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REALIZATION OF DISTRIBUTED MEDICAL DATA REPOSITORY IN AN ENVIRONMENT WITH HETEROGENOUS MIS

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Abstract. *The introduction of centralized registers of medical data after a long time from the implementation of medical information systems and their long-term daily operation is a very challenging and demanding process. In this paper, three ways for the realization of centralized repositories of medical data are considered, and on that occasion, the advantages and limitations of these solutions are emphasized. Due to the heterogeneity of medical information systems in terms of technologies used and implementation, the construction of a distributed centralized national register of medical data emerges as a good solution. A proposal of architecture for the realization of the distributed central republic register of medical data is given. As an example of the proposed solution, the realized collaboration of the central republic radiological information system and its implementation with the medical information system MEDIS.NET is presented.*

Key words: *Distributed medical data repository, radiology information system, medical information system, COVID-19, central radiological information systems*

1. INTRODUCTION

One of the most important areas of application of information systems (IS) is health care [1]. Today, there is almost no health institution (HI) that does not use computers in

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their daily work. The level of use varies depending on the institution. In some institutions it is at the elementary level, and in others medical information systems (MIS) [2] cover all segments of the work of HI, both medical and non-medical work. The fact is that a huge amount of heterogeneous data (text, numbers, images, audio, video) are collected on a daily basis. In order to fully use all the potential of the collected data, it is necessary to combine them from more HIs in a region or the whole country. Therefore, it is not uncommon for countries to decide to create central data repositories, such as central registers [3] of patients, physicians, medical images, blood donors, organ donors, etc. As an example of a central register [4], we will consider further in the paper the central register of radiological imaging and findings of radiologists, but the analogy is almost direct for the realization of any other central register with medical data. These medical repositories can be implemented so that they are independent of MIS of HIs and then all HIs can use a centralized registry (Fig. 1). The second way is to create central repositories based on the data from MIS of HIs by copying the data from MIS into the central register (Fig. 2). The third way is the realization of distributed central registers where all the data are in the MIS of HIs databases (Fig. 3). Each of these 3 ways of realization of the central medical register has its advantages and disadvantages, but it is largely conditioned by the existence of MIS and the time of their realization, which will be discussed later.

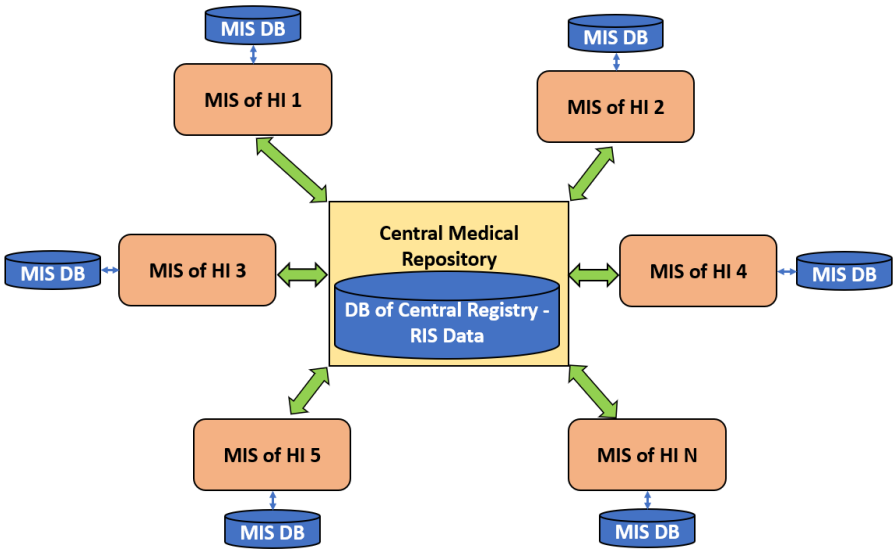


Fig. 1 Radiological Information System (RIS) data are located only in the central registry database

In this paper, the focus is on the problem of realization of distributed central registers in the field of medicine. As an example of a distributed central registry, we will consider the central registry of radiological images. We will consider the ways of collaboration of MIS of HIs with the central radiology registry, or more precisely the collaboration of MIS indirectly through the central registry. Two ways will be suggested to achieve communication, i.e., for the realization of the distributed central radiological register,

which are conditioned by: the place where the radiological imaging is performed, the way of invoicing the performed medical service, the hardware and software potentials of the health services, etc.

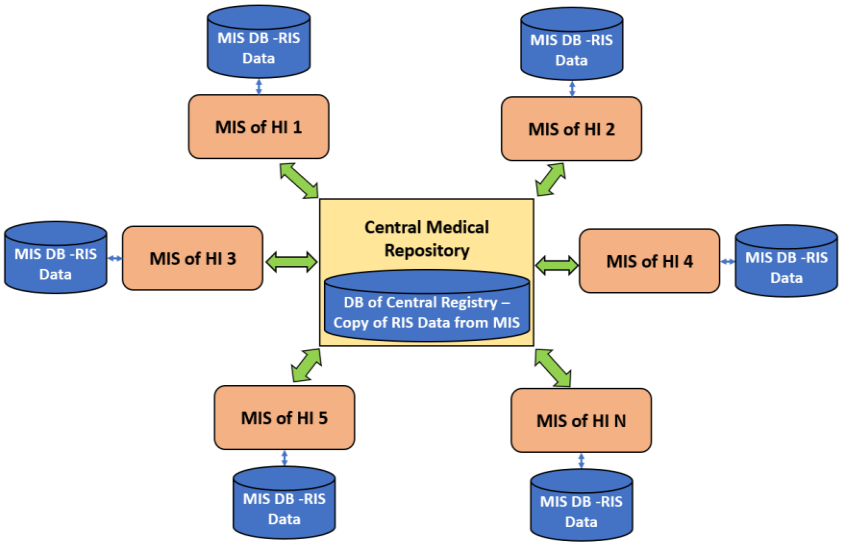


Fig. 2 RIS data are located in MIS databases and copies are in the central register database

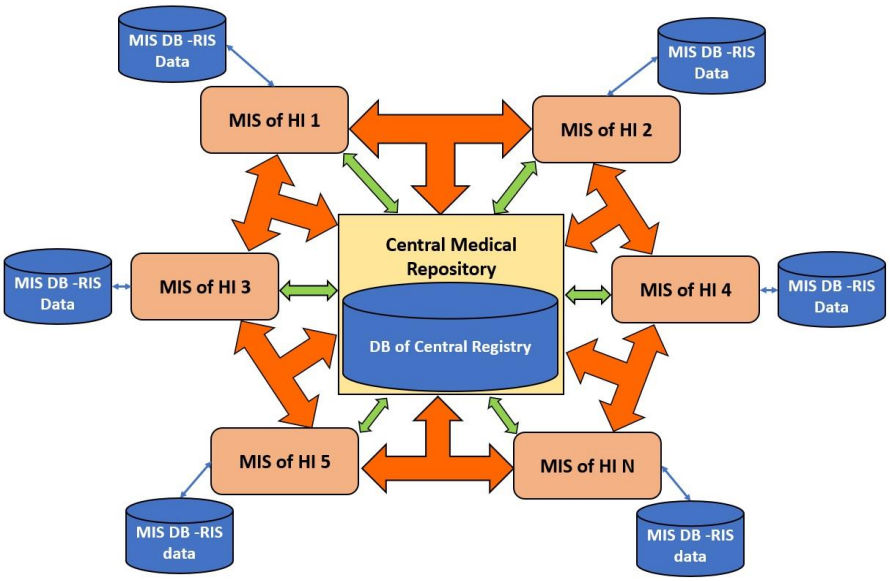


Fig. 3 RIS data are located only in MIS databases

2. RADIOLOGICAL INFORMATION SYSTEM

The RIS may be linked to a single HI when radiological imaging is performed in it and all the data stored relate to patients of that institution. However, the Central Republic RIS (CRRIS) is much more important. CRRIS at the level of one region or the entire country provides access to all radiological data of any patient generated at any radiology department of any HI in the country. This data can be accessed from any HI that communicates with CRRIS. CRRIS, in addition to the expanded possibility of communication between radiology and general departments of different HIs, represents a special potential for advanced data analysis. The centralization of RIS of one area creates a large repository of related patient data with the results of radiological analyzes.

The central RIS can be realized as one system if it is realized simultaneously with MISes of HIs and in that case all radiological data are stored only in central RIS (Fig. 1). If this is not the case, then a solution may be seen in the Distributed Central RIS (DCRIS), where in fact several independent RIS systems collaborate and form a part of the DCRIS with which the MISes of all HIs in the country collaborate. DCRIS itself can be implemented in several ways. One way is that DCRIS collects radiological data from local RIS and collaborates with MISes, and the other way is that all HIs use their own RIS systems for radiological services and to collaborate directly with DCRIS or more precisely that MISes communicate indirectly through DCRIS as it will be explained later. This is exactly the case in the Republic of Serbia (RS) because the idea for central RIS appeared ten years after the implementation of MISes (with RIS modules) in all health centers, where MIS is heterogeneous and implemented by several vendors. The paper will present the way in which CRRIS was implemented in RS, as well as the way in which the collaboration of our MIS MEDIS.NET with CRRIS was realized.

During the COVID-19 pandemic [5], a collaboration was established between MIS MEDIS.NET [6] and the CRRIS of RS, which began operations during the pandemic. The goal of such collaboration was to have all radiologically created referrals, reports of specialists (radiologists), as well as possibly preserved radiological imaging taken from diagnostic devices in one centralized place. Numerous analyses can be performed on such collected data, but also the application of artificial intelligence with different purposes and goals. One of the possible goals of data analysis may be to notice patterns in radiological images of patients suffering from the same disease. By using radiological images of the lungs of patients infected with the SARS-CoV-2 [7] virus, it is possible to create a model of artificial intelligence that would help identify patients who are at risk of more serious clinical complications [8]–[10]. The model created in this way additionally contributes to a better organization of resources in HIs, which is of special importance in the time of a pandemic. In addition to analyses aimed at identifying patients belonging to the risk group, the analysis of radiological data of the centralized repository can be directed at reducing the cost of radiological analyses, as well as reducing the number of radiological examinations. During certain radiological diagnostic procedures (e.g., X-ray, CT, Mammography, etc.), the patient is exposed to radiation that can be potentially harmful and poses a risk factor for certain serious diseases (e.g., breast cancer), so any reduction in the number of radiological diagnostic procedures that are not necessary is desirable. Reducing the number of unnecessary radiological diagnostic procedures leads to a reduction of unnecessary costs, but also to the reduction of the waiting period for the

scheduled radiological examination, because it is known that in the RS there are waiting lists for certain radiological diagnostic procedures [11].

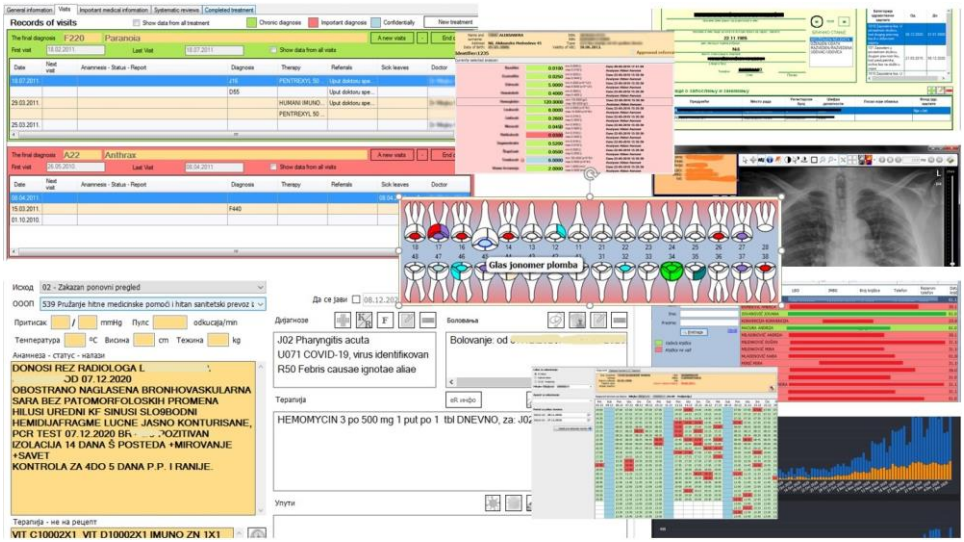


Fig. 4 Medical information system MEDIS.NET

2.1. Medical Information System MEDIS.NET

MEDIS.NET is a MIS developed at the Faculty of Electronic Engineering in Nis in the Laboratory for Medical Informatics [6]. MEDIS.NET (Fig. 4) is licensed by the RS Ministry of Health for the use in HIs of the primary health care level in the RS. It is currently used in 19 health centers and 6 other HIs. In the Health Center Nis (HCN), which is the largest health center in the RS in terms of the number of inhabitants that gravitate towards it (about 400 000), MEDIS.NET has been used intensively for more than 10 years.

MEDIS.NET is used to record the health services provided, starting with the admission of a patient, through the waiting room, visiting the physician, then prescribing and monitoring the application of therapy, creating referrals for specialist services, creating systematic examinations, for the treatment of patients with comorbidities, etc. The system is based on an electronic patient record (EPR) (Fig. 5), which tracks the history of all treatments of the patient from the birth to the death, together with the demographic data, whose history is also preserved in the database [12].

The EPR also contains data about all created referrals for radiological diagnostics, as well as the results of the performed ordered diagnostics with the opinion of the radiology specialist. It can be said that MEDIS.NET possesses the support for the work of the radiology service, i.e., the implemented RIS module which, due to the frequent treatment scenarios in which radiological diagnostics are required, contains a large amount of data. The data from the HCN will serve as an illustration of the number of created referrals.

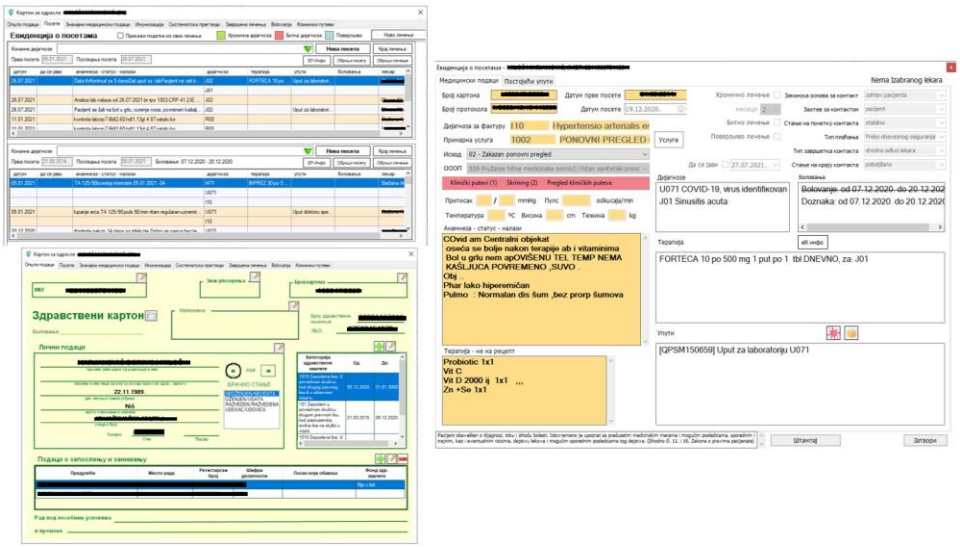
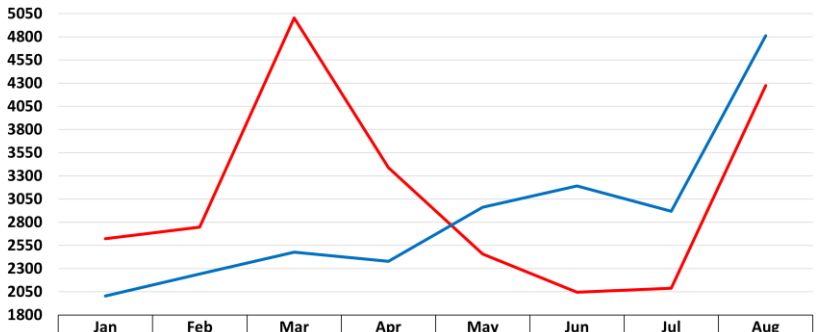


Fig. 5 EPR in the MIS MEDIS.NET

The total number of radiological referrals created in the HCN by using MIS MEDIS.NET for the period from January 1, 2021 to September 1, 2021 is shown in the Fig 6.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Radiology	2624	2749	5004	3389	2458	2046	2090	4275
Ultrasound diagnostics	2005	2242	2478	2380	2963	3191	2919	4811

Fig. 6 Referrals created into EPRs for radiology examinations (radiology and ultrasound diagnostics) from the period from the 1st of January 2021 to the 1st of September 2021 at HCN

The Table 1 shows created referrals in the HCN by using MEDIS.NET for different specializations for the period from 01.08.2020 to 01.09.2021. The total percentage of radiological referrals (radiology and ultrasound diagnostics referrals) out of all created referrals for that period is 7.892%.

Table 1 Percentage of referrals for the period of 1 year (from 1.08.2020 to 1.09.2021)

Specialization	Number of referrals	Percentage of total referrals [%]
Biochemical Laboratory	285148	32.50687
Internal Medicine	50885	5.80089
Radiology	36695	4.18323
Psychiatry	33614	3.83200
Ultrasound diagnostics	32533	3.70876
Cardiology	15698	1.78957
Mammography	127	0.01448

*All data are collected from HCN

3. The Exchange of Medical Data during the Collaboration of MIS MEDIS.NET and Central Republic RIS

As mentioned earlier, many treatments in the phase of diagnosing the disease use radiological procedures, i.e., the necessary radiological imaging is performed. Radiological imaging is just one of the activities in the process of diagnosing, monitoring and treating the disease. The process begins when general practitioners, using MIS, create a radiological referral for the corresponding radiological procedure in the corresponding institution/service in an available appointment, that suits the patient, through the central system for scheduling medical examinations. After creating the radiological referral and selecting the radiological procedure (Fig. 7), the radiological referral is sent to CRRIS via the available service and at the same time stored in the local MIS database, where the physician who created the referral works. When the patient comes to the department for radiological diagnostics, based on the data from the patient health card, the created radiological referrals can be accessed. After the application of the diagnostic radiological method, the radiology specialist creates a report (in response to the created referral). After the creation of radiological report, the referral is available in CRRIS. If necessary, the radiologist can revise the opinion based on the obtained findings, revise the recommended therapy and the established diagnoses. The possibility for more radiologists to express their opinion is also supported, because there are scenarios where the opinion of more radiologists is explicitly required. All these changes are kept and are available through CRRIS. When the patient returns, after the performed imaging, to the physician who created the referral, usually to receive the recommended therapy based on the opinion of the radiologist, open the sick leave, or get further referral (e.g., hospital treatment, further diagnosis, etc.), the physician gets from CRRIS the opinion of the radiologist based on the created referral, and in accordance with this opinion and the condition of the patient proceeds further. The layout of this process in MEDIS.NET is shown in Fig. 8.

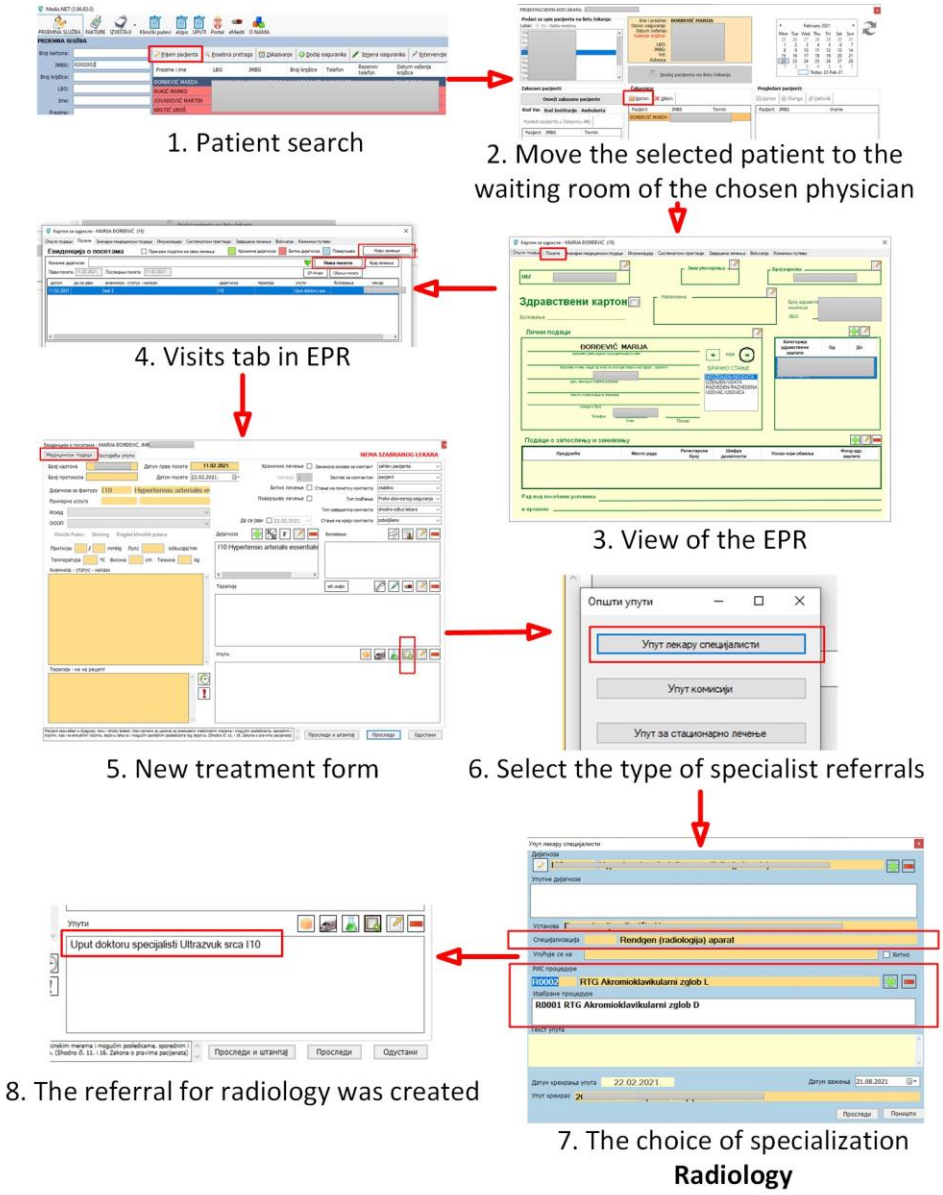


Fig. 7 The creation of radiological referrals from the EPR in MEDIS.NET

The report of radiologists is available in EPR. After obtaining the report, the physician receives information about the suggested therapy, as well as a web link through which the created radiological image made after the radiological diagnostic procedure can be reviewed (this is optional). Radiological devices on which radiological diagnostics are performed are connected with the available software at the Department of Radiology, which enables both archiving and availability of images to CRRIS. When obtaining the report, the

physician also receives the services provided at the radiological department of the health center, which are automatically invoiced to the patient, and later sent for payment to the Republic Fund Of Health Insurance (RFOHI) [13] via the consolidated monthly electronic invoice of the entire health center (Fig. 8).

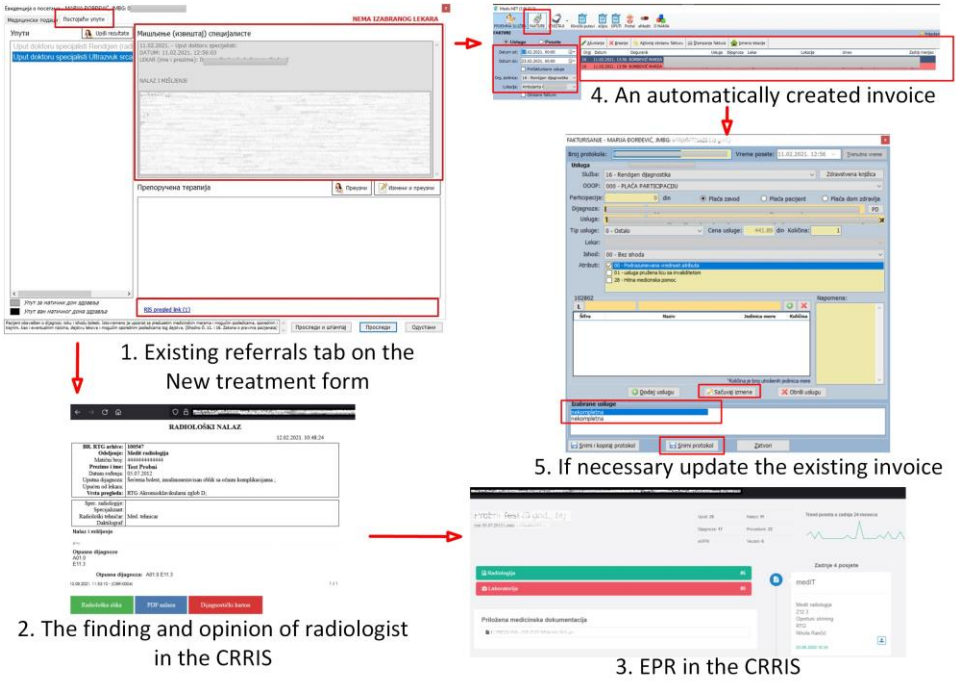


Fig. 8 Obtaining the radiological report

Within health centers in the RS, the radiology service is usually divided into:

- Radiology diagnostics (RFOHI service code: 1016);
- Ultrasound diagnostics (RFOHI service code: 1017);
- Radiology diagnostics of teeth (RFOHI service code: 1019).

Depending on the presumed disease of the patient, a referral is created for the corresponding department of the radiological service. It is precisely determined in which cases the referral is sent to which department. And by the rule, a set of diseases is associated with each department. The detection of patients infected with the SARS-CoV-2 virus during the COVID-19 pandemic is taken as an illustration.

Besides antigen [14] and PCR [15] tests for diagnosing the COVID-19 disease and in order to monitor the progressive advancement of the disease (usually bilateral pneumonia with vitreous body), radiological images of the chest (lungs) created by a corresponding radiological procedure on X-ray and CT are used. Those images will later be available in the entire EPR. The collaboration of MEDIS.NET and CRRIS enabled an easy flow of information made in the radiological service with other services of the health center, as well as the flow of information at the vertical level: primary - secondary, primary -

tertiary, primary - Ministry of Health of RS, which is aimed at providing and enabling the effective treatment to patients.

By the integration with CRRIS, radiological referrals can be sent within the same institution (within one health center, e.g., from the general service to the RO diagnostics service), in the institutions of secondary and tertiary level of health care. After creating the radiological report, it becomes available in the health center. This collaboration enabled both horizontal and vertical integration of HIs at different levels of the patient health care. Such collaboration can, among other things, provide record keeping of the entire radiological treatment of patient, during the exposure to various radiological procedures, which can cumulatively have negative consequences on the patient's health [16]. However, this option has not yet been implemented in CRRIS.

3.1. Possible Problems When Invoicing Radiological Services Provided After Performing Radiological Diagnostic Procedures

With the collaboration of CRRIS and MIS designed in this way, apart from the indisputable benefit, there are also certain problems caused by the fact that the radiological services in a health center actually communicate with the rest of MIS indirectly through CRRIS, which was not the case before the realization of CRRIS. The most significant problem relates to the automatic invoicing of medical services provided (payment for the "work" performed to RFOHI) at the radiology service in the health center. The automatic invoicing of health services provided is a functionality supported by MISes to save time to healthcare professionals, which they can further dedicate to patients. The usual scenario can be described in the following way: the patient comes for an examination to the chosen physician or a specialist who makes a referral for the patient for performing radiological imaging by using local MIS. This referral is sent to CRRIS. The patient goes to the radiology service where the radiological imaging is performed and the opinion of the radiologist is created. The data on the performed imaging and the opinion of the radiologist are entered in CRRIS. After that, the patient goes again to the physician who created the imaging referral for him/her and the physician analyzes the opinion of the radiologist (which was taken from CRRIS) and continues with the treatment of the patient (Fig. 7 and Fig. 8). On this occasion, the automatic invoicing of services provided by a general practitioner and a radiology specialist and support staff is performed. However, there is a scenario in which the patient does not come again to the general practitioner who created the referral for the necessary radiological imaging (the finding is negative, the patient abandoned further treatment with the general practitioner, the patient changed residence and HI where the treatment is performed, the patient died, etc.). In this scenario, the performed imaging service will not be invoiced and HI will not be able to charge RFOHI for the provided health service, performed radiological procedures. Therefore, it is necessary to ensure the invoicing of the performed imaging at the radiology service, regardless of the further sequence of events. This invoicing will be done automatically from MIS itself only if the data on the performed imaging are submitted to MIS.

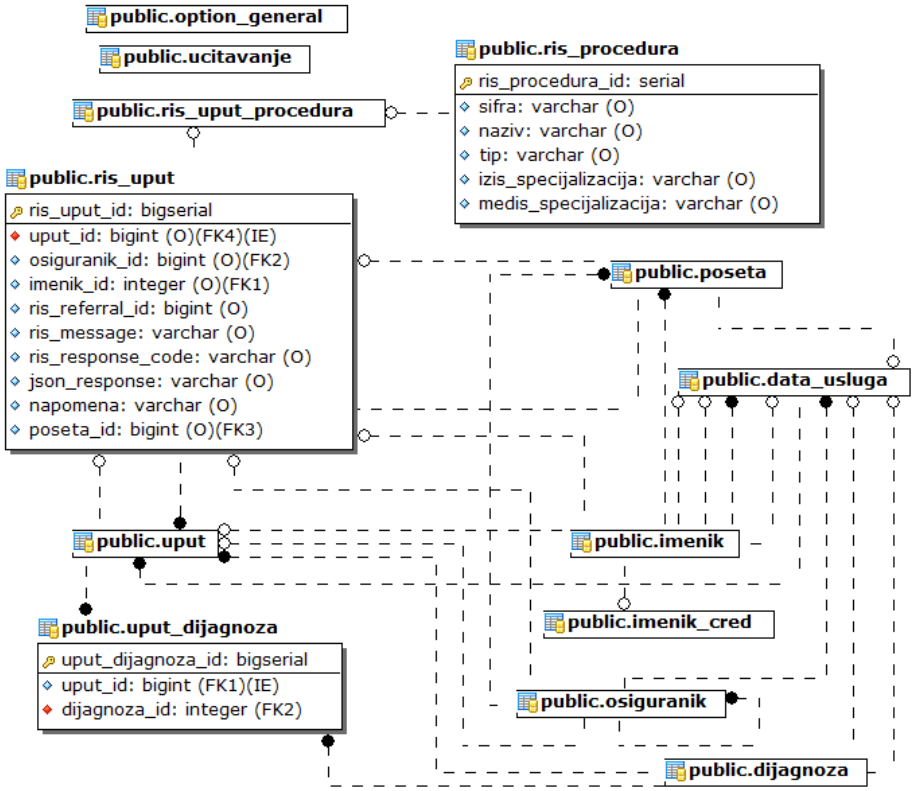


Fig. 9 The most important tables from the MIS MEDIS.NET database needed to achieve the collaboration of MEDIS.NET and CRRIS

4. Database Scheme

It is obvious that the previously described scenarios of patient treatment and communication between the local MIS and CRRIS entail the exchange of data stored in the databases of the local MIS and CRRIS. The figure (Fig. 9) shows the most important tables created for the needs of the collaboration of MIS MEDIS.NET and CRRIS. Patient data are stored in the *osiguranik* table. The *imenik* table contains data on all employees of one HI. The ICD-10 [17] diagnosis catalog is stored in the *dijagnoza* table. When a patient visits a physician, a new treatment is created in EPR and at least one visit in that treatment. Data on that visit are stored in the *poseta* table. During one visit, the physician provides the patient with a certain medical service, which is then invoiced and charged to RFOHI through a cumulative monthly invoice of the health center. Data related to the storing of the provided medical service can be found in the *data_usluga* table. During the visit, the physician can also create referrals (the referral to the specialist, referral for the inpatient treatment, referral to the commission, internal laboratory referral, general laboratory referral). Each referral is modeled by special tables for which the *uput* table is

the basic table (specialized referrals are modeled as extensions of the basic referral). One of the specialist examinations is a radiological examination, for which it is necessary to create a radiological referral by using referral to a specialist. Creating a radiological referral entails entering data in the *ris_uput* table, which is actually an extension of the *referral* table. The *ris_procedura* table provides catalog data for the selection of the radiological procedure on the form of referral during the creation of the referral. The data in that table are taken from CRRIS. One radiological referral can contain a number of required radiological procedures, so this is modeled using the *ris_uput_procedura* connection board. The *ris_message* field from the *ris_uput* table stores data in the *json* format. These data are sent to CRRIS after the creation of a radiological referral as part of a new visit on EPR. The *ris_referral_id* field from the *ris_uput* table contains a unique identifier obtained from CRRIS if the radiological referral was sent correctly. The data accepted from CRRIS represent the report of the radiologist or more of them. The report was formed in response to a previously sent radiological referral.

The *json_response* field from the *ris_uput* table actually contains the report of the specialist consultant after the examination of the patient and the performed radiological procedures. The field *napomena* in that same table stores additional information about the radiological instruction sent. The *ris_response_code* field contains the status value of the referrals and the value is obtained when receiving the radiological report (after entering the value in the *json_response* field). After accepting the report of the radiology specialist based on the received data (the data stored in the *json_response* field of the *ris_uput* table), an invoice with the provided medical services is created (the data are entered in the *data_service* table), only if the radiological service is provided to the patient in the same HI in which the initial radiological referral was created. The *imenik_cred* table saves the credentials (username, password, external system name, token value, token acquisition date, token validity time, etc.) for each employee from the directory table, which are used to access one of the available external services in this case also during the access to the public service of the CRRIS. The *option_general* and *ucitavanje* tables enable the loading of the necessary modules of the MIS when starting the electronic health record application (*Medis.Prijemna.exe*) from MEDIS.NET. In addition, the table *option_general* stores all settings related to the external CRRIS service (in this case, the external endpoints are stored which are required for *CRUD* (*Create*, *Read*, *Update* and *Delete*) operations on the service as well as the vendor credentials).

5. COMMUNICATION BETWEEN MIS MEDIS.NET AND CRRIS

After the centralization of RIS, it is necessary to enable collaboration with heterogeneous MISes. The MISes of different HIs in RS belong to different vendors (MEDIS.NET, Heliant, ZIPSoft, ComTrade, etc.). The essence of all these MISes is the same, but the database schemes differ as well as the way in which the MISes are programmatically designed and implemented. In order to enable MIS of different vendors to communicate with CRRIS in the same way, a special set of web services was created. The communication between MIS MEDIS.NET and CRRIS was achieved through developed web services. CRRIS provides the public service necessary to exchange data with other external systems. The supported web service methods include methods for sending the newly created radiological referral *(POST)*, for updating the sent radiological

referral *(UPDATE)*, for deleting the sent radiological referral *(DELETE)*, for getting the radiologist report *(GET)*, for checking the validity of the token *(GET)*, which is sent every time you call each of the available web service methods. The *Bearer Token* is used for the authorization, which is obtained by initially sending a *POST* request containing the credentials (username and password) of the registered user in the MIS. The data exchange is performed by using *json* messages that are formed by using given *json* schemes. The class diagram created on the basis of the *json* request scheme (*json request*) for creating a radiological referral is shown in the figure (Fig. 10). The created *json* object based on the scheme is sent from MEDIS.NET to the web service of the CRRIS. Fig. 7 shows the procedure of sending radiological referrals from MIS MEDIS.NET.

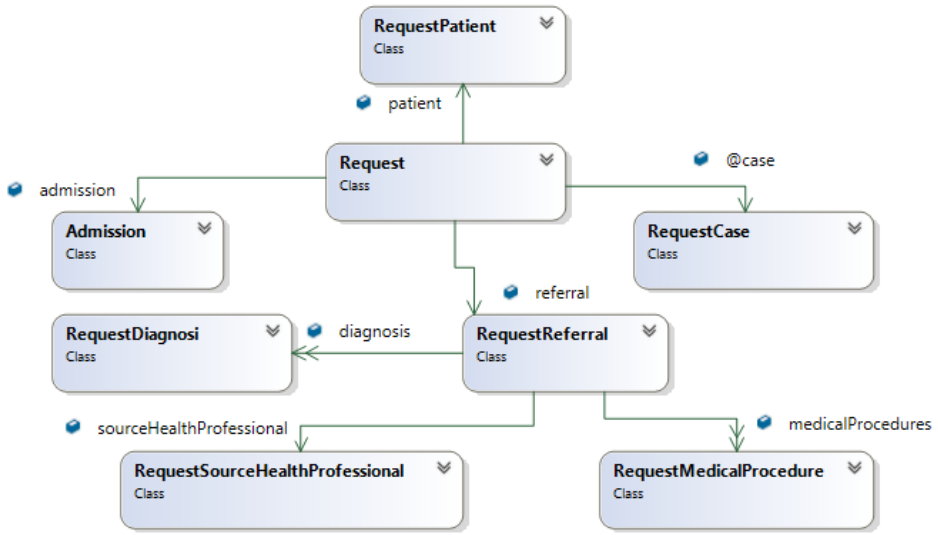


Fig. 10 Class diagram created based on *json* request to create a radiological referral

The report of the radiologist from CRRIS is received in the form of a *json* message containing the following units:

- patient data (*patient*),
- the unique identifier of the initially created referral (*case*),
- data on radiological referral (*referral*),
- data on the organizational unit and staff from that organizational unit that performed the diagnostic radiological procedure (*admission*),
- established diagnoses (*diagnosis*),
- the report of radiologists (*medicalReports*),
- links to obtain the created radiological images after the radiological diagnostic procedure (*medicalImages*) and
- a financial part with a detailed description of the provided medical radiological services to the referred patient (*finance*).

The class diagram created on the basis of the *json* response scheme (*json response*) for describing the radiological report from CRRIS is shown in the figure (Fig. 11). The

diagram shows only the most important classes from the class hierarchy. Obtaining the report of the radiologist from CRRIS was realized in two ways:

- obtaining the report on demand of the physician - *on demand implementation*,
- obtaining the report via the local web service - *web hook implementation*.

Both solutions have their advantages and disadvantages. Depending on which advantages are more suitable or which disadvantages are more disturbing, HIs choose one of the two offered modules.

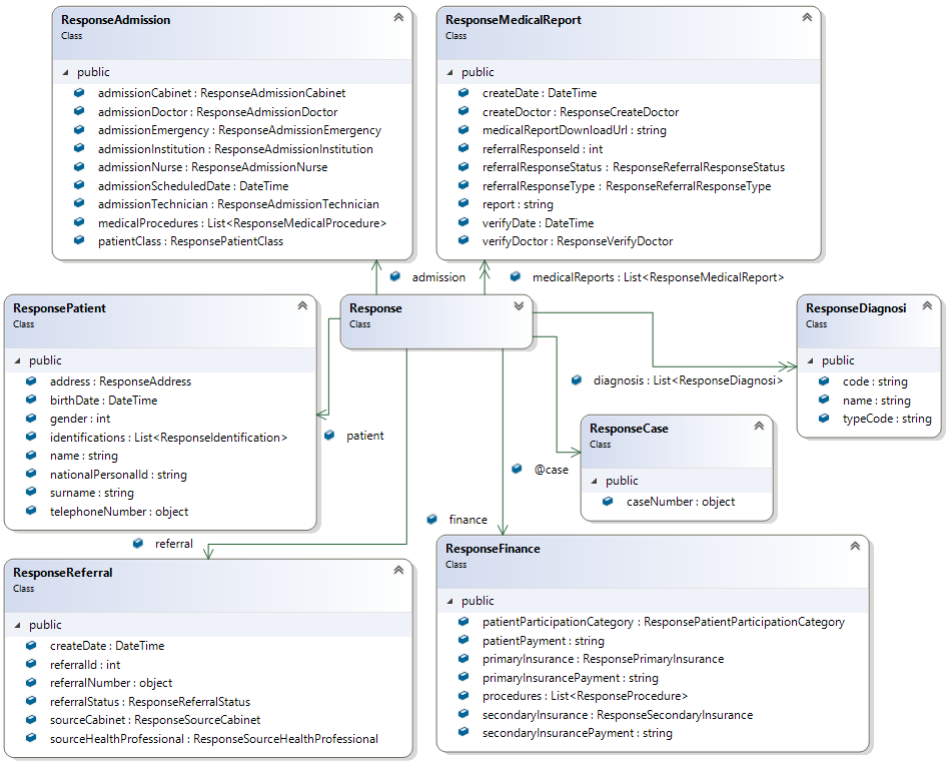


Fig. 11 Class diagram created based on the *json* response for obtaining the radiological referral from CRRIS

5.1. Obtaining the Report on Demand of the Physician (*On Demand*)

The sequential diagram of the creation of the radiological referral is shown in Fig. 12. When the patient (after the radiological examination) comes for a re-examination, the physician who referred him/her for a radiological examination can consult the reports of specialists (Fig. 13) in the EPR. At the time of opening the radiological report, if there is no report stored in the internal database, the report can be obtained from CRRIS.

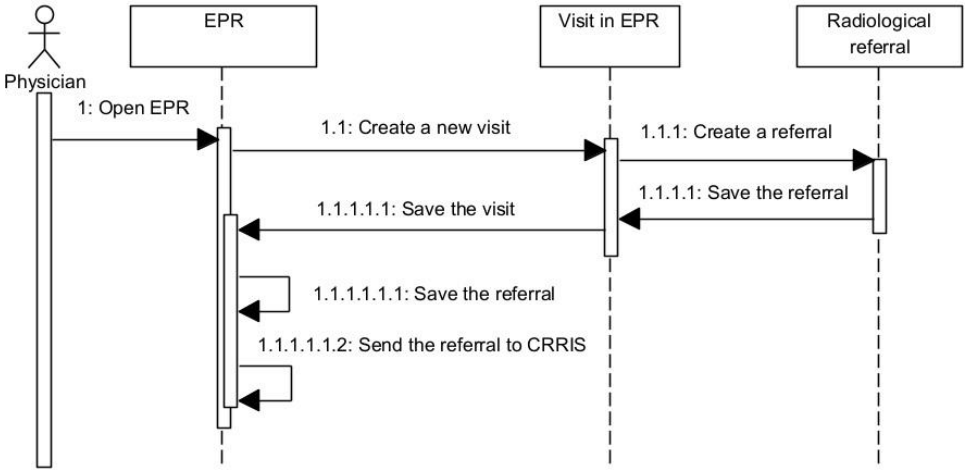


Fig. 12 The sequential diagram – the creation of radiology referral

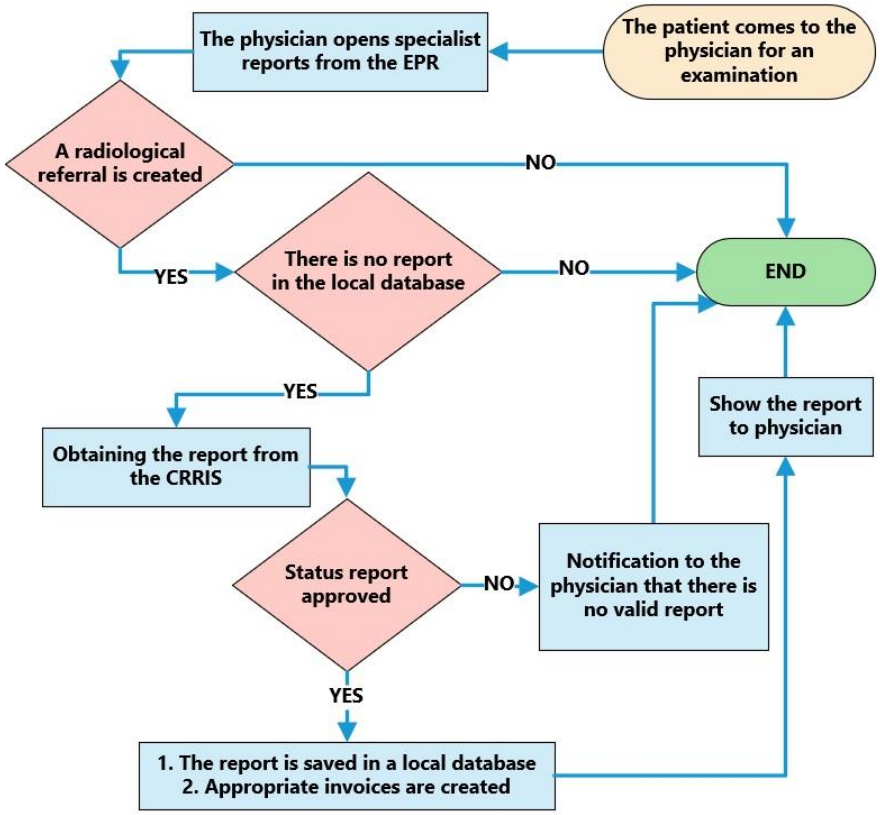


Fig. 13 Obtaining the report on demand of the physician

If there is an approved report in CRRIS, it is firstly entered into the MIS database, and then the physician is shown the text of the report, as well as the websites through which the physician can open radiological images. When entering the report in the database, the obtained financial part of the report is also stored as a new one or more invoices (this is valid only if the radiological report was created in the same HI in which the radiological referral was created, i.e., the imaging was performed in the same HI in which the physician who referred the patient for imaging works). If the imaging was done in another HI, then the financial part of the report is not of interest, because the service is invoiced by the institution where the radiological imaging was done.

5.2. Obtaining the Radiological Reports via the Web Service (*Web Hook*)

Another way to obtain radiological reports is realized by using the web service (Fig. 14) and implementing the web hook handler *eMeditWebHookHandler* from the *eMedit.Webhooks.Receiver.dll* library [18] of the vendor *EMedit* developed by CRRIS. The library is available through the *NuGet* package from the Microsoft Visual Studio development environment. Implemented events from the handler are executed under different circumstances. The most important event *OnRspVer* is triggered when a notification is pushed from the service of the CRRIS to which the realized local web service MEDIS.NET is subscribed. If there is a change with the created radiological report on the part of CRRIS, the notification is pushed and the *OnRspVer* event is immediately triggered on the local web service, that processes the new version of the pushed radiological report. This external service subscription mechanism makes the radiological report available in MIS at the time the radiological report occurs or undergoes a change in the external system (CRRIS) and is approved for further distribution. This solution with push notifications is good, because it is not necessary to periodically check whether there is a created specialist report of a radiologist for a specific created and sent radiological referral. The disadvantage is that it is necessary to provide a public *IP* address and hosting a local web service.

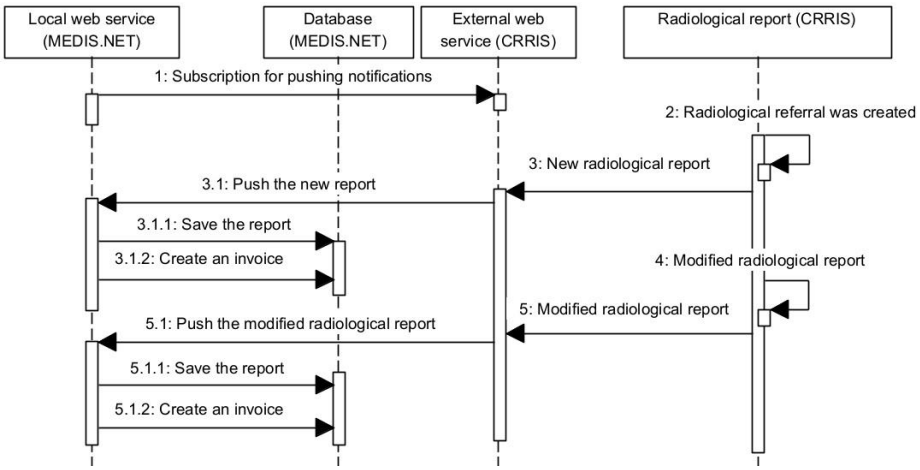


Fig. 14 The sequential diagram for obtaining radiological referrals by using the web service - *web hook implementation*

6. DISCUSSION

Both the *on demand* and web *hook* modules have various advantages and disadvantages. HIs choose one of the two offered modules, taking into consideration which advantages are more appropriate for their work and which disadvantages are more disturbing.

For the first module, *on demand module*, any additional financial support by HI for the realization (hardware and software) is not needed. This module was created within the implemented MEDIS.NET and is called when the patient visits the physician after the performed radiological examination. However, it can also happen that the patient after the radiological examination doesn't visit the physician. In this case, the corresponding services provided in HI cannot be invoiced, i.e., they will not be charged to RFOHI through the consolidated electronic monthly invoice of the entire HI.

The second module, *web hook module*, does not have issues with invoicing as the first module. Irrespective of the fact if the patient visited the physician after the radiological examination or not, MEDIS.NET will be notified after the completion of the radiological imaging and the opinion of the radiologist. The service is automatically invoiced, as soon as MEDIS.NET receives information about the performed examination. However, a special server for the implementation of this module is needed, which should be provided by HI, as well as a static *IP* address and a potential financial support.

It is also possible to realize the collaboration by periodically calling the *on demand module* (e.g., several minutes) for the referrals which are created and unfinished. However, this option would negatively affect the pace of the server using MEDIS.NET, so for practical purposes it can be accepted only for health centers of the smaller scope, whose MEDIS.NET server cannot be heavily loaded.

It is important to stress that having two solutions is plausible only in HIs that include a radiology service in their structure, and if physicians create referrals for the imaging performed in that specific radiology service. However, if the HI does not possess its own radiology service or has a radiology service that is not equipped for the required imaging (the imaging required is performed in some other HI), or the physician creates a referral for imaging in the radiological service placed in some other HI, the invoicing issue does not exist and either of the two collaboration methods realized can be applied.

If the radiology service of the HI performs the imaging according to the referral created in some other HI, the invoicing of performed radiological imaging service must be processed by the institution where the imaging was done.

The best way to implement the central repositories of medical data/registers at the level of one state, in a situation when HIs already use some MIS (institutions use different MIS), is to create a distributed state central repository.

The advantages of this solution are:

- Contains all registers in one centralized location;
- Data are found in both local health center registries and centralized state registries, which significantly affects data security;
- Data from all registers (local and central) are available to all MISes of health centers;
- Valid and up-to-date data available at all times.

On the other hand, there are some limitations that are reflected in:

- A constant and quality Internet connection is needed in every health center, especially if it is necessary to download digital content such as high-resolution images or videos from the state central registers;
- Hardware and software constraints in health centers that exist due to limited funding of these institutions;
- High-performance hardware and software to secure state central registries.

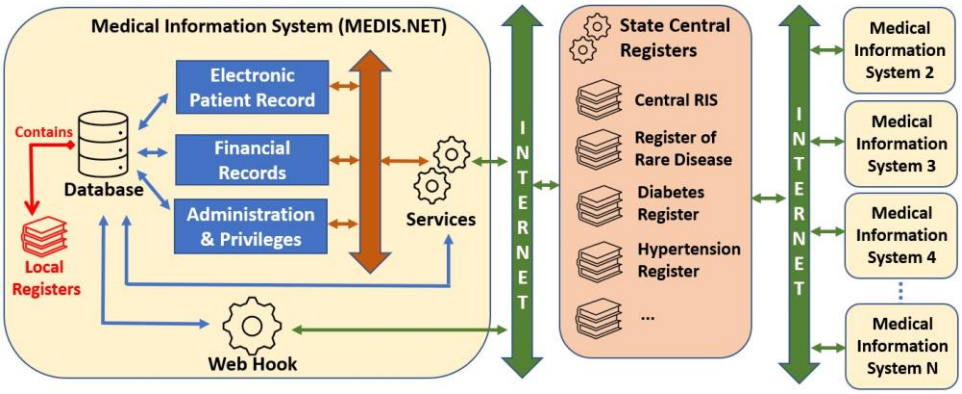


Fig. 15 The proposal of architecture of distributed state central registers

Based on all the information mentioned above, the general architecture for the realization of the distributed state central register can be proposed (Fig. 15). A distributed state central registry would consist of local registries guided by using heterogeneous MISes in HIs and state central registries. State centralized registers would include a larger number of centralized registers (e.g., RIS register, Register of rare diseases, Register of diabetics, Register of patients with high blood pressure, etc.). The state central registers are connected to the local registers in HIs, which are guided by the MIS in use, via available web services. The Fig. 15 shows the proposed collaboration between local HI registries with state central registries by using MISes. Local registers are stored in the MIS database and synchronized with the state central registers in two ways already described: *on demand* and *web hook implementation.*

7. CONCLUSION

The use of IS in the daily work of HIs emerges as an imperative of successful work. The process of introducing IS in all HIs of a country is a long and challenging process with many positive consequences. In this process, the realization of central repositories for different types of medical data stands out, both by type and importance. In RS, the process of introducing IS in HIs takes more than 15 years. The situation is similar with the implementation of central medical data repositories. Out of the 3 ways of realization of central repositories, the most challenging is the one that is performed with the existence of implemented MIS in HIs by different vendors. The situation is further complicated if, in addition to the usual functionalities of central repositories, there are additional requirements,

such as the provision of automatic invoicing of provided health services by sending an electronic invoice to RFOHI. This scenario exists in the implementation of CRRIS in RS, which in addition to providing storage of data about all the radiological imaging done followed by radiologists' opinions should enable the collaboration with MIS of HIs, but also the indirect communication between MIS in all HIs in the country regarding the radiological data exchange.

In this paper the problem of realization of collaboration between MIS of HI and the central republic repository, which was realized as a distributed system, is considered. The two realized ways of communication between MIS MEDIS.NET and CRRIS are described. The advantages and disadvantages of both realized ways are discussed, as well as the conditions under which it can be justified to apply them. A proposal for the architecture of the distributed state central register is also given.

The proposed methods of collaboration can be used in the implementation of any distributed central data registry that has similar requirements and characteristics as CRRIS and that has been developed in similar circumstances as CRRIS in RS.

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