"was to design a practical health support service, which is acceptable for the residents and potential service providers in Tago-Nishi, by reflecting the residents" feedbacks on the service through experimental data measurement and questionnaire survey among them.

Firstly, we examined the feasibility of procedures to acquire the residents' personal data in the Health Support Service. One survey showed that the majority of participants in Tago-Nishi considered personal data protection as a major issue for health support service and the reliability of data management organization as an "extremely important" issue. Another survey showed that most of the residents felt measurement by wearable sensors was troublesome, and some of them disagreed to participate in the project. The result suggests that even when wearable devices are downsized for general use, measurements using wearable devices may not be accepted widely in the Health Support Service. Detailed results on two questionnaire surveys are shown in D5.3 [12].

Secondly, we examined the usefulness of and expectation for the Health Support Service among staffs of health service providers and sectors in Tago-nishi. The results showed that our Health Support Service was basically accepted by them. Moreover, they could expect to reduce their burden of work using the Health Support Service, as compared with traditional health support services. These results indicated that the target values of KPIs for the Health Support Service were achieved. The details of this survey are described in D5.4 [6].

3.3.2.Roadmap

Throughout the whole process in this project, the Health Support Service was designed based on the needs of health service, the awareness of personal data, the feasibility of procedure to acquire personal data, and the expectation for the Health Support Service among the residents and potential service providers in Tago-nishi. In order to validate the feasibility of the presented service design, it is necessary to implement the Health Support Service based on the service design made in iKaaS project and to evaluate if the service contributes to health promotion, although this implementation is beyond this project. In addition, we need to clarify benefits for users (i.e. residents), not only for service providers as described in D5.4, and cost-effectiveness by presenting prototype services.

3.4. Ambient Assisted Living in Smart City

3.4.1.Description of pilot

The Ambient Assisted Living in Smart City is a solution for Smart Home and Smart Health Care that comprises of an implementation of the Cloud-based iKaaS platform and an accompanying mobile AAL application for home automation and remote health monitoring aiming to provide the following services:

- Automated home environment adaptation with functionality for learning user patterns to forecast user desires with respect to home and appliances configuration and proactively take actions/offer recommendations. Bayesian statistics are exploited for the estimation of future temperature settings in the home desired by the user.
- Remote Health Monitoring, comprising functionality for learning patterns in user physical status and behaviour to identify pattern irregularities (any abnormality in usual patterns). The corresponding information can also be provided to family members and/or professional caretakers, and appropriate alarms may be raised if necessary. Timeseries forecasting is exploited for deriving future vital signs measurements.
- Smart mobility for the provision of navigation instructions, helping with the use of public transportation, taking into account user preferences and health/well-being status.
- Smart city dashboard for visualization of measurements on interactive graphs and "heat-maps" that aim to present the overall city picture at a

glance. This includes the visualisation of real time and historical data on weather, pollution and pollen.

The scenarios showcased, scale from the initialization processes in the system for the introduction of real-world devices and the registration of simple services that actually allow the association of data sources to the local cloud, to the dynamic creation, provision and reconfiguration/migration of complex services for automated home environment adaptation, remote health monitoring and smart mobility.

Detailed results on the implemented use case prototype and results from the different scenarios are available in D5.4 [6]. Experiments were performed for response time, scalability of service creation process, scalability of service reconfiguration process, and scalability of federated queries over distributed semantic data. The implementation utilises several technologies. More specifically, the mobile application is hosted in an Android version 4.4.4 (API level 19) device. The components of the Global and Local cloud have been packed into Docker images. Global cloud components are deployed on the CREATE-NET Kubernetes platform while local cloud components are deployed in a Minikube installation. The Gateways are Ethernet shield Arduinos with Luminosity sensors, Temperature and Humidity sensors and LEDs as actuators, representing real devices and their status. More details on the corresponding environment specification for the Global and Local Cloud deployments can be found in D5.4 [6].

3.4.2.Roadmap

The implementation of the AAL use case prototype has been in line with the roadmap set out in D5.2 [9] and has been completed according to plan. The AAL prototype has been integrated with the other two use cases (Madrid and Tago-Nishi) and extensions for the cross border application have been implemented (further described in section 3.5). The developed software is further exploited towards forthcoming ventures [11]. WINGS has exploited iKaaS results in the first phase of the Select4Cities PCP (http://www.select4cities.eu/). WINGS is also continuing experimentation and validation of the AAL platform developed in iKaaS as part of the FIESTA-IoT (http://fiesta-iot.eu/) 3rd Open call in the category Innovation. In addition, WINGS has started actions that concern the commercialization of the final product/services deriving from the implementation of the AAL use case prototype. These involve the contact of vendors, operators, and municipalities/local-governments. Indicatively, WINGS is in advanced discussions with:

- Nokia regarding the realization of pilots on various areas related to smart cities (e.g., air-quality monitoring, transportation, assisted-living;

- OTE (Greek telco operator) regarding the realization of pilots on water management;
- Among others, the municipality of Kozani and the administrative region of Western Macedonia in Northern Greece.

WINGS, being active internationally, is also in contact with operators and local authorities in the UK, France and Portugal.

3.5. Cross border application

3.5.1. Description of pilot

The cross-border application starts from an integration of elements of the three core use cases: Madrid, Tago-Nishi and AAL. The integration mainly focuses on the smart mobility service of the AAL use case for providing instructions on how a person can reach a particular destination based on information on individual health, transportation, traffic, city events, weather, pollution, pollen. Such information is derived from the Madrid and Tago-Nishi pilots. Additions for the cross border application include the integration with data sources from Madrid and Tago-Nishi for the retrieval of data on pollen, pollution, traffic, etc. [9]. Moreover, as part of the Madrid/AAL integration, WINGS, EMT, ATOS and Madrid partners have been working on the extension of the AAL mobile application that has been provided to citizens using the EMT public transport network and:

- Displays routes for favourite destinations in real time for public transport (buses), walking or public bicycle system, based on environmental healthy factors.
- Shows/sends notifications about high level of pollutants (also according to thresholds defined by users).
- Shows a layer over the routes map with the pollen/pollutants distribution over the city (Points, measures, alerts…)

For this, a route engine developed by EMT has been exploited which provides the capability for calculating aforementioned routes in real time.

In the scope of the Tago-Nishi/AAL integration, the following additional scenario around Remote Health monitoring and forecasting has been realised:

- Data processing functionality for forecasting the evolution of vital signs implemented as part of the AAL prototype retrieves historical and real-time Heart Rate data from the Tago-Nishi Local Cloud. Predictions on the evolution of the heart rate are made based on the retrieved data.
- A Japanese Sleep support application obtains the predicted data (in an asynchronous way) from the Data Processing (AAL), via the Global Service Manager (AAL).

- The Japanese Sleep support application detects abnormal conditions during the sleep time of a user based on the acquired predictions.

3.5.2.Roadmap

The implementation of the cross border application has followed the time plan set out in D5.2 [9]. Some additional features have been added (such as the extension of the AAL smart mobility part to be offered to EMT users and the Japanese Sleep Support application). Details on the implementation and results from the corresponding evaluation are provided in D5.4 [6]. As in the case of the AAL use case the developed software (from WINGS side) is further exploited towards forthcoming ventures. In addition, the integration of the AAL use case with two large pilots contributes to higher validation of the developed AAL solutions, which is deemed as particularly beneficial for its commercial exploitation. Further details on the exploitation outcomes relevant to the cross border application can be found in D6.6 [11]. The designed sleep support application is considered to have potential for achieving great development in terms of high demand of sleep support in the field of health support as well. A future step beyond this project is to design the additional/improved functionalities. This work should be carried out concurrently with validation tests involving appropriate users as well as medical and health organizations. From fundamental technological aspects, we will keep investigating the way to optimize the environment for good sleep using IoT devices. The iKaaS project, as a three-year short-term project, clarified what measurement methods are acceptable and what are not. We still need to clarify benefits for residents and cost-effectiveness by presenting prototype services. A long-term validation in a real environment would be required to estimate actual business impacts; thus, further long-term validation is necessary.

4. Technical work balance among EU and Japan

This section provides an overview of the technical work balance among the project partners. Table 1 and Table 2 show the contribution of EU and Japanese partners to iKaaS components implementation respectively. Further details on the implemented components can be found in D4.5 [3].

Table 1: Contribution of EU partners to iKaaS components implementation

Component	EU Partner
Virtual Entity	UNIS, ATOS, EMT, WINGS
Data Processing	UNIS, ATOS, WINGS, EMT, Madrid-City
Service Manager	WINGS
Resource Catalogue	WINGS
Local Cloud DB	ATOS/EMT
Application	WINGS, EMT

Table 2: Contribution of JP partners to iKaaS components implementation

Component	JP Partner
Data Processing	Uni-Tohoku
Security Gateway	KDDR
Policy DB	KDDR
Local Cloud DB	KKC, Hitachi

Regarding the cross border application, EU and Japanese partners have collaborated on the specification of scenarios and the implementation of the corresponding components. Initially, several phone conferences took place between EU and Japanese partners to finalise the scenarios. Then the implementation process started with some refinements of the scenarios, resulting in an additional application for Sleep support from the Japanese side. The main partners involved in the development of the cross border application have been Oulu (for the coordination), WINGS, ATOS, EMT, KDDR, Hitachi and Uni-Tohoku.

5. Conclusion

This document presented the project key technical outcomes in terms of the implemented iKaaS platform, pilots and use case prototypes. An overview of the iKaaS platform prototype environment was provided. Similarly, an overview of the iKaaS use cases and cross border application prototypes was presented. The document also provided an overview of the contributions of the European and Japanese partners in terms of the implemented components of the iKaaS architecture.

References

[1]. iKaaS D4.3 Deliverable "1st Prototype of the iKaaS Platform", March 2017
[2]. iKaaS D4.4 Deliverable, "2nd Prototype of the iKaaS Platform", May 2017
[3]. iKaaS D4.5 Deliverable , "Consolidated iKaaS Platform", September 2017
[4]. SIRIS experimentation platform, https://create-net.fbk.eu/siris/experimentation, accessed May 2017
[5]. Running Kubernetes Locally via Minikube, https://kubernetes.io/docs/getting-started-guides/minikube/, accessed May 2017
[6]. iKaaS D5.4 Deliverable "2nd Evaluation of iKaaS Pilot Results", September 2017.
[7]. iKaaS D1.7 Deliverable, "3rd iKaaS technological roadmap", May 2017
[8]. iKaaS D3.2 Deliverable "Final Specification of Multi-Cloud Mechanisms for Knowledge Acquisition, Service Provision, Security and Privacy", October 2016
[9]. iKaaS D5.2 Deliverable "Use-case specific Roadmap Concept and Methodology", March 2016
[10]. iKaaS D6.4 Deliverable "Interim Exploitation Plan", March 2017
[11]. iKaaS D6.6 Deliverable "Final Exploitation, Standardization, Dissemination and Collaboration Bridge Building", September 2017
[12]. iKaaS D5.3 deliverable "1st Evaluation of iKaaS Pilot Results", March 2017

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