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PROTECTION OF DIGITAL ARCHIVES IN THE ARCHIVES OF BOSNIA AND HERZEGOVINA

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Abstract:

One of the basic tasks of every archives, in addition to collecting and making archival records available, is to protect them from damage and loss. Records, regardless of whether they are „traditional" or digital, are subject to deterioration. Daily careless handling and improper storage conditions contribute to increasing the risk of their permanent disappearance.
The author will discuss current experiences of the Archives of Bosnia and Herzegovina in manipulating digital records, especially in the aspect of preservation and protection, taking into account sharp contrast between historical importance of the fonds that are stored and the outdated and technically insufficient IT equipment which is currently in use.

Key words:

hardware failure, data loss, database, softweare, backup

Izvleček:

Zaščita digitalnega gradiva v Arhivu Bosne in Hercegovine

Zaščita arhivskega gradiva pred poškodbami in izgubo je poleg zbiranja in dajanja arhivskega gradiva v uporabo ena izmed glavnih nalog vsakega arhiva. Zapisi, ne glede na to, ali so »tradicionalni« ali digitalni, so predmet staranja. Vsakodnevno rokovanje in neprimerni pogoji za hrambo povečujejo možnost njihove trajne izgube.
Avtor bo predstavil trenutne izkušnje Arhiva Bosne in Hercegovine pri upravljanju z digitalnimi zapisi, s poudarkom na vidiku hrambe in zaščite, pri tem pa bo upošteval močan kontrast med zgodovinsko pomembnostjo ohranjenih fondov in zastarelo ter tehnično nezadostno informacijsko opremo, ki je trenutno v uporabi.

Ključne besede:

odpoved programske opreme, izguba podatkov, podatkovna baza, programska oprema, varnostne kopije

1. Foreword

One of the basic tasks of every archive, in addition to collecting and making archival records available, is to protect them from damage and loss. Records, regardless of whether they are „traditional“ or digital, are subject to deterioration. Daily careless handling and improper storage conditions contribute to increasing the risk of their permanent disappearance.

For „traditional“ documents in paper form, the protection procedure is generally known and standardized, while the protection and backup procedure for digital materials is still insufficiently regulated in Bosnia and Herzegovina.

The Archives of Bosnia and Herzegovina has already had the unfortunate opportunity to encounter the permanent loss of a certain number of scanned materials, and on one occasion the entire database was compromised. Only thanks to a timely reaction and a certain amount of luck, the complete disappearance of data did not occur. On that occasion, the importance of pre-prescribed security procedures regarding the handling of digital material (which did not exist until then) was demonstrated.

The digital era has already started in a big way and without adequate professional adaptation it is impossible to follow modern archival trends. And yet, the fact is that the transition to the mass installation and use of archival databases in Bosnia and Herzegovina has not yet rea ched the desired level.

2. Too Fast Evolution

If in some fifty years or so, our descendants stumble upon a CD or DVD with videos and photos or scans of old documents in the attic of the family home, the chances are high that its content will remain a mystery. Two factors will contribute to this outcome to the greatest extent. The first is the lifetime of the disk itself, which is currently estimated at a maximum of 30 years. Microscopic chemical changes in the recording layer caused by oxidation or physical delamination will render it permanently unreadable. If the disc overcomes physical deterioration thanks to better manufacturing and ideal storage conditions, it will face the inevitable scourge of today's technology - obsolescence.

Our descendants will probably recognize it from old movies, but they will not have the software or hardware necessary to "read" it. Therefore, in addition to all the technology and progress, in only fifty years (though probably much earlier) the only thing that will be usable in the mentioned case is a note on the cover that specifies the content of the disc and thus informs that there might be something interesting there.

Although information in digital form is theoretically insensitive to the passage of time, the physical media on which it is stored is far from immortal. Any magnetic record can easily be damaged by the short-term effect of a magnetic field, the aforementioned oxidation or physical deterioration.

The traditional association that accompanied every archive - stacks of papers bundles on the shelves or endless rows of boxes with documents - is gradually but surely giving way to another setup. A monitor, a computer and a database have become an indispensable part of every modern and well-organized work with documents. It is impossible to imagine serious scientific work that will not involve, to a greater or lesser extent, searching through data or using all the advantages of the digital format.

Despite vast improvements in the capabilities and performance of IT systems, technology continues to evolve rapidly. The introduction of new processes and systems is primarily driven by market forces over which consumers have little influence. Hardware

and software manufacturers are increasing their market share by introducing new technologies with new features and improved capabilities. As a result, institutions often upgrade their systems and completely change computer systems every few years.

The relatively short lifetime of hardware and software significantly affects the long-term storage of electronic records. Organizations replace their systems when equipment, vendors stop supporting outdated systems or when new products are more advanced than old ones. In order to ensure the availability, comprehensibility and usability of records created by old systems for users of new systems, organizations must transfer their old records to the new format. Most software today has reverse compatibility between old and new versions of the same software, but compatibility between two competing products is not common. Complex systems created for specific business processes or for the needs of a particular organization are often difficult to transfer to a new system. Transferring records from older proprietary systems - the so-called legacy systems - to current technology may require significant reformatting and restructuring of records. This procedure is expensive and requires serious changes in the structure and format of the record, which calls into question the integrity of the old digital record as evidence. This is important to keep in mind because archives, by the nature of their work, must keep records accessible without time limits. As long as information technology continues to develop and new ways of using computers in handling information are invented, archivists should be ready to give advice and guidance in this changing environment.

3. Old School Digital Media Used in the Archives of Bosnia and Herzegovina

Due to unfavorable political and financial circumstances, the Archives of Bosnia and Herzegovina started applying IT technologies in its daily work relatively late. Archives received its first professional equipment only in 2012, primarily thanks to a foreign donation.

Until 2012, technical problems that arose during the storage and preservation of digital data existed exclusively with the use of 3½-inch floppy disks, CDs and DVDs.

Although not relevant as a medium for long-term and secure storage, the floppy disk foreshadowed the type and nature of digital record security problems that would arise in the future. Although it was already outdated, it was widely used in the Archives as an all-purpose media up to some ten years ago. With its limited capacity of 1.44MB, it could store a certain number of text files and nothing more. It was very sensitive to dust, heat, moisture and mechanical forces and it often happened to be easily damaged in the seemingly harmless office environment. In addition, due to the sensitivity to magnetic radiation, sometimes it was not possible to read the data even from a physically perfectly preserved diskette. Instead, the well-known message *„A:\ is not accessible“* was received. Because all of this, the floppy was never used for permanent data storage, but only as an auxiliary tool in everyday work.

Photos 1,2 and 3 – Old data carriers can still be found in the Archives of Bosnia and Herzegovina. Some of them are no longer readable due to outdated hardware, physical damage or improper storage conditions.

On the other hand, CDs and DVDs were recognized as reliable high-capacity media and many archives recorded the first „databases“ of scanned documents on them. With their impressive capacity of 700MB (CD) up to 8.5GB (DL DVD), they became a real sensation and many archives stored serious amounts of scanned archival material on DVDs; not only standard written documents, but also photos, maps and audio recordings.

Due to the lack of strict scanning standards, those documents were not always in high resolutions or were recorded in non-standard formats. The main problem was not in the quality of the scanning itself, but mostly in the slow and difficult search of the media and its life span, which turned out to be shorter than initially expected. Specifically, in the Archives of Bosnia and Herzegovina, some 15 - 20% of the discs remaining from the period when they were most widely used are unreadable. The reason for their unusability lies in the damage of the writing layer, which in a smaller number of cases was caused by physical force due to careless handling (breakage, scratches), and in a larger number due to oxidation of the metal layer (disc bronzing) and the chemical reaction with aggressive adhesives and markers. The use of non-branded discs of lower quality and data recording at high speeds contributed to a short lifespan and an unreadable record. Marking discs with markers that are not intended for writing on plastic caused an aggressive chemical reaction where the ink reacted with polyvinyl and damaged the record. The same thing happened with discs that had pasted labels. The adhesive reacted with the surface and the disc became unreadable, although some specimens show no damage to the naked eye. Notably, discs stored in a paper envelope were more susceptible to deterioration than those in a plastic case, due to the paper's ability to absorb moisture from the air.

Fortunately, as all the scans that could not be accessed still exist in their original format, the Archives of Bosnia and Herzegovina did not suffer a significant loss of data. These problems of data loss from floppy disk and CD/DVD highlighted the need for timely data migration.

4. The Necessity of Data Migration

During migration, it is not enough to follow trends in hardware, but also in software. The recording medium often becomes unusable due to the appearance of newer, better, but incompatible formats. In order to understand the consequences of these processes, one does not need to go far into the past. It is enough to try to read a digital record from twenty years ago.

That record was most likely created on a personal computer whose operating system was DOS and used WordStar software, an early version of today's Word. The document is saved on an 8" or 5¼" floppy disk, which requires a correct 8" or 5¼" reader, and these are no longer manufactured. Ejected from the system that created it, our floppy becomes an "orphan" - almost impossible to open and read.

Accessing records from outdated media could be more complicated than deciphering some ancient inscription. The key to read the string of bits could be put on a disk, but again one would need a program in which it is written to be able to read it. A string of bits has some meaning primarily to the software that created it. Microsoft Word stores not only the text in its document, but also information about the font, font size, spacing, margins, text structure, etc. A saved *.doc* or *.docx* file is actually more of a description of the document, which comes back to life only when it is processed by the native program. Without the program, the document is trapped in the code in which it is saved.

Theoretically, the document can be partially opened with a program that is similar to the original, but expecting that this will solve all problems is unfounded optimism. Software often becomes outdated faster than hardware and newer versions sometimes have completely different algorithms than the previous ones. It is naive to believe that every program used today will be available in the future.

Even if another disc with the original program was left together with the data disk, its compatibility with the computers of the future and their operating systems will not be a matter of routine. It is possible that there will be suitable emulators, programs that imitate the operation of the necessary hardware. However, the main disadvantage of emulation is that it requires detailed specifications of outdated software. In order to preserve them for future generations, they must again be in digital form independent of any software, otherwise we would need an emulator to get the emulation data.

Preservation of electronic records is a new and challenging requirement for archivists. It is an established rule that the content, context and structure of the record should be preserved in order for the record to retain its credibility. With digital records, preserving the medium itself is not enough, since content, context and structure are independent of the medium. In the traditional paper environment, efforts were focused on preserving its physical form. Since the content, structure and to a certain extent the context of the records were tied to physical media, the preservation of records as evidence was ensured. In an electronic environment, archivists can devote a considerable amount of resources and effort to preserving physical media (magnetic tape, optical media, HDD) and still fail to preserve the record.

For now, the only solution is regular data migration, periodic transfer to more modern media. Just one lost cycle is enough to make stored material unavailable. Migration planning is a complex job, especially in the Archives of Bosnia and Herzegovina due to the deficit of knowledge, practice, standards and protocols. It is necessary to determine an appropriate methodology that would ensure long-term availability of a complex digital database. There was an initiative to keep the original hardware and software with the electronic record, but it was rejected as expensive and

impractical. The migration process is often time-consuming and expensive, and great efforts are made to find a record carrier that would provide longer-term storage.

5. Transition to Larger Capacity

With the appearance of external hard disks (HDD) on the market, the Archives of Bosnia and Herzegovina has for the first time been able to store and back up digitized archival material with a capacity of up to several TB. Unlike previous data carriers, access to documents on HDD is fast, with higher speed of data transfer. The external HDD was used to store the first complete scanned fonds and photo collections. They were kept in a separate cabinet where they were protected from excessive heat, humidity and magnetic fields.

Regardless of its practicality, this media is still not ideal for long-term storage due to sensitivity to vibrations and shocks, since hard drives are largely mechanical devices. Underneath the top of a hard drive there are several rotating disks known as platters. These platters are coated in a magnetic material that is electronically divided into billions of sectors. A mechanical hard drive fault involves the failure of one or more moving parts of the hard drive. Repairing a hard drive with a mechanical fault is a specialist operation that often involves removing the failed component(s) from the hard drive and replacing them with working ones. This is a complex repair task that is not as simple as it sounds. During their use so far, two mechanical failures and one involuntary deletion of data have been recorded in the Archives[1].

Photo 4 – External HDDs are still mostly used as data storage media in the Archives of Bosnia and Herzegovina

Regarding the mentioned two mechanical failures, the consequence was a complete loss of data, which fortunately, in both cases was backed up. The data could not be accessed and when the HDD was running, a characteristic clicking sound was heard, which is a common sound in such a case. Hard drives with mechanical faults will frequently make clicking, buzzing or beeping noises when they are powered on.

[1] *The most common accompanying failures that occurred were contact breaks in the data cable or at the input connector on the disc's motherboard itself. They were easily repaired by replacing the cable itself or by soldering broken contacts on the motherboard. These failures were caused by careless and rough bending of the cable.*

Mechanical faults can occur due to wear and tear and are frequently seen on external hard drives that have been dropped or have received a severe knock or jolt. This type of symptom will often relate to the fault with the drive. Hard drives that tick (often referred to as the 'Click of Death') usually have a head fault. The heads are the parts of the hard drive that read and write the data to the disk surface. When a hard drive is powered on it goes through a self test procedure, a ticking drive indicates the self test is not passed and drive enters a reset loop until it eventually times out.

In all cases of mechanical hard drive failure, repairing the hard drive is a complex and highly skilled task. Firstly, as the inside of a hard drive is a clean and dust free environment, the whole hard drive repair operation needs to take place in a clean room, otherwise the disk will be contaminated with airborne dust particles which will lead to severe operational problems with the hard drive. Secondly, the spare parts required will often need to be an exact match from the original manufacturing run of the original drive. It is not a case of simply finding a similar drive by the same manufacturer of the same capacity. Finally, once the spare parts have been fitted, the drive will need to be recalibrated before the data is retrieved. It is important to know that once a hard drive has been successfully repaired it will not function in the same way it did originally; the drive will be slow and very prone to fail again. That is why it is usual for the recovered data to be promptly written to a new hard drive – the repaired one now functions very poorly and has a very limited lifespan.

During the aforementioned case of involuntary data deletion, the HDD was and remained mechanically perfectly sound. No hard drive repair was necessary and specialized software was used to recover the deleted / lost files and folders. However, from experience so far, when using freeware software, the percentage of data saved is maximum 60%. The rest of files are always incomplete or corrupted. If there was important data on the accidentally deleted disk, it is necessary to hire a professional company. Archives of Bosnia and Herzegovina does not have the necessary know-how or IT equipment.

Regardless of its serious drawbacks, the use of HDD for long-term storage is currently the most prevalent in the Archives.

That which determines the selection of storage medium are modern IT trends, reliability, access speed and price. One should be aware that nowadays the obsolescence of the record carrier is a much more real threat to what is stored on it, than the danger of damage or failure of physical drive. Because of this, any record holder is only a temporary solution and periodic data migration is a mandatory part of any digital preservation strategy. There is a huge offer of the most diverse storage disks on the market, and there are no official standards that define and guarantee their longevity. Manufacturer's claims about durability are most often unconfirmed in practice. For now, the most reliable way of saving is on the server, with default backup in another location. The price of space on the server is rapidly decreasing and they allow the fastest access to the data they store.

EXPECTED LIFETIME OF DIFFERENT DATA CARRIERS	
Magnetic tape	2 years
VHS tape	4 years
Floppy disk	5 years
HQ CD / DVD	30 years
HDD	3 to 5 years
SSD	10 years

6. Close Call

The most serious problem that happened so far in the Archives of Bosnia and Herzegovina was a hardware failure in 2016 on the server where the complete CRPC (*Commission for Real Property Claims of Displaced Persons and Refugees*) database was stored.

Namely, the *Commission for Real Property Claims of Displaced Persons and Refugees*, better known by its English acronym CRPC, was established on March 19th 1996 of Annex 7 of the Dayton Peace Agreement on refugees and exiles. It was responsible for confirming the property rights of displaced persons and refugees, and had the authority to receive and decide on property claims for real estate in Bosnia and Herzegovina in cases where the applicant is not in possession of the property and when the property has not been voluntarily sold or otherwise transferred from April 10th1992.

After the last war in Bosnia and Herzegovina (1992-1995), in addition to all the post-war problems, property and legal chaos appeared in the country. More than four years of the absence of a valid legal structure created the problem of the return of hundreds of thousands of displaced and exiled people to their homes. Property was stolen, illegally transferred to third parties or sold without the knowledge and consent of the rightful owner. The peace process and stability in the post-war period would be unthinkable without the impartial return of real estate. The Commission worked on the basis of its own rules, independently of the regulations and laws of Bosnia and Herzegovina. Its decisions could not be reviewed by any institution in the country. Decisions of the CRPC were final and any transfer, deed, mortgage or other legal document made or assigned by this Commission was recognized as legal throughout Bosnia and Herzegovina. Only the CRPC, upon objection by an interested party or *ex officio*, could review its own decision. The CRPC formally ceased to operate on January 1st, 2009, but its mandate ended in 2003.

In the preparation of archival material for handover to the Archives of Bosnia and Herzegovina, the complete material created by the work of the Central Office in Sarajevo and the Regional Offices was arranged. The method of using archival material, the conditions, the deadline for using the material and the method of issuing original certificates were specified by Annex "C" of the Agreement on the handover of archival material between the CRPC and the Archives of Bosnia and Herzegovina, which was signed on October 30th, 2003. In addition to more than 3,000 boxes of documents, the Archives of Bosnia and Herzegovina also took over a server with a complete database with accompanying software installed, which was used for issuing certificates of property ownership at the written request of an authorized person. Along with the server, one CRPC officer who was in charge of managing and accessing the database moved to the Archive. The server was in operation since 1999 and worked for 17 long years until 2016 when the fatal failure of the motherboard occurred.

While a standard desktop PC can act as a server, there are a few key differences in the hardware that make dedicated servers different from a standard desktop computer. The servers are built for reliability. As such most data center servers, feature hardware with more than one power supply. Now while these machines can most definitely run on just one of those power supplies, the purpose is to have reliability through redundancy. Unfortunately, the servers do not come with two built-in motherboards, so this particular failure could only have been avoided by regular professional hardware supervision and a timely transition to a more modern platform.

Photo 5,6 and 7 – Outdated IT equipment can easily lead to permanent data loss

Therefore, the root of the problem was the lack of rules and procedures for periodic monitoring of the operation and functioning of the server. As the database contained sensitive data, only a CRPC official had access to the server, and at the same time handled the requests of authorized persons and issued certificates. While the hardware was working properly, none of the other employees came into contact with the server. No one was informed about the possible existence of a database backup, nor was the question ever raised. This kind of attitude towards such an important database seems irresponsible and amateurish today, but it should be taken into account that at the time of taking over the CRPC IT equipment, the Archives of Bosnia and Herzegovina was without a single employee who had experience with computers.

The exact cause of the specific failure on the motherboard has not been established, but it is most likely due to a combination of component fatigue and unstable voltage. Simply put, motherboards can fail if they are close to their end of useful life. The server could not be started at all, and the big problem was that all its components were heavily outdated. So outdated that no suitable spare parts could be found either in specialized shops or among scrapped equipment in the Archives itself. Fortunately, the hard drives remained undamaged. The problem was to find suitable adapters to connect a functional computer since their interface was different from the standard (modern) one. When this was finally done, it was possible to copy the complete database file to the new computer. After that, a new search program had to be written, which would redisplay all the data and make it available again. This time a corresponding backup was made. After a little more than a month of downtime, the Archives of Bosnia and Herzegovina was once again able to issue certificates of realestate ownership to the citizens of Bosnia and Herzegovina.

This example shows the importance of professional supervision over the operation of IT equipment and its periodic modernization.

7. New Times, New Technologies

Currently, two servers and one Network-Attached Storage are in operation in the Archives of Bosnia and Herzegovina. One server serves as the updated CRPC database and the other as storage for the fonds and documents scanned so far. Both are regularly monitored and have a backup at another location. It is planned that they will be available online as well, but it is necessary to complete a project that would provide financial resources for the purchase of the supporting equipment. Until then, the digitized documents of the Archives of Bosnia and Herzegovina can only be accessed in the reading room.

Photo 8 and 9 - Server Dell PowerEdge 2900 and Network-Attached Storage Synology DS920+ in use in the Archives of Bosnia and Herzegovina

Network-Attached Storage has recently been used as a backup storage location (NAS)[2]. NAS devices typically do not have a keyboard or display and are configured and managed with a browser-based utility. Each NAS resides on the LAN as an independent network node, defined by its own unique IP address. The purpose of network-attached storage is to enable users to collaborate and share data more effectively. It is useful to distributed researchers that need remote access or work in different time zones. NAS connects to a wireless router, making it easy for distributed employees to access files from any desktop or mobile device with a network connection. NAS type used in the Archives is designed for use in offices or small businesses. The device contain four drive bays, with capacity of 2TB each as a backup target, for archiving and disaster recovery[3]. The NAS is not connected to the Internet and for now it is used exclusively internally. It is planned to be online as well as the Archive's servers, as soon as the project of acquiring the necessary equipment is realized.

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[2] *Network-attached storage (NAS) is dedicated file storage that enables multiple users and heterogeneous client devices to retrieve data from centralized disk capacity. Users on a local area network (LAN) access the shared storage via a standard Ethernet connection (Performance, s.d.).*

[3] *Disks are configured as RAID 1 (mirroring).*

8. Conclusion

As the focus in the manipulation of traditional archival material is increasingly shifting to the management of digital documents, it is a duty and need of archives to join modern trends in order to better meet the demands of the contemporary researcher and make their holdings more accessible and transparent. The Archives of Bosnia and Herzegovina is no exception when it comes to inevitable modernization and the adoption of a new approach to work, but first of all it is necessary to acquire the necessary equipment and train employees to be able to use it in the most utilitarian way.

Digital records, for all their speed of management and ease of reproduction, are equally, if not more, prone to damage and permanent loss. Much effort is required to ensure their durability. Unlike a paper document, a digital record cannot function without the accompanying hardware and the professional staff that service that hardware. Nowadays, changes in the digital environment are fast and expensive. If we do not adapt to changes in a timely manner, digital records are in constant danger of disappearing. The main problem of the Archives of Bosnia and Herzegovina is technological lagging, untimely migration of data, work on outdated equipment and lack of money intended for the IT sector.

So far, only a few smaller archival fonds have been digitized, but thanks to the experience gained during their preservation and migration, the entire process is now much more comprehensible, which will be of great help when the mass digitization project is implemented. Likewise, the problems and dangers to which databases are exposed will be removed as soon as the slightest hint appears.

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POVZETEK

ZAŠČITA DIGITALNEGA GRADIVA V ARHIVU BOSNE IN HERCEGOVINE

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Zaščita arhivskega gradiva pred poškodbami in izgubo je poleg zbiranja in dajanja arhivskega gradiva v uporabo ena izmed glavnih nalog vsakega arhiva. Zapisi, ne glede na to, ali so »tradicionalni« ali digitalni, so predmet staranja. Vsakodnevno rokovanje in neprimerni pogoji za hrambo povečujejo možnost njihove trajne izgube.

Za »tradicionalne« dokumente na papirju je postopek zaščite splošno znan in standardiziran, medtem ko sta zaščita in postopek varnostnega kopiranja digitalnih zapisov v Bosni in Hercegovini še vedno na nezadovoljivi ravni.

Arhiv Bosne in Hercegovine se je v preteklosti že soočal z neljubim dogodkom, ko je izgubil določeno število digitiziranega gradiva, v enem primeru pa je bila celo poškodovana celotna podatkovna baza. Samo zaradi pravočasnega odziva in nekaj sreče ni prišlo do popolne izgube podatkov. Ob tem se je pokazala pomembnost predpisanih varnostnih postopkov pri upravljanju z digitalnimi zapisi (ki do takrat niso bili vzpostavljeni).

Digitalna doba se je začela že pred časom, vendar ne glede na dejstvo, da se brez primerne prilagoditve ne moremo približati modernim arhivskim trendom, prehod na široko uporabo arhivskih podatkovnih baz v Bosni in Hercegovini še ni na zadostnem nivoju.

Avtor predstavlja trenutne izkušnje Arhiva Bosne in Hercegovine pri upravljanju z digitalnimi zapisi, s poudarkom na vidiku hrambe in zaščite, pri tem pa upošteva močan kontrast med zgodovinsko pomembnostjo ohranjenih fondov in zastarelo ter tehnično nezadostno informacijsko opremo, ki je trenutno v uporabi.