professionals. The patient has access to all useful information and services related to the disease,

(ix) synchronous or asynchronous communication with healthcare professionals, and

(x) access to instructions, information, and other related material from reliable sources such as the national public health organization and the ministry of health.

3.3. Business logic tier

This tier consists of middleware services necessary for enabling communication between healthcare professionals and citizens, symptom tracking, managing personalized information and user profiles, personal health records, position tracing, and recommendations. As the Safe in COVID-19 framework is based and significantly extends a fully-fledged PHR system, state of the art communication, user profiling and personal health records come out of the box, whereas the specific COVID symptom monitoring and recommendations along with the position tracking have been implemented specifically for addressing the COVID-19 outbreak. All the services communicate with the semantic tier to retrieve, update and store data, which are further visualized and presented to the user through the application tier.

3.4. Semantic tier

This tier includes a data lake where all available data are staged. Those include data collected by the mobile and the web apps, additional data about healthcare resources and geolocation information, as well as external open data sources and registries. All these datasets are staged in the data lake that currently supports relational and NoSQL databases.

Independent of the model the individual data use, a high-level ontology has been used to integrate, homogenize and make FAIR the available COVID-19 data. To this purpose the WHO COVID-19 rapid version case record form (CRF) semantic data model has been used for exposing the data, along with the MHA Semantic Core Ontology [21]. The WHO COVID-19 rapid Version CRF Semantic Data Model is an approach to model all relevant COVID-19 data for the various clinical research forms as recommended by WHO. On the other hand, the MHA Semantic core ontology has been developed through the MyHealthAvatar and the iManageCancer projects [21] for modelling all health information for individuals. A screenshot showing the intersection of the modules of the two ontologies used is shown in Figure 5.

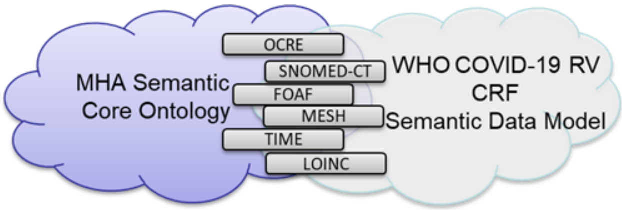

Figure 5. Modules of the semantic model used for data FAIRification

The available data in the platform are mapped [22] to the aforementioned ontologies in order to be homogenized, and subsequently queried and exported. Besides the mapping to aforementioned semantic models, annotations are also available on the available data using terms from the included modules, whereas specific attention is paid to the fact that the ontologies are continuously evolving artefacts [23][24].

For accessing the available information, both in its native and in its semantically uplifted form the available APIs have been implemented and are available. The data access APIs is used by the business logic tier modules to enable efficient data access and can also be offered to external services that require access to the data.

3.5. FHIR interoperability

Fast healthcare interoperability resources (FHIR) have been used for the representation of the medical data related to COVID-19 [25]. More specifically *valueSet* for COVID-19 Patient Reported Outcome Observations[21], that includes the following symptoms: cough, fatigue, pain in throat, dyspnea, headache, diarrhea, nausea, loss of sense of smell, and temperature has been adopted. This *valueSet* is used for the recording of vital parameters related to COVID-19 for the citizens' application. FHIR resources (i.e. Problem and Condition resources) are also appropriate for representation of the underlying diseases related to COVID-19.

In addition, the Simplifier.NET[22] project contains FHIR resources covering patient self-assessment, remote practitioner-driven clinical assessment and subsequent exams for patients whose epidemiological assessment has already been completed, as well as resources to track the clinical outcome defined for them (home-quarantine, admission to intensive care or non-intensive care, etc.). It also supports telemedicine/ self-monitoring to track the subsequent telemedicine process for home-quarantined subjects and self-monitoring of relevant clinical parameters.

Moreover, the Situational Awareness for Novel Epidemic Response Implementation Guide[23], published by the HL7 International Public Health Workgroup, enables transmission of high-level situational awareness information from initially inpatient facilities to centralized data repositories to support the focus and response to novel influenza-like illness, such as COVID-19. This implementation guide addresses the need to have immediate awareness of available aggregate status,

[21] http://build.fhir.org/ig/hl7ch/covid-19-prom/branches/master/ValueSet-covid-19-prom.html

[22] https://simplifier.net/covid-19

[23] http://build.fhir.org/ig/HL7/fhir-saner/

5.2. Software/Hardware Requirements

Applications and Operating Systems hosting "Safe in Covid-19" platform must be compatible with VMWARE 6.0.

(i) The minimum resources that should be user are 8 logical cores.
(ii) The minimum memory that should be is 64GB.
(iii) The proposed operating system is Windows Server 2019 (64-bit, Standard, Foundation, Datacenter editions), including Server Core installations
(iv) It is required to use database Engines SQL Server 2019 or later. Alternatively, Oracle Database 12c Release 2 or later.

5.3. Network Requirements

Regarding the internet connection infrastructures, connection to public administration networks (such as SYZEFXIS[24] in Greece) is proposed, with a double-direction optical ring of Metro Ethernet technology, in high-availability (active-standby).

5.4. Supported browsers

The following browsers are supported:

Desktop

(i) Mozilla Firefox (latest) for Windows and Mac OS
(ii) Microsoft Internet Explorer® 11.x for Windows
(iii) Microsoft Edge® for Windows 10
(iv) Apple Safari (latest) for Mac OS
(v) Google Chrome (latest) for Windows and Mac OS
(vi) Opera (latest) for Windows and Mac OS

Smartphones and Tablets

(i) Chrome Mobile
(ii) Default browser (Safari) on iOS 8
(iii) Default browser on Android 4.x
(iv) Default browser (IE) on Windows Phone 8

Complying with the above specifications can ensure the correct and smooth operation of the platform without interruptions and problems.

At the same time, the operation and use of the application is enabled by a very large number of users, while the support of L4 to L7 load balancing techniques in combination with the "offline" operation and the asynchronous synchronization guarantees that there will be no burden on the network load.

[24] https://www.syzefxis.gov.gr/

6. Discussion and conclusions

This paper presented a digital platform with applications for public health authorities, healthcare professionals and citizens to support surveillance of suspect, probable and confirmed cases outside the hospital. The described tool can be used for self-reporting of symptoms by contacts and currently is not linked to proximity applications. The solution supports return to the "new normal" with less stress and more security for individuals, more direct and safer management of patients by physicians, and better possibilities for monitoring the epidemic by public health authorities.

Foreseen benefits for public health authorities include decongestion of the healthcare units (hospitals and specialized primary care centers) in situations that prevent citizens from attending health institutions (hospitals, specialized health centers) to receive the relevant diagnostic test, provision of real-time information on the evolution of suspected, candidate and confirmed cases, online monitoring of the spread of the virus, and decision-making support regarding required measures to be taken. Benefits for citizens include systematic recording of symptoms, provision of help for self-assessment of virus-related symptoms, and access to personalized information, instructions and reminders about their symptoms and health status. Benefits to healthcare professionals include support in managing the patients traced/ monitored, reduced time for direct contact with patients, and improved working conditions. In order for these benefits to be realized to their full range, it is important to have an interoperability framework such as the one already described in [29] to connect with the relevant national registries and digital health services.

The effectiveness of such a tool depends on several, interrelated factors:

(i) a comprehensive national epidemiologic strategy articulating instrumental support to the public health system,
(ii) n appropriate architectural, technological but also organizational model of implementation, and
(iii) widespread connection with mobile devices, while acknowledging that considerable segments of the population are unable to acquire or use them, in particular high-risk groups such as the elderly.

Putting such a tool in operation requires close cooperation with public authorities for the development and deployment of the solution at a national and international level, compliance with approved medical protocols [30], interoperability with national registries for citizen identification and COVID-19, quality assurance, and the existence of the appropriate legal framework.

There has been enough evidence to support that digital solutions can play an instrumental role in integrated care in the era of COVID-19. Implementing digital platforms at a

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