THE USE OF INFORMATION TECHNOLOGY TOWARD THE ETHICS OF FOOD SAFETY

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Abstract
Food safety is a core concern of the European Union in terms of the related legal provisions and of the importance that is given to it. While the food labeling system is already standardized to a large extent, there are areas that still need improvement. In this article, we will present the existing labeling standards, highlight the issues that these standards are facing, identify the possibilities of improvement for the food labeling system and propose a concrete way of using Information Technology to benefit the ethics of food safety. Starting off from the current technological capabilities and from the need to improve the labeling system, we will integrate the Quick Response code technology into a new software architecture able to resolve some of the issues identified. The software architecture relies on a relational data model and on web services that are integrated into an Android application, so that consumers may benefit from additional useful information when they must make a buying decision concerning food products. Our architectural proposal also involves smart information integration with health insurance systems in order to increase the usefulness of the data displayed on food labels.

Key words: *ethics of food safety, information integration, Quick Response labels, software architectures, smart label*

JEL Classification: *O33, L15, Q18.*

I. INTRODUCTION

The European Union lays special emphasis on food safety and strives, through legal provisions, to support its citizens in making decisions related to food consumption. As nutrition and health aspects are considered, one of the most important elements in this discussion is the labeling system. Labeling standards evolved in time, driven by the aim of helping consumers have a balanced and healthy diet and thus meeting the prerequisite of an ethical approach of beneficiaries.

In the study that we conducted for this article, we revealed the fact that the label is an important factor in consumers' buying decisions and we are, therefore, trying to make the best of this piece of information. Starting off from the importance given to food safety in the European Union, the aim of this article is to have a concrete contribution to improving the labeling system of food products by integrating the new information technologies. Thus, we are proposing the prototype of a software application that employs technologies such as QR labels, web services, databases and mobile apps. The objective of this paper is to prototype a complex form of information integration (consumer, food products, labels, data servers and the system of the national health insurance card) and to present the final results of the tests performed in conditions of laboratory prototype.

The information integration that we are proposing implies the simultaneous use of the data from the labeling system and of the data from the national health insurance card system, so that consumers may receive real-time alerts about the food products that may be harmful to them. These alerts generated by the smart app are customized according to the users' individual profiles and to the product that they intend to buy or eat.

The result of this article is the valid prototype of a smart mobile app that fosters ethics in food safety by helping users with updated information obtained by means of an intelligent application. This result also falls within the scope (Agheorghiesei (Corodeanu), 2013) of the ethical requirements related to the users of the public health insurance system.

II. REVIEW OF SCIENTIFIC LITERATURE

Food safety in the European Union is very important, being treated as a cross-border issue. Many of the foods consumed in the common area come from various countries. The free movement of food products within the European Union determines an increase in competitivity, but also in the number of quality-related risks. That is why it is important to observe ethical norms, models and systems of food safety management, such as the HACCP – Hazard Analysis Critical Control Points (USDA, 1997) – model and the ISO 22000:2005 (International Organization for Standardization, 2005) standard**.**

An efficient analysis of the threats to food safety must consider aspects such as (Dima & Diaconescu, 2006):

- name of the product;
- origin of the product;
- biological, chemical and physical characteristics that are relevant for food safety;
- ingredients that make up the recipe, including additives and processing aids;
- label markings related to food safety and/or instructions for handling, preparation and use;
- storage conditions and duration of storage;
- preparation and/or handling before use or processing;
- methods and procedures of manufacture;
- methods of distribution.

A series of official regulations (The European Parliament and The Council of Europe, 2011) on informing consumers about food products is based on European directives (Conseil de l'Europe, 1990) concerning the indication of the nutritional value on the label of the food products. These lay down norms regarding the contents and the display of nutritional information on prepackaged food products. Under these norms, the inclusion of nutritional information is voluntary, except for the case when a nutritional mention is made regarding the food product.

In the spirit of the ethics of food safety, through (Conseil de l'Europe, 1990), at the request of the Codex Alimentarius Commission, the Council of the European Union recognized consumers' right to be informed of both the ingredients contained in the foods purchased and of their nutritional profile. Nutritional information concerns the energy value, the proteins, the carbohydrates, the lipids, the dietary fibers, the sodium, the vitamins and the mineral salts. Consumers also pay special attention to other elements, such as the nutrition facts label, which concerns the carbohydrates, the lipids etc. The Council of the EU accepts a number of templates of nutrition facts label that contain the amounts of nutrients found in the food at the time of purchase. For the products that will be subjected by the consumer to further processing stages, these amounts may also refer to the ready-to-eat product, on condition that enough information is provided on the method of preparation. Medical recommendations found on the label are particularly appealing to consumers, given their importance. Food recommendations that are allowed include those on reducing the risk for osteoporosis, high blood pressure, cancer and heart diseases.

There is an ongoing international concern regarding the modern labelling of food products in such a way that it may provide richer, more diverse information to the benefit of trade and consumers; at the heart of this information lies nutritional data, namely the nutrition facts label, seen as a management and marketing factor. Aside from the legal provisions of the international bodies (Codex Alimentarius Commission, WHO, EU), the nutrition facts label is acknowledged both as a social necessity and as a valuable marketing tool. It gives companies the opportunity to sell and, at the same time, to guarantee a fair food manufacturing behavior to consumers.

Pursuant to the regulations in force (European Parliament, 2011), the labels of prepackaged food products must contain:

- the name under which the product is sold;
- the name and address of the manufacturer, packager or distributor. For imported products, the label will show the name and address of the importer or of the distributor registered in Romania;
- the date of minimum durability or, in the case of foodstuffs which, from the microbiological point of view, are highly perishable, the "use by" date;
- storage conditions and/or conditions of use, when these require special directions;
- the country of origin or place of provenance, if its omission is likely to create confusion in the consumer's mind;
- alcoholic concentration for beverages, if such concentration is higher than 1.2%;
- the list of the ingredients used;
- the substances that can cause allergies or intolerance (groundnuts, milk, mustard, fish, cereals that contain gluten etc.);
- the amount of certain ingredients or categories of ingredients;
- the net quantity for prepackaged foods;
- instructions for use where it would be difficult to make appropriate use of the food in the absence of such instructions.

Labels must also inform on the allergens contained by foodstuffs that are not prepackaged, including in the case of restaurants and cafés. The new provisions also include the requirement to inform the persons who suffer from allergies, in order to ensure a better protection of their health, making it mandatory to indicate the substances that cause allergic reactions or intolerance both in prepackaged foodstuffs and in foodstuffs that are not prepackaged.

According to (Maryanski, 1997), the food products that can cause food allergies are: shellfish – shrimp, crab or lobster; nuts, almonds, peanuts (their presence in various cakes, ice creams or other foods is usually indicated on the label); certain fruit – especially strawberries, but people can also be allergic to watermelon, pineapple and tropical fruit; tomatoes; fish; wheat and other cereals that contain gluten; cow milk and other dairies; corn products. Other authors (Tofana, 2006) highlight the fact that, more and more frequently, allergies are reported to foodstuffs that contain food additives such as color additives, thickening agents and preservatives.

European states have implemented various labeling systems, seeking both to observe the EU regulations and to help their own citizens. Thus, the British (Food Standards Agency, UK, 2008) lay the most emphasis on the influence of the food product on health and use the colors of traffic lights (green, yellow and red) to encrypt their labels. A red label used by Britain's Food Standards Agency (FSA) warns the consumer that the food product is dangerous to health, while a green label indicate that the product is green and healthy. This traffic light labeling system was designed to fight obesity and seeks to indicate the amount of calories, fats, carbohydrates, sugar and salt contained by a product, which consumers should be aware of when making a buying decision.

In October 2016, France conducted a 10-week-long experiment on informing consumers using four types of tested nutrition facts labels: SENS, NutriScore, Nutri-Repère and Semafor (Bloomberg, 2016). The objective was to accurately determine which system was the most efficient from the point of view of the consumer buying behavior, based on a research protocol established by an independent scientific committee. The results of the study will determine the type of label that will be adopted by France in order to support the health of its population.

In Romania (Cam. Dep., 2016), there was a draft law regarding the tricolor labeling of processed food products, with a view to reducing the risk of cardiovascular diseases. This draft law was repealed in early 2017, on account of there already being enough regulations on informing consumers accurately at the European and national levels.

In the area of the European Union, the label for environmentally-friendly food products, bearing the logo "organic farming", was adopted in 1999, as a complement to the national labeling systems (Verain, Dagevos, & Antonides, 2015). This label is placed on the packaging in the language of the country where the foodstuff is sold.

III. RESEARCH METHODOLOGY

To conduct this study, we used:

- documentary research;
- questionnaire-based quantitative analysis;
- software prototyping.

The aim of the questionnaire is to determine the extent to which consumers are interested in the improvement of the way of using the information on the labels of food products by means of a smart mobile app. The detailed results are given in the section below.

Questionnaire:

1. When buying a food product, do you read the label?
   a. Yes
   b. No, because…

Table 1 – How many respondents read the label?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	82	82.0	82.0	82.0
	No	18	18.0	18.0	100.0
	Total	100	100.0	100.0	

2. If there were an app for the smart scanning of the label, using the mobile phone, that **would warn you** about ***a component of the food product that may worsen certain disorders***, how much would such an app matter to you? The app correlates the history of your disorders from your health insurance card to the components of the product. The data is only accessible to you.
   (rate your answer 1=very little; 5=very much)

....

Table 2 – How much does the warning app that correlates the components of the product to your disorders count?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very little	3	3.0	3.0	3.0
	Little	13	13.0	13.0	16.0
	Much	58	58.0	58.0	74.0
	Very much	26	26.0	26.0	100.0
	Total	100	100.0	100.0	

3. What would you like to know about the product? (Rate from 1 to 10)
   a. Recommended daily intake according to the activity performed
   b. Allergens
   c. Caloric intake per 100 grams
   d. Contents of sugar, saturated fats and salt
   e. How healthy the product is for the body

Table 3 – Hierarchy of the items on the label of the food product that are important to respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Recommended daily intake according to the activity performed	16	16.0	16.0	16.0
	Allergens	34	34.0	34.0	50.0
	Caloric intake per 100 grams	17	17.0	17.0	67.0
	Contents of sugar, saturated fats and salt	11	11.0	11.0	78.0
	How healthy the product is for the body	22	22.0	22.0	100.0
	Total	100	100.0	100.0	

4. To what extent do you agree to the following statement: "The detailed information about the product provided by the app give me confidence and the reassurance that I can make the best buying decision"? Totally disagree, Disagree, Neither agree, nor disagree, Agree, Totally agree

Table 4 – The feeling of confidence and reassurance in choosing the product adequately * Respondents' gender

			Respondents' gender		Total (%)
			female	male	
	The detailed information about the product provided by the app give me confidence and the reassurance that I can make the best buying decision.	Totally disagree	2	0	2
		Disagree	2	6	8
		Neither agree, nor disagree	13	7	20
		Agree	17	13	30
		Totally agree	25	15	40
Total			59	41	100

5. What is your gender?
   a. Male

b. Female

Table 5 – Correlation between: The extent to which respondents read the label and Respondents' gender

		Respondents' gender		Total
		female	male	
When do you buy a food product, do you read the label?	Yes	52	30	82
	No	7	11	18
Total		59	41	100

The questionnaire essentially reveals the following major points: 82% of interviewed consumers read the product label, 84% would be interested in using the information on the label more efficiently by means of a smart mobile app, 34% are interested in being warned about allergens and 70% think that a smart app would help them to make the best buying decision.

Software prototyping. Architecture and components

In view of the arguments presented above, we are going to propose an architectural model of application that enhances consumer access to the data on the label as far as its semantics is concerned. In fact, we are aiming at a smart integration of the data on the QR (Quick Response) label with the data that exists in the public health insurance card system. The architecture relies on the following main components:

- the QR label that is attached to the food product;
- web services for mobile data access;
- databases (given that our study is in the prototyping stage, we are choosing a relational model).

The QR (Quick Response) codes are a standard of storing information in the form of a square label. According to (Denso Wave Incorporated, 2017), the standardization specifications were included, in time, in multiple systems: AIM International (1997), Japanese Electronic Industry Development Association (1998), ISO International Standard (2000), Japanese Industrial Standards (2004), GS1 (2011). QR codes can contain data such as texts, images, telephone numbers or web addresses. They can be used in various fields such as secure mobile payments (Lu, et al., 2017), surgical navigation systems (Katanacho, De la Cadena, & Engel, 2016), modern education systems (de Azevedo, Koch Delgado, & Cortina Silva, 2017), turning local data in global data (Dospinescu & David, From Local Data to Global Information Using Zxing Library in Android, 2012) or the traceability of animals and food products (Hongwu, et al., 2017).

According to the afore-mentioned standards, QR codes can store up to 4,296 alphanumeric characters and 7,089 numeric characters. These codes can be of two types:

- Micro QR codes – are typically used to encrypt and store text-type data;
- Design QR codes – are used to encrypt and store mode complex data, such as images or logos.

The fact that the QR code technology allows the encryption and the storage of data in various formats enables us to propose a new labeling system that includes additional information and functionalities to the mandatory ones that the European law provides for. With regard to generating QR codes, there are currently several software tools that are able to perform that operation. The best known and most widely used include QR Stuff, Kaywa QR Code and qr-code-generator.com.

As far as reading QR codes is concerned, there are several free applications on the market, running on various operating systems: BeeTagg, ScanLite, QuickMark, Kaywa Reader, Nokia Barcode Reader.

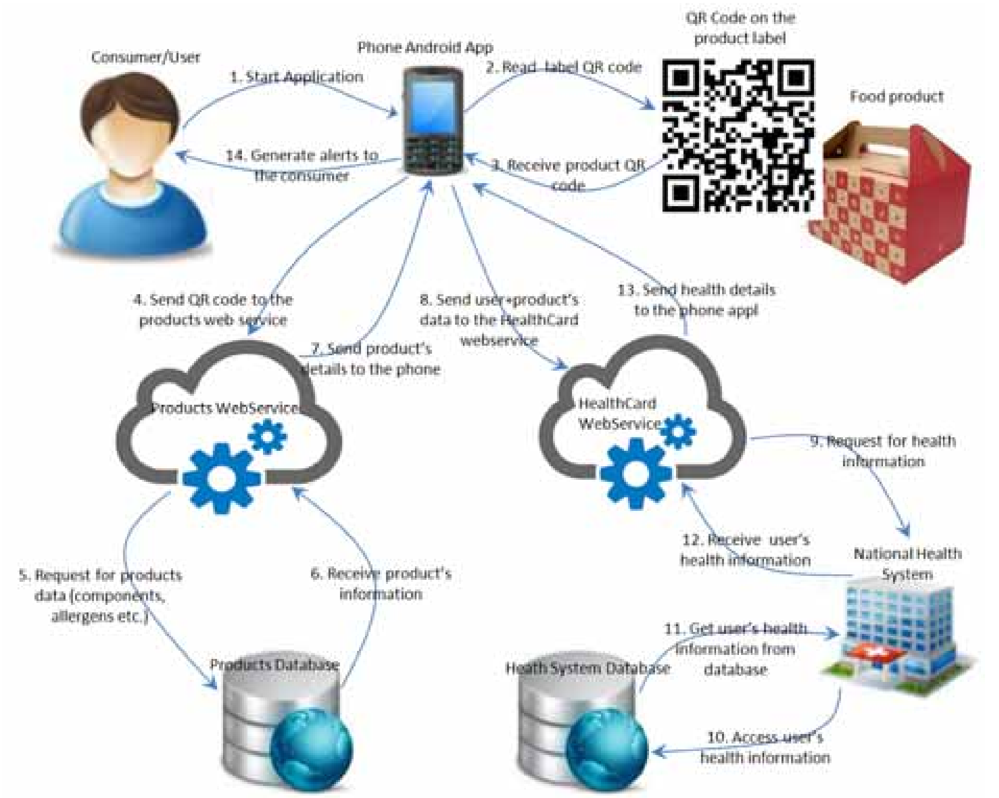

Figure 1 – Architecture of the information system prototype

The operating scenario for the prototype contains the following stages:

- stage 1: the consumer starts the application on the mobile phone;
- stage 2: the consumer uses the application on the mobile phone to read the QR code on the label that is attached to the food product;
- stage 3: the application receives the QR code of the food product that has been scanned;
- stage 4: the application connects to the web service that allows access to the analytical data of the product identified based on the QR code in stage 3;
- stage 5: the web service requests the analytical data of the product from the database (detailed components, quantities, allergens etc.);
- stage 6: the web service receives the analytical data of the product from the database;
- stage 7: the web service sends the details of the product to the application on the mobile phone;
- stage 8: the application connects to the web service that allows access to the consumer's data in the national health insurance card system;
- stage 9: the web service requests data about the consumer's health from the national health insurance card system (list of allergens, list of forbidden food components etc.);
- stage 10: the national health insurance card system queries the database to obtain the information about the consumer in question;
- stage 11: the national health insurance card system receives the information requested in stage 10 from the database;
- stage 12: the national health insurance card system sends the consumer's sensitive health details to the web service;
- stage 13: the web service sends the information obtained from the database of the national health insurance card system to the application;
- stage 14: the smart Android application generates specific alerts for the current user. These alerts are generated as a result of the local processing of the two sets of data obtained from the two different systems accessed during stages 4 and 8: the system for labeling food products with QR labels and the national health insurance card system.

The QR label in the architectural model shown in Picture no. 1 was generated using the QR Code Generator tool available at www.the-qrcode-generator.com and stores the address for the test product named "cheese", which corresponds to the webpage http://aplicatii-mobile.ro/cheese/. It is this page that the web service will actually access to get the data about the analytical contents of the product. When operating the application, the user does not need to access this address directly; it is the application that makes the automatic redirection and collects the analytical information via the web service.

Figure 2 – Reference model for the QR label

Web services are used in most mobile applications thanks to their flexibility. They have clearly-defined roles, from Internet of Things applications (Han & Crespi, 2017), (Wang, Hou, Gao, & Ji, 2017) to social services applications (Aguilera, Pena, Belmonte, & Lopez-de-Ipina, 2017), to speech processing applications (Kisler, Reichel, & Schiel, 2017). Web services can be developed on different platforms than the client application; in that case, they are accessed by using specific software libraries. In our case, in order to design the prototype, the implementation of the web services is carried out on the .NET Framework platform and they are accessed using the ksoap2 library.

The implementation of the request to the web service related to the food product that was scanned by means of the QR code is described below.

```
import org.ksoap2.SoapEnvelope;
import org.ksoap2.serialization.PropertyInfo;
import org.ksoap2.serialization.SoapObject;
import org.ksoap2.serialization.SoapSerializationEnvelope;
import org.ksoap2.transport.HttpTransportSE;
public class CallProductWebService
{
public final String SOAP_ACTION = "http://tempuri.org/Add";

public  final String OPERATION_NAME = "Read";

public  final String WSDL_TARGET_NAMESPACE = "http://tempuri.org/";

public  final String SOAP_ADDRESS = "http://aplicatii-mobile.ro/Product.asmx";
public CallProductWebService()
{
}
public String Call(int a,int b)
{
SoapObject productRequest = new SoapObject(WSDL_TARGET_NAMESPACE,OPERATION_NAME);
        PropertyInfo pi=new PropertyInfo();
        pi.setName(productQRcode);
        pi.setValue(pqr);
        pi.setType(Integer.class);
        productRequest.addProperty(pi);

SoapSerializationEnvelope envelope = new SoapSerializationEnvelope(
SoapEnvelope.VER11);
envelope.dotNet = true;

envelope.setOutputSoapObject(productRequest);

HttpTransportSE httpTransport = new HttpTransportSE(SOAP_ADDRESS);
Object response=null;
try
{
httpTransport.call(SOAP_ACTION, envelope);
response = envelope.getResponse();
}
catch (Exception exception)
{
response=exception.toString();
}
return response.toString();
}
}
```

Figure 3 – Implementation of the request to the web service related to the food product

The implementation of the requests to the web service that allows the application to access the data in the national health insurance card system is carried out in a similar way. It is worth mentioning that, in order for the application to function accurately, the government agencies that manage the national health insurance card system should provide users with an API-type software interface, so that data may be accessed by means of the parametrized methods of the web service.

The specialized literature currently documents several practical possibilities regarding the data persistence layer. Thus, according to (Strimbei & Fotache, 2011), we can choose between SQL databases and active, event-based structures. The database diagram that we propose in our architecture is based on an SQL (Structured Query

Language) model where the structure was designed in the third normal form (3NF). The tool we used was DbDesigner, accessed in July 2017 at www.dbdesigner.net.

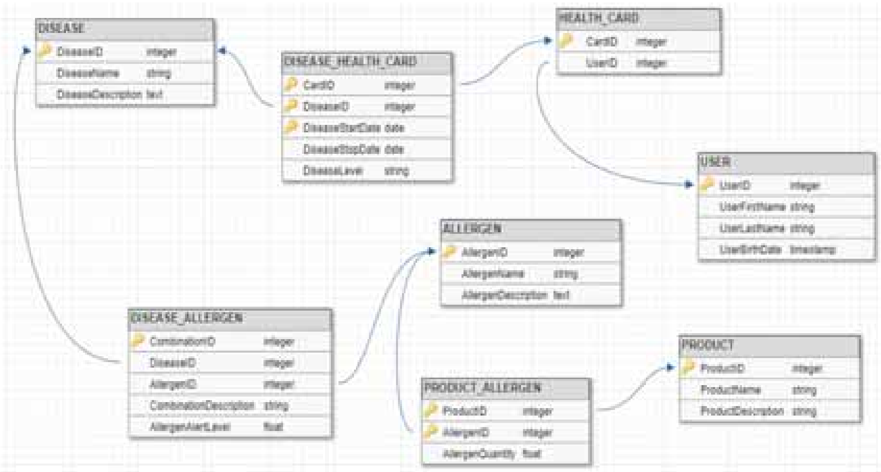

Figure 4 – Relational 3NF diagram of the database for the mobile application

The tables contain data that concerns the medical disorders, which are recorded via the national health insurance card system, combinations of allergens and alert levels (e.g. subacute, acute, chronic). At the same time, the system we propose in this article has access to the analytical list of allergens for each food product (the PRODUCT_ALLERGEN table). At the level of the persistence layer, using SQL queries, it is possible to make "mirrored" comparisons and analyses of the allergens to which the user is likely to react and the allergens contained in the food product.

As far as the process of reading and interpreting the QR label on the food product is concerned, we use the ZXing software library available for the Android system.

```
@Override
public void handleResult(Result labelResult) {
    AlertDialog.Builder builder = new AlertDialog.Builder(this);
    builder.setTitle("QR Scan Result");
    builder.setPositiveButton("OK", new DialogInterface.OnClickListener() {
        @Override
        public void onClick(DialogInterface dialog, int which) {
            myQrScanner.resumeCameraPreview(QrActivity.this);
        }
    });
    builder.setNeutralButton("GoTo", new DialogInterface.OnClickListener() {
       @Override
       public void onClick(DialogInterface dialog, int which) {
        Intent browserIntent = new Intent(Intent.ACTION_VIEW, Uri.parse(labelResult));
            startActivity(browserIntent);
        }
    });
    builder.setMessage(labelResult.getText());
    AlertDialog myAlert = builder.create();
    myAlert.show();
}
```

Figure 5 – The Android code sequence for reading a QR label using the ZXing library

IV. RESULTS AND DISCUSSIONS

The intended result is useful to the consumer from the point of view of food safety, because the application generates an instant alert regarding the components of the food product that may cause problems to the user. The picture below shows an alert model, based on the prototyped example described in the previous chapters.

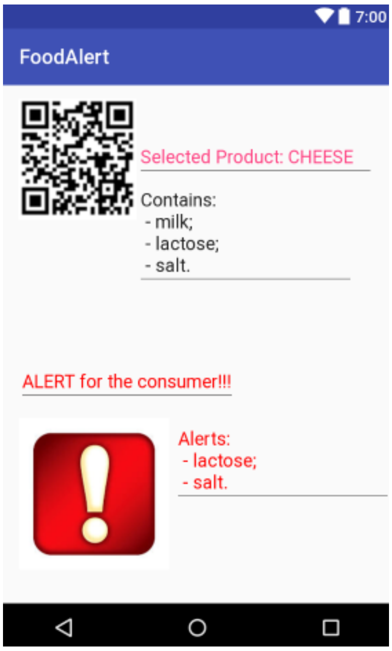

Figure 6 – Result of the testing of the FoodAlert application prototyped on Android

While the architecture proposed in this article has many benefits, it also comes with some issues, including the access of the application to personal data. The final users of the application, as well as all parties involved in data transfers, must be made aware of the need to observe the relevant legal requirements on transferring and using personal data.

The performance test results for the application were obtained after trying the application on two different versions of the Android operating system and on two different hardware devices: a Samsung Galaxy S5 terminal and a Huawei P10 terminal. Tests were performed on both 3G and 4G connections, by running 100 requests of the application. The test results are shown in the table below.

Table 6 – Performance test results of the FoodAlert application

Mobile device	Average running speed on 3G connection (milliseconds)	Success rate for running the application in 3G	Average running speed on 4G connection (milliseconds)	Success rate for running the application in 4G
Samsung Galaxy S5	528	93.00%	384	95.00%
Huawei P10	430	98.00%	211	99.00%

In this proposal, the application and its functionalities are presented as a prototype. In the event of its implementation in a real-life environment, one must consider the costs associated with: full development of the application, complete testing of the application, regular maintenance of the software architecture and the update of system data.

As they were presented above, the information exchanged managed within the software architecture rely almost entirely on access to an Internet connection (application, web services, data server, the national health insurance card system etc.). While it is true that Internet access incurs a certain cost, most mobile operators currently provide access to mobile data at reasonable prices throughout the European Union, pursuant to the community regulations (The European Parliament and the Council of the European Union, 2015).

The benefits of the application include accessibility, given the fact that the latest reports (Eurostat, 2016) estimate that the majority of the EU citizens already owns a mobile phone with a built-in camera. Therefore, the hardware equipment that is needed for the application to run is already widely available. Moreover, a feasible possibility is the integration with eye-tracking technologies (Dospinescu & Perca-Robu, The Analysis of E-Commerce Sites with Eye-Tracking Technologies, 2017), especially with those adapted to e-commerce websites.

V. CONCLUSIONS

For this article, we have successfully developed and tested the prototype of a mobile application that is able to enhance significant aspects in food safety. This way, a considerable improvement may be achieved in the ethics of food safety, by informing consumers more comprehensively. Our contribution refers to the information integration of data from different systems (the labeling system and the national health insurance card system), triggered by the reading of a QR label attached to the food product.

The architecture is a valid one, having proven its practical applicability in its prototyped form, with relatively low costs, thanks to the fact that it mostly relies on an existing hardware infrastructure. Among the future paths that arise from the study that we have presented in this article, we mention the following:

- integration of the application that we have proposed with shopping list-type applications. This way, information integration will reach a higher level, because the alert system will be able to anticipate certain problems of the user based on a simple list of intended purchases.
- making the application compatible with other mobile operating systems (iOS, Windows Phone). While, as we have shown in the article, devices based on the Android system are the most widespread in the current market, making the application available for other operating systems would significantly increase the number of potential beneficiaries.
- making a multilingual interface. Given that the European Union has 24 official languages (European Commission, 2017), adjusting the interface to support several languages would definitely be a benefit for the users.

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