STRUCTURAL ORGANIZATION AND OPERATION PRINCIPLES OF THE NATIONAL FINGERPRINT IDENTIFICATION SYSTEM (NAFIS) OF MINISTRY OF INTERNAL AFFAIRS OF REPUBLIC OF BELARUS

D.L. Gordey, A.A. Gotin, S.M.Zavgorodnev, O.V.Lopatenko, V.V. Revinsky

Abstract

In the report offered to Your attention is described the structural organization and operation principles of the National Fingerprints Identification System (NAFIS) of Ministry of Internal Affairs (MIA) of Republic of Belarus and is explained the advantages of selected system decisions.

Introduction

Development of practice in struggle with criminality, in exposure of public order had come to such limit when traditional methods became unacceptable. It is necessary development of means that allow to provide a timely information of necessary type for interested militia services.

One of the most perspective directions in use of latest achievements in informatic is creation of information-and-search systems based on computer data bases of criminals, crime instruments, methods of crime commitment and so on, as well as on a powerful software allowing processing of this data. Analysis of state in computerisation of law-enforcement agencies in foreign countries has shown that in National programs on struggle with criminality a special place is allotted to creation of a national computer-assisted dactylography system as most effective from point of view of practical application in process of crime exposure. Development of such systems is prestige science-consume problem. Systems of such type are characterized with powerful hardware and are oriented on use in large regional information processing centres.

Computer-assisted dactylography identification systems (their modifications, separate units) can be used not only in force structures of state, but in large information systems too (for example in a bank, interbank information systems) on which is made a specialized data processing (an electronic signature, use a fingerprint as an electronic signature or as a mean of access to data, to resources.)

Decision description

Structure of NAFIS

NAFIS of MIA Republic of Belarus is an electronic version of the republican archives of dactylocards and fingerprints of hands from places of crime commitment together with high developed system for search within this archives.

NAFIS structurally is represented by three levels hierarchical model reflecting an existing structure of dactylography information flows and correspond to the organization structure of subdivisions MIA of Republic of Belarus:

- Republican level is a single complex node including a node “Information Centre MIA of Republic of Belarus” (IC MIA) and a node “Expert and-criminalistical Centre MIA of Republic of Belarus” (ECC MIA);
- Regional level consists from seven complex nodes (according to number of regions in Republic of Belarus plus city Minsk having state of region, in limits of MIA structure), each of them includes in themselves the node “Information Centre Administration of Internal Affair of a region” (IC AIA) and a node “Expert-and-criminalistical Division Administration of Internal Affair of a region” (ECD AIA);
- District level consist from more than one hundred and fifty nodes “District Division of Internal affair” (DDIA).

The nodes of IC MIA/AIA are included the electronic archives of dactylocards of common use:

- up to 1 500 000 in IC MIA - the summary republican archive;

- up to 200 000 in each of the IC AIA.

In the nodes of ECC MIA/ECD AIA are held an electronic archives of common use with fingerprints from the places of crime commitment:

- up to 40 000 in ECC MIA - the summary republican archive;
- up to 10 000 in each of the ECD AIA.

In each node of DDIA is held particular electronic archives of dactylocards and fingerprints of hands from places of crime commitment:

- up to 10 000 dactylocards;
- up to 3 000 imprints;

Realized functions

For realization of its own main function - to promote exposure of crimes with use of dactylographic information, in the NAFIS is realized a series of function.

In expert-and-criminalistical divisions of MIA exist large amount of the dactylographic information (more than 500 000 dactylocards and more than 30 000 imprints) on the hard medium (paper, film). In such form this information does not suitable for identification in limits of NAFIS, it should be transformed into special electronic format. For conversion of existed and newly entering dactylographyc information into electronic format is intended workstations “Dactylocards input” and “Imprints input” in ICs and in ECC/ECD accordingly.

Inputted dactylographic information consist from descriptive part and fingerprints images.

After processing on workstation “ Dactilocards input” an dactylographic information is transformed in electronic format and what’s more apart images of fingerprints is formed additional code characteristic. This code is a result of automatic image processing with special algorithm and it namely take part in next search operations. It is allowed editing (translation) of dactylographic information. All inputted (edited) information is personolized, that is in any time can be ascertained who namely was inputted (edited) information. This is necessary for exception of abuses and estimation the quality of operators work at input of fingerprint information. In presence of electronic archive of dactylographic information it is possible to carrying out search operations-requests.

It is allowed the next types of requests:

- a dactylocard in the dactylocard archives;
- a dactylocard in the imprints archive;
- an imprint in the imprints archive;
- an imprint in the archive of dactylocards.

As a sample for search is used a previously inputted information from a dactylocard or an imprint by means of workstation “dactylocards input” or “Imprints input” respectively.

The code characteristic is a main parameter for realization of a search procedure and can be added with other conditions from description part.

A result of execution of request is a list of indexes of most probably candidates in archives corresponding to sample sorted at probably parameter.

Using this list the expert visual compare the images of candidate and the sample. After identification of coincidences is made a preparation of judicial documents.

All requests , results of investigation are personolized that is always can be known who personally was formed the request to made an investigation. This is necessary for excluding of abuses and for analysis a work quality of experts.

For execution of above mentioned functions is intended workstations of “Expert of IC” and of “Expert ECC/ECD”.

Each from nodes of Republican and Regional levels as well as have workstation “Administrator” with which the administrator of the node executes an administrative functions:

- registration and configuration of concrete node in system;
- registration of users and determine theirs categories;
- sequence of request execution management;
- maintenance of dactylographyc information archives;
- keeping of statistical and report documentation.

At the district level in the node of DDIA with taken in account relatively small capacity of keeping dactylographic information possessing particular character and combination by expert obligations on input of dactylocards and imprints, execution of examinations and administration as means o instrument is used complex workstation combined itself with some restrictions, functions of specialized workstation.

System architecture

NAFIS is the system consisting from many component of hardware and software. It is made distinction between components of "Client" and components of "Server".

Component "Client" make up namely the working places of the system and gives described functions. Executing of this functions in the system is created the jobs that is processed locally or is send to the components of "Server" in form of messages. Transferring of the messages from "Client" part already is an asynchronous process.

The "Client" consists from following components:

- user interface realizes the functions described above inherent one or another workstation;
- encoder make up local coding of the fingerprint;
- manager of messages is intended for transfer the messages to the server and receiving of the results;

The "Server" processes all messages from client and send following results;

"Server" consist from the next components:

- data base server executes all requests related to DBMS;
- parallel processing server is originally dispatcher making distribution received from data base server code characteristics of fingerprints of original and then candidates for comparison for some number of local computers receiving results of comparison from them, sorting with pre-emption of the indexes list on most likely candidates;
- local computer is made specialized processing and comparison code characteristics of fingerprint sample and candidates for determine the degree of agreement;
- queue management server is formed jobs on search from queue of requests entering from clients using priority mechanism;
- message manager provides receiving of the messages from client and sending to them the results.

Client components are functioned in Windows-95 environment, server components, except local computers - in UNIX environment, local computers in Windows 95 environment.

Interaction between workstations of the system NAFIS and data base server and in its turn between server and local is based on TCP/IP protocol.

This message can also be used for connection between nodes both within complex nodes and between nodes of various levels.

Performance

The most resource-consuming operation during execution of search requests is an operation of specialised processing of code characteristics of fingerprints and it takes about 95 percent of equipment resources during execution of request. Remaining 5% are accounted for an option of data extraction from the data base and sorting with it with excluding of indexes list at most likely candidates.
For increasing of performance is used the method of parallel search process. It is possibly two version of realization.
<u>The first version</u> implies in that to use some data base servers that parallel executing the request which in limits of this job execution as the data base server will be used only on 5 percents and as computation units at 95 percents.
The advantage of this decision is that realization of such decision is relatively simple and reliable.
Firms, producers of DBMS of corporative type submit special software provided possibility of making a parallel search in data base request.
The disadvantage is that since a data base servers should be used powerful, expensive hardware and in limits of this system in search regime they will be used as the data base servers only on 5 percents.

The second version consist in that it should be used one powerful data base server and to use it as such at maximum for its direct purpose and as the computation units are used from some point of view inexpensive hardware and software.
The advantage is that expensive data base srever is used maximum at its direct use, as a computation units are used relatively inexpensive hardware with minimal configuration. Cost of this version from point of view of hardware and special software cost is in several times less.
The disadvantage is a necessity of development of special software providing parallel calculations ("Server of parallel calculations").
With very large archive capacity it is allowed a parallel use of data base servers for increasing the rate of data extraction from data base and purpose of computation units is invariable.
In NAFIS is used the second version of schematic realization providing a parallel execution of search requests.

Data support

In the system as a data management system is used DBMS of ORACLE corporation. Facilities of ORACLE Server is providing by:

- - an optimal regime of data holding;
- - operative data access;
- - support of data access;
- - data backup and other.

From the point of view of data holding on the technical data medium constituents of fingerprint information is distributed in the following manner:
- A descriptive part and code characteristics is held on high performance magnetic disks, that provide the highest efficiency in execution of search operations. Descriptive part is no more than 512 bytes, part with code characteristic of a fingerprint - 1 K;
- In the Republican and Regional ICs owing to amount of fingerprint cards in number images of fingerprints is held on the optical discs (compact discs) in libraries - that much far less high speed devices with large capacity. In other nodes is used magnetic discs. Access to the images is made in main by direct pointer during reailization of investigations.
The images are hold in compressed form and are not large than 32 K for one fingerprint. It is used JPG algorithm of compression with coefficient equal three that allows to restore an original picture practically without losses. This fact gives an ability to transfer primary (source) fingerprint information in other fingerprint systems without losses.
Data access (insert, change, delete, read) is made through special process on server. With this is guaranteed their reliability and integrity.
System has access to the banks of fingerprint information of common use with several levels of protection from unauthorised access:

- - level of the UNIX operation system;
- - BDMS ORACLE level;
- - application level.

The first levels are universally known, an application one is unique for this system.
Each node of system is unique identificated with territorial and administrative attributes (a country, a region, a district, a department) and with additional address characteristics of global network.
In limits of nodes is made registration of applicated users with given a privilege for execution one of other actions, that is determination of user roles.
It is take place the next user roles:

- - operator of dactylocard input;
- - operator of input imprints of hands fingers from the place of crimes commitment;
- - expert of information centre, who makes an examination of dactylocard in archive of dactylocards;
- - expert of examination-criminalistic department. who made all types of examinations;
- - system administrator;
- - statistician (super).

It is permits holding of more than one roles by one user.
Users as well as are divided on local and external in relation to node. External users is experts of adjacent node and receiving results of examinations made by the local experts.
In limits of complex nodes is foresee an ability of committing examinations in one node by expert from other node that is a part of the same complex node. That is take place in those cases when expert qualification in the node is not satisfied for making of examination at external request.

Registration of external user in obligatory order is came before a registration of external node which they are belonging, This is the necessary condition of authorization for regime of external access to the data. With taken in account the difficulties of creation and volubility of the fingerprint information bank at all nodes of system it is foresaw a possibility of backup copies creation.
In Republican and Regional ICs owing to large amount of dactylocards the backup copy is made on optical discs , at other nodes is used magnetic discs. Procedure of backup copy is realised by an administrator of the node in limits of execution a scheduled works.

Communications

The NAFIS nodes of all levels is joining in global computation network.
The complex nodes belonging to the Republican and Regional levels is connected by network for data transfer with commutation of batches (X.25). This departmental network was developed previously in "Passport" project interests and all newly designing global projects use it as a network base.
The nodes of district level are connected with the Regional nodes through switched communicational circuits.
The nodes is included into the complex nodes are joining into local network.
All elements of the nodes (a data base server, workstations, computational units) is joined in local network. Connection between the data base server and computation units has increased capacity (100 Mbit/sec). This is necessary for practice removing of restrictions on number of parallel computation units that can be appeared as a result of insufficiently network capacity.
Algorithm of interaction between nodes is built on the scheme Client - Agent - Server. In this scheme Client has a short-time contact with server within which it puts a request on search into queue or takes a results of made examinations.
Performing of request being in the queue of requests is entrusted for Agent working at the server - "Queue scheduler".
Such scheme permits to avoid problems connected with low quality of communication circuits and with service costs of communication service departments.

Hardware

As a main hardware in limits of NAFIS is used:

IC MIA			
	Data base server	K 400	1 unit
	Computation units (computers)	Pentium/120	10 units
	Workstations	486DX2/66	5 units.
ECC MIA			
	Data base server	E 55	1 unit
	Workstations	486DX2/66	5 units.
IC AIA			
	Data base server	K 200	1 unit
	Computation units (computers)	Pentium/120	4 units
	Workstations	486DX2/66	5 units.
ECD AIA			
	Data base server	Pentium/120	1 unit
	Workstations	486DX2/66	5 units.
DDIA			
	Complex workstation	486DX2/66	1 unit

All main hardware of the NAFIS is produced by one company - HEWLETT PACKARD that excluded problem with integration of equipment within of system complexes. Technical support is maid by good operating infrastructure created by the Business partners of Hewlett Packard in Republic of Belarus.

Project characteristics of NAFIS
On above stated amounts of fingerprint information using the mentioned above hardware the system provided following results:
- coding of one finger in the dactylocard data base is no more than 30 seconds
- search of the dactylocard in the dactylocard data base:
  - in DDI — no worse than 50 dactylocards/sec
  - in IC AIA — no worse than 200 dactylocards/sec
  - in IC MIA — no worse than 500 dactylocards/sec
- search of the dactylocard in the imprint data base:
  - in DDI — no worse than 3 imprints/sec

- in IC AIA no worse than 10 imprints/sec
- in IC MIA no worse than 10 imprints/sec

(search is made at each finger of dactylocard)

- search of the imprint in the dactylocard data base:
  - in DDI no worse than 3 dactylocards/sec
  - in IC AIA no worse than 50 dactylocards/sec
  - in IC MIA no worse than 140 dactylocards/sec
- search of the imprint in the imprint data base:
  - in DDI no worse than 30 imprints/sec
  - in IC AIA no worse than 100 imprints/sec
  - in IC MIA no worse than 200 imprints/sec

Conclusion

The system decisions proposed in the context of realization of NAFIS MIA (Ministry of Internal Affairs) of RB can be successfully used in designing of large information systems (for example: in bank. interbank information systems), where exists specialized processing of data (electronic signature, a fingerprint as an electronic signature or as a means of access to the data or resources) and it is necessary to receive the greatest outperforms of system reaction.