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## THE SYNCHRONIZATION OF MEDICAL SYSTEMS DATABASES: MODELS AND METHODS

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**Summary.** *In order to build a system of medical information exchange, it is necessary that different medical systems are compatible with each other. If the systems are incompatible, compatibility must be achieved by achieving semantic and syntactic compatibility of systems. If compatibility is achieved, databases of different systems must be synchronized. To achieve this goal, a study was conducted to examine the most popular models and methods of synchronization of medical data. Thus, there are several different ways to synchronize medical information between two systems. The most common are replication, ETL, and two-way synchronization.*

**Key words:** *EHR, medical information system, data exchange, database*

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**Statement of the problem.** The medical systems databases are the integrated databases which are used to store the medical data of the patients. The data stored in these databases can be used for the purpose of diagnosis, treatment and research. The medical systems databases are designed in such a way that they can be accessed by the medical professionals from any location. The medical systems databases can be used to store the data of the patients who are suffering from the same disease. This will help the doctors to compare the data of the patients and to find out the best treatment for the patients. The medical systems databases can be used to store the data of the patients who are from different geographical locations. This will help the doctors to find out the trends of the diseases in different geographical locations. The medical systems databases can be used to store the data of the patients who are from different age groups. This will help the doctors to find out the trends of the diseases in different age groups. The medical systems databases can be used to store the data of the patients who are from different social groups. This will help the doctors to find out the trends of the diseases in different social groups.

**Analysis of the available investigations.** The databases of medical systems are constantly expanding and evolving. The data they contain are becoming increasingly complex and diverse. This makes it difficult to keep them synchronized. There are many different approaches to synchronization of medical databases according to the paper [1]. The most common are:

1. One-way synchronization: In this approach, only one database is synchronized with the other. This is typically done by copying the data from the source database to the target database according to the paper [2].

2. Two-way synchronization: In this approach, both databases are synchronized with each other. This is typically done by copying the data from both databases to a third database, which acts as the master database according to the paper [3].

3. N-way synchronization: In this approach, N databases are synchronized with each other. This is typically done by copying the data from all databases to a central database, which acts as the master database according to the paper [4].

The most common method for synchronization of medical databases is two-way synchronization according to the paper [5]. This is because it allows for the data in both databases to be updated simultaneously. It also allows for the data to be kept consistent across all databases.

The biggest challenge in synchronization of medical databases is dealing with the different formats of the data according to the paper [6]. The data in each database is typically stored in a different format. This makes it difficult to convert the data from one format to another. Another challenge is dealing with the different schemas of the databases. The schema is the structure of the data in the database. Each database has its own schema. This can make it difficult to query the data in one database and use it in another database.

The biggest benefit of synchronization of medical databases is that it allows for the data to be shared between different systems. This can be very beneficial for medical research. It can also be beneficial for patient care.

**The Objective of the work** is to develop models and methods for synchronizing databases of different medical information systems in order to create a system for exchanging medical information. The goal is to design a system that can take data from multiple medical databases and merge them into a single database. This will allow for information to be exchanged between different medical systems, and make it easier for researchers to access data from multiple sources.

**The statement of the task** is to develop a model for the synchronization of medical systems databases. The model should be able to handle different types of data and be scalable. The model should also be able to handle different types of queries.

**A comparative study of synchronization models and methods.** The synchronization of medical databases is a process of comparing and exchanging data between two or more databases. The purpose of this process is to ensure that the data in each database is accurate and up-to-date. There are many different models and methods for synchronization, and the choice of which to use depends on the specific needs of the organization.

One common model for synchronization is the snapshot model, in which all of the data in one database is copied to the other database at a specific point in time. This can be done manually, or it can be automated using a tool such as a database management system. Another common model is the incremental model, in which only the data that has changed since the last synchronization is exchanged. This is more efficient than the snapshot model, but it can be more difficult to implement.

There are several methods for synchronizing data, including replication, ETL, and synchronization software. Replication is the process of copying data from one database to another. ETL (extract, transform, load) is a process in which data is extracted from one database, transformed into a format that can be loaded into another database, and then loaded into the second database. Synchronization software is a tool that helps to automate the process of synchronization.

Replication synchronization is a process of copying data from a source database to a destination database. This process is typically used to keep two or more databases in sync with each other. There are two main types of replication synchronization: full replication and incremental replication. Full replication copies all data from the source database to the destination database. Incremental replication only copies data that has been added or changed since the last replication. The process of replication synchronization can be represented by the following equation:

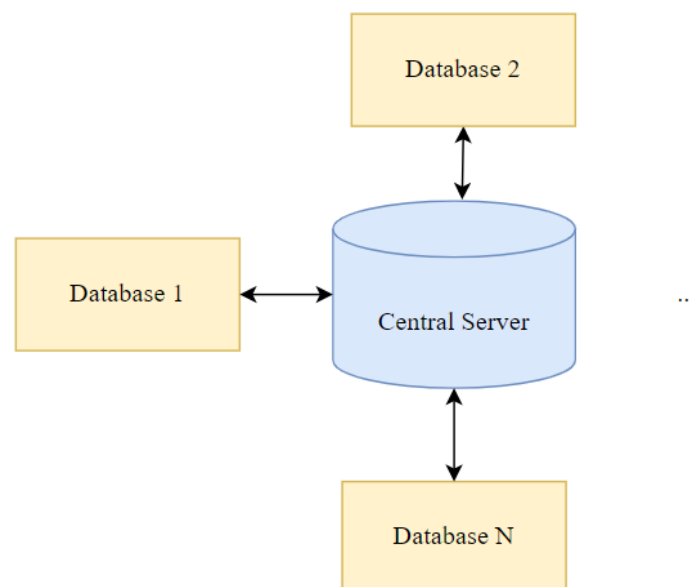
$$\textit{Destination DB} = \textit{Source DB} + \textit{ChangeLog},$$

where the Change Log is a record of all the changes that have been made to the source database since the last replication. Replication synchronisation medical databases model is a

mathematical model used to keep track of changes made to a database. It is used to track changes made to a database so that they can be applied to other databases in a consistent manner. This model has a number of advantages, including the ability to track changes made to a database over time, the ability to apply changes to other databases in a consistent manner, and the ability to track changes made to a database by multiple users. However, this model also has a number of disadvantages, including the need for a centralised database, the need for a separate database for each user, and the need for a number of additional tables to be created in order to track the changes made to a database.

The ETL process extracts data from the source database, transforms the data, and then loads the data into the target database. The data in the target database is then synchronized with the data in the source database. The ETL process can be used to synchronize databases that are on different servers or on different platforms. The ETL process can be used to synchronize databases that are on different versions of the same platform.

Synchronization software for medical databases typically uses synchronization algorithms to keep data consistent across multiple devices. The most common type of synchronization algorithm is the two-way synchronization algorithm, which is designed to keep data consistent between two devices. A two-way synchronization algorithm medical databases model would be one in which data is updated in both directions, from the source database to the target database, and from the target database back to the source database. This would allow for data to be updated in real-time, and would be especially useful for medical databases which need to be kept up-to-date in order to provide accurate information to doctors and other medical professionals. There are two main ways that two-way synchronization EHR systems databases to create medical data exchange system works. The first way is by using a central server that stores all of the data from the various EHR systems (Figure 1). This central server can then be used to query the data and generate reports.



**Figure 1.** Central server software synchronization

The second way is by using a peer-to-peer network where each EHR system synchronizes its data with the other EHR systems on the network. This allows for real-time data exchange and eliminates the need for a central server (Figure 2).

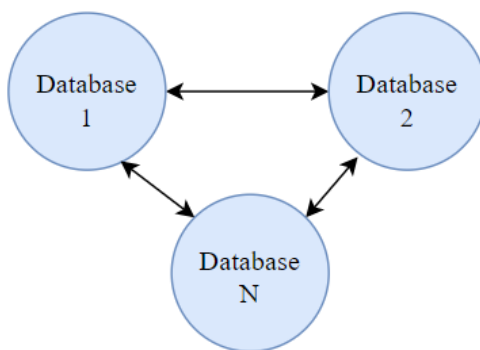


Figure 2. Peer-to-peer synchronization

Table 1

A comparison of basic models and methods for medical data synchronization

Synchronization method	Advantages	Disadvantages	Where to use it
Replication	<ol style="list-style-type: none"> <li>1. Real-time updates: When data is updated on one server, it is immediately replicated to the other server, ensuring that both servers always have the same, up-to-date data.</li> <li>2. Availability: If one server goes down, the other server can continue to provide access to the data.</li> <li>3. Reduced downtime: When one server is down for maintenance, the other server can continue to provide access to the data.</li> <li>4. Reduced costs: By using two servers, you can reduce the amount of hardware and software you need to purchase and maintain.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replication can be complex to set up and maintain.</li> <li>2. Using two servers can increase the cost of hardware, software, and maintenance.</li> <li>3. Replication can impact the performance of your system, as data must be copied from one server to the other.</li> <li>4. Risk of data loss: If the servers are not properly configured, data can be lost if one server fails.</li> </ol>	<p>Replication can be used in any situation where you need to ensure that data is always available and up-to-date. This is especially important in medical applications, where data loss could have serious consequences.</p>
ETL	<ol style="list-style-type: none"> <li>1. Efficiently manage large data sets.</li> <li>2. Ensure data accuracy and completeness.</li> <li>3. Reduce processing time.</li> </ol>	<ol style="list-style-type: none"> <li>1. Requires significant investment in time and resources.</li> <li>2. Can be complex to set up and maintain.</li> </ol>	<ol style="list-style-type: none"> <li>1. When data sets are large and complex.</li> <li>2. When data accuracy and completeness are critical.</li> <li>3. When processing time needs to be reduced.</li> </ol>
Two-way algorithm	<ol style="list-style-type: none"> <li>1. Two-way sync algorithms can help to ensure that data is more accurate by synchronizing data between two different systems. This can help to avoid errors that can occur when data is manually entered into a system.</li> <li>2. Two-way sync algorithms can help to make data entry and retrieval more efficient. This can save time and money for healthcare organizations.</li> <li>3. Two-way sync algorithms can provide healthcare organizations with more flexibility when it comes to data entry and retrieval. This can be beneficial for organizations that need to change their data entry processes frequently.</li> </ol>	<ol style="list-style-type: none"> <li>1. A two-way sync algorithm can add complexity to your EHR system. This complexity can make it more difficult to use and maintain.</li> <li>2. A two-way sync algorithm can also increase the risk of data loss. If one of the systems involved in the sync process fails, you may lose data.</li> <li>3. A two-way sync algorithm can also decrease the flexibility of your EHR system. This can make it more difficult to customize your system to meet your specific needs.</li> </ol>	<p>In general, two-way sync algorithms can be used whenever data needs to be synchronized between two systems in real-time. This might be necessary, for example, when patient data is being shared between a hospital and a primary care provider, or when a patient's medical records are being accessed by multiple providers</p>

**Conclusions.** The choice of model and method will depend on the specific needs of the organization. For example, if data accuracy is more important than efficiency, the snapshot model may be more appropriate. If data accuracy is less important, the incremental model may be more appropriate. If data security is a concern, replication may be the best option. Different organizations have different needs, and there is no one «right» way to synchronize medical databases. The important thing is to choose a model and method that will work well for the specific needs of the organization.

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## МОДЕЛІ ТА МЕТОДИ СИНХРОНІЗАЦІЇ БАЗ ДАНИХ МЕДИЧНИХ ІНФОРМАЦІЙНИХ СИСТЕМ

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**Резюме.** Для побудови системи обміну медичною інформацією необхідно, щоб різні медичні системи були сумісними між собою. Якщо системи несумісні – необхідно досягти сумісності за допомогою досягнення семантичної та синтаксичної сумісностей систем. Якщо сумісність

досягнена, виникає необхідність синхронізувати бази даних різних систем. Для досягнення даної мети проведено дослідження, в якому розглянуто найпопулярніші моделі та методи синхронізації медичних даних. Отже, існує кілька різних способів синхронізації медичної інформації між двома системами. Найпоширенішими є реплікація, ETL та двостороння синхронізація. У кожного є свої плюси та мінуси, які слід враховувати при виборі рішення. Реплікація – це процес копіювання даних з однієї системи в іншу. Зазвичай він використовується, коли дані необхідно синхронізувати в режимі реального часу, наприклад, для системи моніторингу пацієнта в реальному часі. Основна перевага реплікації полягає в тому, що її відносно просто налаштувати й обслуговувати. Основним недоліком є те, що це може бути ресурсомістким, оскільки кожній системі потрібно постійно перевіряти наявність змін, а потім копіювати ці зміни. ETL (extract, transform, load) – це процес, коли дані витягуються з однієї системи, перетворюються у формат, який може використовуватися іншою системою, а потім завантажуються в цю систему. ETL зазвичай використовується, коли є необхідність регулярного переміщення даних з однієї системи в іншу, наприклад, для нічного резервного копіювання. Перевага ETL полягає в тому, що його можна легко налаштувати відповідно до конкретних потреб задіяних систем. Недоліком є те, що його налаштування та обслуговування може зайняти багато часу, а також він може не впоратися з синхронізацією даних у реальному часі. Двостороння синхронізація – це процес, коли дані синхронізуються між двома системами в обох напрямках. Тобто зміни, зроблені в одній системі, реплікуються в іншу систему, і навпаки. Перевага двосторонньої синхронізації полягає в тому, що її відносно просто налаштувати й обслуговувати. Недоліком є те, що, як і реплікація, вона може бути ресурсомісткою. Вибір моделі та методу буде залежати від конкретних потреб організації. Наприклад, якщо точність даних важливіша за ефективність, модель моментального знімка може бути прийнятнішою. Якщо точність даних менш важлива, інкрементна модель може бути прийнятною. Якщо безпека даних викликає занепокоєння, реплікація може бути найкращим варіантом. Різні організації мають різні потреби, не існує єдиного «правильного» способу синхронізації медичних баз даних. Важливо вибрати модель і метод, які будуть добре працювати для конкретних потреб організації.

**Ключові слова:** медична інформаційна система, база даних, синхронізація.

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