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RESEARCH

Tribology Database as Platform for Mobile Database and use of Mobile Technologies

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A B S T R A C T

In the last few years changes in information technologies, are numerous and dynam. One of those changes is the massive use of mobile devices. They have not only been used for communication, but also for access to applications and data in databases. Interactive processing of data from social networks, which is a priority for the mobile device, is expanded in the field of scientific research and data processing. In this article the possibilities of application of mobile systems (devices, applications and databases) in tribology research are presented.

1. INTRODUCTION

At present level of development and application of modern information technology, scientific research area is now entirely connected. Each node of this area possesses the ability to communicate in some way. Specific nodes generate, other process, review or just transmit data. Some nodes have all of these features. This fully linked scientific research space by information technologies could be created and maintained by integration of database systems and wireless or cable connections. This space should allow scientists and researchers to be timely informed about latest scientific achievements both, in their own and in other scientific fields.

This paper shows the possibilities of mobile systems (devices, applications and databases) application in a tribology studies, and platform i.e. scope of their application that are already developed - tribology database. One part of the paper has aim to review of literature related to these areas. The authors in the paper [1] described and analyzed the impact of distributed mobile database on the mobile device with the Bluetooth. The analysis were done on a specific case of SQL Server CE database engine on the iPAQ Pocket mobile device, while the response time of queries, generated traffic and consumption of energy (batteries) in relation to the number of inquiries were measured. In the paper [2] the authors described a certain number of possible mobile accesses to databases, identified, analyzed and performed classification of mobile accesses through two schemes, namely: one is a query processing strategy, and the other is a caching management strategy. Issues of mobile databases management and challenges (problems) in relation to mobile databases use are the focus of the authors in the paper [3].

Mobile devices and mobile database, within the present case, should allow researchers access to current information, on the research institutions tribology database server. Based on these access to current information, researchers can bring certain conclusions, decisions and/or take some action or to create important data (information) and as soon as possible should be registered in the tribology database server because they represent a new information's for other mobile or stationary users/researchers during the experiment (research/testing). Figure 1 shows one of the possible scenarios of the general concept of using the information from developed tribology database, whose description of the structure and content is shown in [4,5] with the use of modern mobile technologies (devices).

Today, in the category of mobile devices the relatively large numbers of electronic devices are classified. From the point of mobile databases, data and signals transmission with the research equipment, the following are in the focus of interest: mobile and smart phones, PDA (Personal Digital Assistant) devices, iPods, ultra-mobile PCs (UMPC - ultra mobile PC). Laptop computers are not classified in the category of mobile but in category of portable devices, primarily because of its size and less mobility, while tablet computers and electronic books readers are on the border between these two categories, but in a broader sense they all can be considered as mobile devices.

Through technology development enable mobile devices to receive certain functions and features that until then were only possible on personal computers, i.e. it is possible to install additional applications, use word processing programs, spreadsheets, reading e-books or view multimedia and foremost it is possible to install custom relational database management systems. In this way, mentioned mobile devices, primarily PDA devices, have become a substitute for PCs, while the user (researcher) is located on the road or simply is away from its research point (workplace) or wants to manage data in addition to research equipment. So these devices need to have developed connection system to connect to a wireless computer network, to exchange data (information) and to get synchronized with PCs.

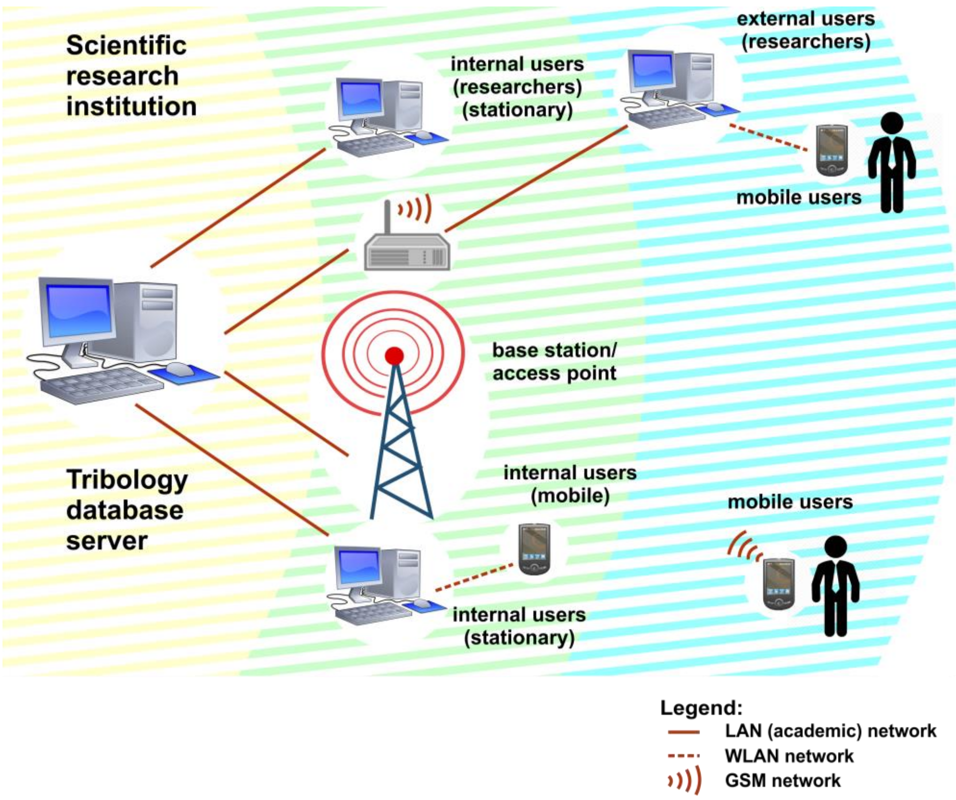


Fig. 1. Schematic representation of the general scenario of mobile technologies used to access the tribology database server.

The emergence of mobile phones substantially changed the world of telecommunications and significantly facilitated the life and business in many segments. However, PDAs offered a wide range of computer applications and useful tools. Therefore, it is a natural tendency in recent years for these two types of devices to converge to each other, i.e. for mobile phones to add functionalities and computational capabilities of PDAs and for PDAs to add the ability to call via the cellular mobile networks. Such a hybrid devices that have the ability to communicate by voice through a network of mobile operators, the operating system of a higher level and the possibility of installing new software applications, the ability to create and preview multimedia content (music, photos, audio and video recordings, etc.), powerful computing features PDAs, the ability to connect to wireless local area networks are smart phones (smartphones).

Daily development and a better performance of mobile devices, hardware and software, open up new possibilities of application of these devices, both on business, and on a personal level, and in this paper the concept of use or access to tribology applications and databases are shown.
An important feature of the mentioned mobile device is related to synchronization with computers and data backup system. Synchronization is obtained by connection of mobile device to a desktop computer (usually via a USB port), and by using specialized software on both systems (such as ActiveSync), while respecting appropriate rules depending on the changes to be performed. During synchronization with the computer, it is possible to occasionally back up all the data from the mobile device and to archive and store them on computer.

Another important feature of the considered mobile devices is related to communication in order to transfer and share data in this case with a tribology database or available research equipment. Depending on the technological generation or class of devices, the following standards, protocols and services are supported: IrDA (Infrared Data Association), Bluetooth, GSM (Global System for Mobile communications), GPRS (General Packet Radio Service), WAP (Wireless Application Protocol), MMS (Multimedia Message Service), EDGE (Enhanced Data rates for GSM Evolution), IMT-2000 (International Mobile Telecommunications – 2000), HSDPA (High Speed Downlink Packet Access), WiMax (Worldwide Interoperability for Microwave Access) based on IEEE 802.16 standard and other standards. Figure 2 schematically shows the development of technologies for mobile and wireless communications.

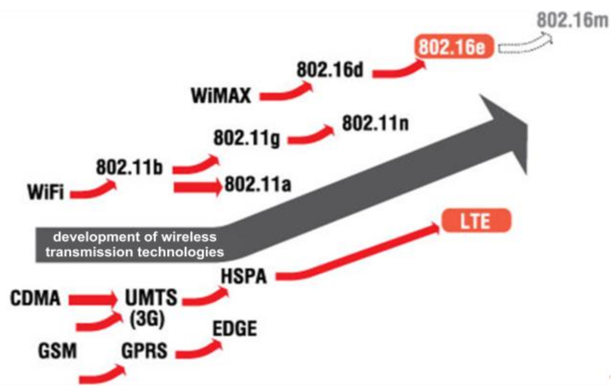


Fig. 2. Schematic representation of the development of technologies for mobile and wireless communications [6].

The rapid development of technology, the miniaturization of components and reduction of their prices have been enabled the approach to Wireless Local Area Network (WLAN) not only for laptop computers, but also for nearly all modern mobile devices. Today, the most commonly used Wireless Fidelity (WiFi) wireless network are established based on IEEE 802 group of standards. This group of standards emphasizes the existence of an access point - router that covers a specific area and allows all devices in this area connection and access to a network (Figure 1). Data transfer and Internet access via Wi-Fi network is significantly faster and more reliable than with cellular networks. Wi-Fi technology, due to the greater range (from, for example, Bluetooth) and higher transfer rate, is characterized by higher consumption of energy, so this new batteries and higher CPU load, were the obstacles for wider use with mobile devices. It should be noted that the new standard from the IEEE 802 group of standards provides access speeds of up to 100 Mbit/s for mobile users and up to 1 Gbit/s for stationary users. Figure 3 shows the relationship between transfer ratio and mobility of certain technologies for data transmission. Wi-Fi provides high transfer rate, but due to the small range of access points, it is difficult to provide a signal to the wider area and the ability for the user on the move to access the network. On the other hand, GSM network coverage is exceptional (most operators in Serbia have network coverage of over 98 %), with a very low data transfer rate.

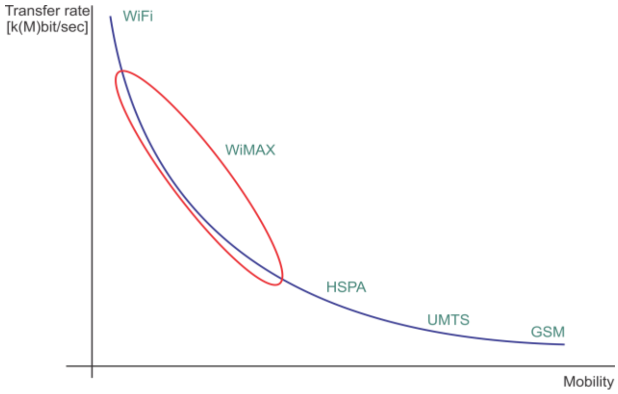


Fig. 3. Relationship between transfer rate and mobility technologies for data transfer.

Databases in different forms and formats exist from the very emergence of computers. The need for storing and searching information has always existed, but only recently, with the increasing popularity of computers, it became accessible to everyone. Methods of electronic storage of data from the beginning until today have experienced number of evolutionary and revolutionary changes. Starting from simple files (sequential and index- sequential), through mainframe databases, the first desktop database until to today's powerful database servers, which other than the basic purpose, yield many additional features.

Today's technologies make data collection simple, and their storage and safekeeping cheap. Therefore, the focus of interest in working with the data is no longer collecting and storing of data, but their analysis and understanding. The distribution of databases, created the need for the development of analytical tools that can convert saved data into useful information and new knowledge. In the Serbian market in the beginning Clipper applications were very popular - behind which stood dbase (popular dbf) database format in different versions, as the first relational database on the PCs. Great popularity due to the ease of use and reliability had Microsoft Access, which was not only used for databases, but it could be used to develop Windows applications. However, when it comes to large-scale systems that need to store and manipulate large amounts of data and concurrent users, it is referred to the database servers that can meet these needs in terms of performance, security features and administration.

Restrictions on access to databases on mobile devices are connected to the limited capabilities of mobile devices primarily CPUs, cache memory, battery power, interference with the signal reception depending on the position of a mobile device, insufficient bandwidth of mobile and wireless networks, and limited memory. So DBMS for mobile devices present stripped server DBMS. From the viewpoint of information practices worthy of attention are: Oracle Database Lite 10 g (An integrated and complete solution for rapid development of applications for mobile and portable platforms. Large corporations use it due to the high reliability, reduced costs and faster and better use of services for the end users.), DB2 Everyplace (One of the IBM families of software for relational databases management systems – RDBMS on mobile platforms and features: IBM DB2 Database Engine, IBM Sync i Query By Example (QBE)), SQLite (Relational database management system data that is contained within the C programming language), SQL Server Compact (free, optimized, very powerful, easy to use server embedded database that allow the execution of desktop or mobile applications running on Windows platforms)).

2. SYSTEM ARCHITECTURE

Model of tribology database shown in [3,4] was implemented for storage of numeric and text data. Due to use of modern measuring devices (modern research equipment) such as tribometer, nanotribometar, AFM, SEM, scratch tester, indenter in studies of tribology characterization of materials it was necessary to expand model of tribology databases in order to store other information such as pictures, videos, reports [7], etc.

Examples of such data might include the following:

- 3D topography and roughness profile of grinding surface of the lithium disilicate glass ceramic (Fig. 4),
- nanoindentation curves (Fig. 5)
- indentation imprints analysed by optical and atomic force microscopy (Fig. 6),
- friction force and penetration depth (Fig. 7),
- optical microscopy of wear tracks (Fig. 8),
- SEM and EDS wear track analysis (Fig. 9).

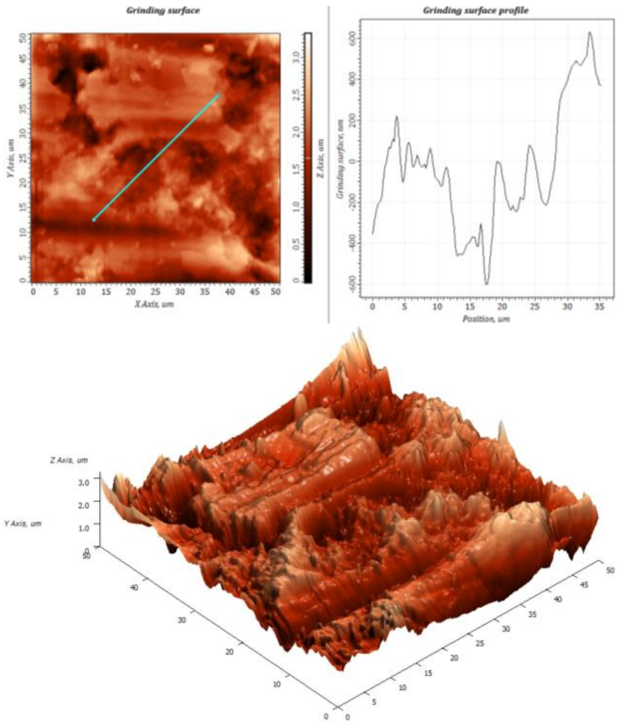


Fig. 4. 3D topography and roughness profile of grinding surface of the lithium disilicate glass ceramic [8].

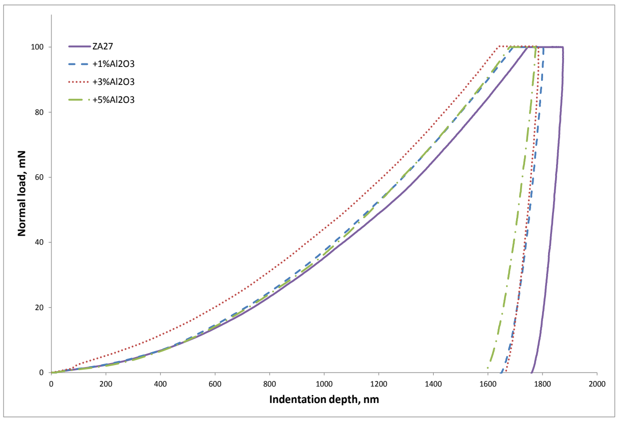


Fig. 5. Nanoindentation curves for ZA-27 alloy and tested nanocomposites reinforced with 1, 3 and 5 vol. % of Al_2O_3 [9].

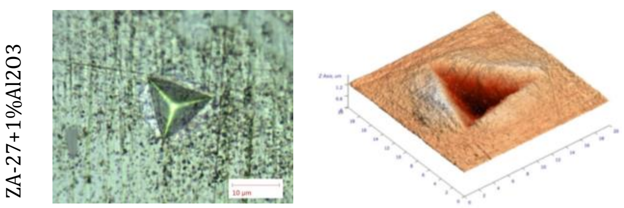


Fig. 6. Indentation imprints analysed by optical and AFM microscopy [10].

Data were obtained from Atomic Force Microscopy (AFM) which enables 3D scanning topography of the contact surfaces of different materials at micro and nano level, in the form of 3D images with high-resolutions. The Figure 4 shows 3D topography and roughness profile of grinding surface of the lithium disilicate glass ceramic (*IPS e.max CAD*). The measurement range on all samples is 50 x 50 µm [8].

Nanoindenter (Figs. 5 and 6) and Nano-tribometer (Figs. 7 and 8) could be used for investigations of tribology properties of material, varying contact elements and regarding that contact geometry, type of movement, normal load, moving speed and contact conditions with or without lubrication or any other type of fluid. In this case of CSM nanotribometer is with ball on plate contact geometry and these tests were performed without lubrication with alumina ball as a counter-face to the examined nanocomposite material in tribology characterization of metal matrix nano composite (MMC) with the base of ZA-27 alloy reinforced with Al_2O_3 and graphite.

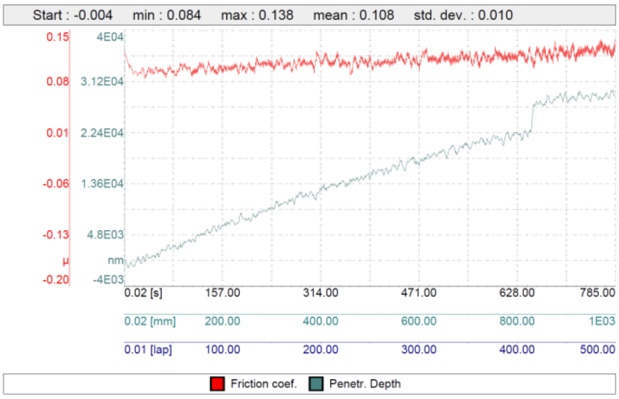


Fig. 7. Friction force and penetration depth dependence on time/sliding distance/laps for ZA-27 nanocomposite reinforced with 1 vol. % Al2O3, obtained under 200 mN normal load and 2 mm/s sliding distance [9].

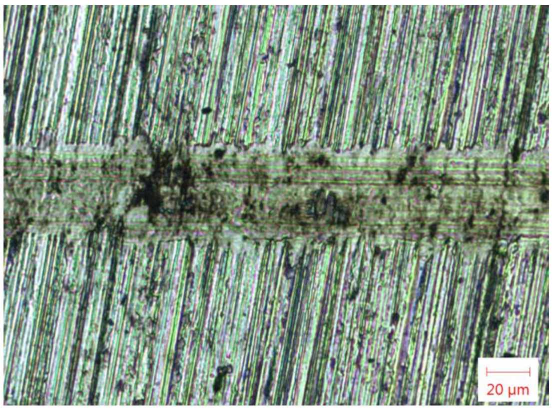
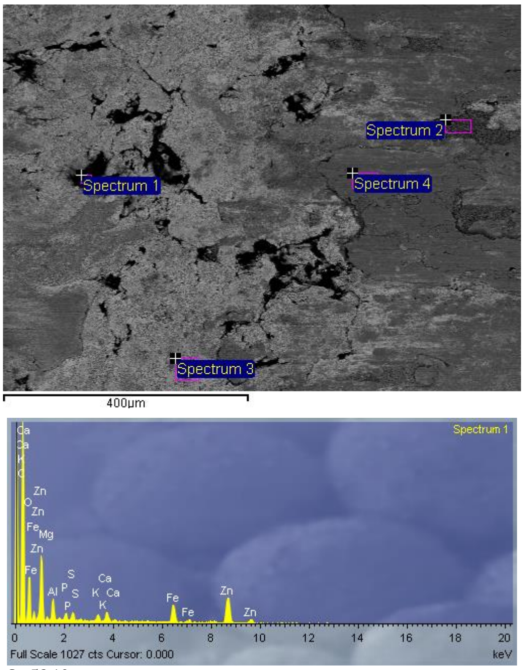


Fig. 8. Optical microscopy of wear tracks for ZA-27 nanocomposite reinforced with 1 vol. % Al_2O_3, obtained under 200 mN normal load and 2 mm/s sliding distance [10].

Scanning Electron Microscopy - SEM can be used for detailed inspection of surface layers, which can provide chemical analysis of those layers if it is equipped with EDS (Energy Dispersive Spectroscopy), Fig 9.



C – 53.10
O – 18.26
Mg – 0.34
Al – 1.60
P – 0.70
S – 0.55
K – 0.63

Ca – 0.91
Fe – 4.74
Cu – 0.00
Zn – 19.16
Total 100.00
Values are expressed in wt.%

Fig. 9. SEM and EDS wear track analysis of ZA-27 composite reinforced with 1 vol. % of graphite [9].

Tribology databases with expanded structure allow storage of information on the total number of published papers per researcher, project, journal, measuring device or equipment in the research institution, and also by all these objects information on the number of citations are available. Economic parameters recorded in the extended databases provide monitoring of economic profit by scientific activity generated through research in the scientific and research or commercial projects, equipment, researcher, etc.

Also, the extension of tribology databases structure gives the contribution in obtaining the answers to the questions that are related to the validity of researchers and research groups through performance indicators, the role of books, magazines and conferences, spending on scientific/research projects and profit from scientific activities, the functioning of communication in science and training quantitative methods of processing and analysis of data on scientific activities. By measuring the total number of published paper, measuring the number of papers published in a one specific journal, measuring the number of citations per article and the total number of current citations provides a platform for creation of the reference criteria of scientific success. It must be mentioned that this quantification of scientific success makes the scientific and government institutions job easier as well as the job of funds that evaluate projects and importance of scientific research, on condition that the role of ethical and social influencing factors has not be ignored.

Based on the typical scenario shown in Fig. 1, IT concept and way of realization of problem solving by using mobile systems and mobile tribology database server using the tribology database expanded structure were developed. Based on the concept shown in Fig. 1, one possible software solution in Fig. 10, UML (use cases) model is illustrated.

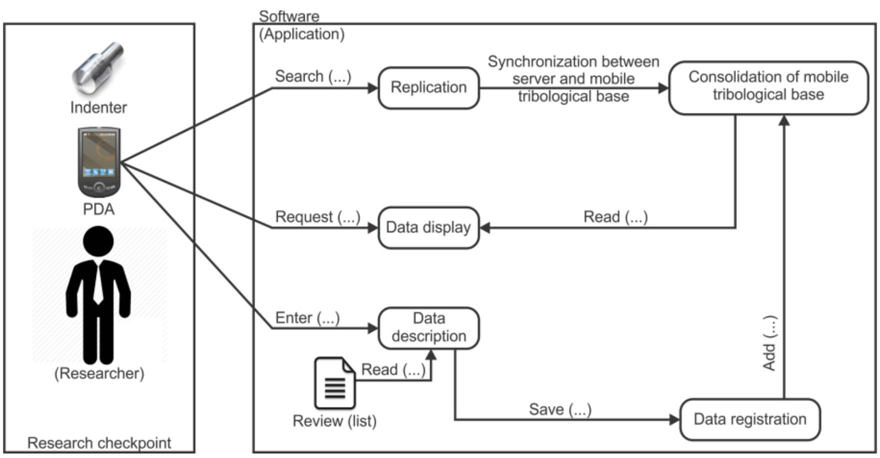


Fig. 10. UML application model of tribology mobile database use.

For the successfully use of software application, having in mind used equipment on which testing is done, researcher initiates replication procedure that will synchronize data within PDA device mobile database with data from server tribology database. This is a requirement needed for the researcher to use the necessary information within logical projection and selection operations, at the level of the each query. Other functionality of the illustrated application solutions is the registration (saving) of the obtained test data in mobile tribology database.

Considering given device and software system environment one of the possible technological solutions for the realization of the above-described requirement, involves the use of mobile devices in combination with a standard desktop computer (server) and tribology database expanded structure. The mobile device can operate independently or over a network to connect to the server on which the tribology database is located. On the mobile device is positioned mobile base with tribology management system that is compliant with the system for management of tribology database on the server, enabling full synchronization of the mobile and server databases. It requires development of software platforms that enable their relatively simple programming by using standard programming languages such as C ++ or Visual Basic.

By connecting mobile device directly with research equipment or through a desktop computer that is connected to the research equipment in order to transmit data, it is possible to realize the direct connection via USB or serial port, whereby desktop computer must have software installed that supports this connection (Microsoft ActiveSync). Connection to the Internet or to the other local network can be realized via the mobile phone network and a wireless network that can be realized in two ways: conventional wireless networking (Wi-Fi), or by using Bluetooth technology. For an application model shown in Fig. 10 in order to work properly, it is necessary to set up a complete desktop client (a PDA with a mobile tribology base) and the server on which the tribology databases with expanded structure is located.

To manage mobile tribology database on the mobile device Microsoft SQL Server CE can be installed, which in addition to engine, includes Query Analyzer and SQL Server CE Client Agent, which allows the exchange of data between the tribology database on the server and the mobile device. It is necessary to install the .NET Compact Framework if the user application is developed by using .NET technology. Operating environment at the server side is described in the papers [4,5].

Replication is the mechanism for the exchange of data between the server tribology database and mobile tribology databases. In addition to replicate, to exchange data between the mentioned databases Remote Data Access (RDA) mechanism could be used. The advantages of this mechanism are greater execution speed and lower requirements for computing resources, but generality, configurability and usability are on the side of replication.

Mentioned utilizations can be executed in the corresponding SQL scripts in Query Analyzer or with Enterprise Manager, SQL Server management console. The replication process supports such an exchange of data between the client (mobile device) and the server, in which the content exchange between tribology databases does not have to be completed, but only partial with a few relations (reduction), with only some attributes within a relation (projection), and with only some of the data (selection). These properties allow transfer from server tribology database to the mobile tribology database and the vice versa, only of those data which are necessary to the researcher (user). To synchronize data between the mobile database (DBMS is SQL Server CE) and server database (DBMS is SQL Server) replication must be of a merginge type, specified for synchronization with SQL Server CE, and must allow pull distribution mode i.e. initiation of the replication at the request of the client or mobile users (PDA). Merge replication is bi-directional so that data can switch from MTBP on STBP and vice versa. Such replication enables the transfer of data from the research checkpoint, i.e. mobile device. Figure 11 shows the architecture of replication.

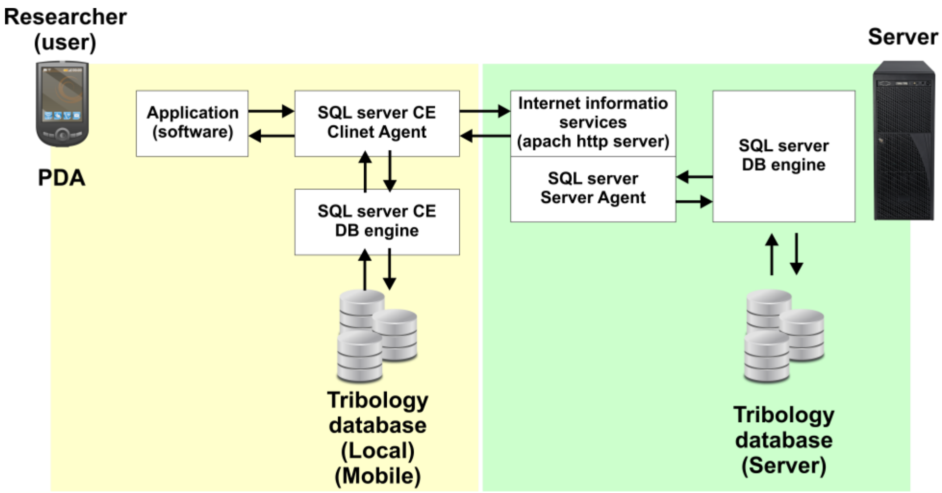


Fig. 11. Replication architecture.

From Figure 11 can be seen that MTBP on a mobile device PDA is synchronized to a STBP over established HTTP connection from SQL Server CE to SQL Server through IIS. In this way, IISs capabilities of authentication and authorization could be used.

Concerning security, there are two security layers that mobile users encounter during replication; these are IIS's security system and security system of SQL Server. SQL Server CE Server Agent access is enabled only after a successful authentication by IIS. SQL Server Agent CE access to a server database and start of the replication are possible only after successful authentication by the SQL Server. It is recommended that the used name and password should have extra protection over the Internet by SSL (Secure Socket Layers) and if the replication is performed via the public network name and password that is sent to IIS needs to be encrypted.

3. CONCLUSION

The development of information and communication technologies especially mobile computing made it possible to use all the advantages of fast computers and electronic communications, in the field of tribology materials characterization. The two most important characteristics of mobile computing, separating them from other forms of computing are:

- Mobility. As already pointed out, mobile devices are relatively small, so they can always be carried around.
- Availability. With a mobile device carried around, the user is always available for contact, in this way connection can be made from any location. Displayed architecture enables increased mobility and availability of researchers.

The paper analyzes the condition justification needs for the outlined concept (and the corresponding scenarios for the application use on mobile devices). This paper describes one of the possible data access from a mobile device or data replication between the server database and the mobile tribology database stored on the mobile (PDA) device.

Also, some security issues of data protection that require attention in the development of mobile applications (applications developed for mobile (PDA)) are presented. They are referring to the proposal and scenario type, so that:

1. Data can be obtained on the research equipment instead of using the file system for data transfer by mobile database on the PDA (mobile devices) with the possibility of a preliminary analysis of the obtained data, with the possibility of repeating the research (experiment). The analysis would be carried out by using the developed PDA applications. In this way, the process of data registering into the tribology database is speeded up.
2. Data and information from mobile tribology databases could be used at the research checkpoint (place were the experiment is conducted) in order to clarify the current concerns in the course

of research. Inquiry can be sent, if some current data are needed based on which decisions can be made and/or some appropriate actions can be taken related to research.

The presented concept, based on the usagee of mobile technologies, could represent a good response to IT challenges of modern times that are placed in front of tribo-informaticians.

Acknowledgement

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