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Distributed System for Parallel Data Processing of ECT Signals for Electromagnetic Flaw Detection in Materials

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Abstract. The paper proposes a distributed system for parallel data processing of ECT signals for flaw detection in materials. The measured data are stored in files on a host computer, where a JAVA server is located. The host computer is connected through Internet to a set of client computers, distributed geographically. The data are distributed from the host computer by means of the JAVA server to the client computers according their requests. The software necessary for the data processing is installed on each client computer in advance. The organization of the data processing on many computers, working simultaneously in parallel, leads to great time reducing, especially in cases when huge amount of data should be processed in very short time.

I. INTRODUCTION

A new inspection technology, based on eddy current testing (ECT) signals measurement is developed in the last years for flaw detection in materials. For example 100% of steam generator (SG) tubes of nuclear power plants in Japan are subject to ECT over the full length every year (see [6]). The advantages of this technology are: 1) rapid testing of several thousand of tubes and 2) high sensitivity to surface cracks and thinning (see [19]).

Usually impedance signals in specimens are measured and the results are stored in data files, which contain the specimen number, x,y coordinates of the measured points, the real part, the imaginary part and the module of the impedance signal in each point for two frequencies of the input AC current in the probe coil. Here are used data files received from the Japan Society of Applied Electromagnetics and Mechanics.

The purpose of this paper is to propose a distributed system for parallel data processing of ECT signals. The data files obtained from the measurement of ECT signals are stored on a host computer. Thereafter numerical methods are applied for data analysis and for calculation of the flaw coordinates in case there are flaws in the material. The data processing may be performed simultaneously on different geographically distributed computers, so that the technological time necessary for this process will be reduced considerably

II. THE DISTRIBUTED SYSTEM

There are different ways for development of distributed applications for multiple clients (multi-user applications), as for example: 1) Applying Java language environment with direct use of Java sockets [13,14], 2) Use of Remote Method Invocations (RMI) [17], 3) Use Common Gateway Interface (CGI) [2,18], 4) Common Object Request Broker Architecture (CORBA) [16] used together with Java language environment and World Wide Web, 5) Java servlet technology [1,11].

The advantages and drawbacks of RMI, CGI and CORBA approach are considered in details in [1, 5, 9]. The complexity of the distributed data processing system depends on the requirements to the concrete application. If the users need to access remotely a sophisticated set of server based capabilities, the data processing system should be created by means of CORBA approach or Java servlet technology, which use in most flexible and economical way the server resources.

The data processing system proposed is based on the direct use of Java sockets (see [14]) and is an extension of the system presented in [13], designed for concrete data processing of ECT signals. The measured data of ECT signals are stored in files on the host computer, where a JAVA server is located. The host computer is connected with a set of client computers through Internet. The client computers send requests to the server on the host computer in order to obtain data for the data processing. Each request is restricted for example to no more than hundred data files. The necessary data are send in a suitably compressed form from the host computer to the clients via the JAVA server. The compression is necessary in order to minimize the network resources used and the transfer time. The first server response to each client includes an additional (benchmark) data file with data from a specimen without defects in the material. All other data files with measured data are compared with the benchmark data file, so that the files where existence of flaws is supposed, can be quickly separated. The uniform distribution of the data is not possible, because the data processing for the files where flaws exist is more time consuming than for files where no flaws are available and equal large different data samples may need different data processing time, that is not known in advance. In addition the different client computers may have different resources. So that each client computer sends its next request to the server after the data processing of the current data sample is finished. In this way the technological time is optimally used from all the clients.

The distributed data processing system is presented on Fig. 1.

The data processing may perform the following steps:

1. Separate the data for specimens where existence of flaws is supposed, called for example $F_1, F_2, \ldots, F_n$.
2. For each data array F_i, $i=1,\ldots,n$; do:
   a) Determine the type of the flaw (crack, thinning).
   b) Evaluate the 2D coordinates of the flaw (see [7,8]).
   c) On the base of threshold values, presented as a table for flaws with different lengths determine the flaw depth (see [8]).
3. Determine precisely the flaw coordinates
   a) Make refinement of the obtained flaw coordinates by means of more precise FEM-based technique (see [3,4,10]).
   b) Reduce the obtained error by means of a technique described in [15] with finer subdivisions of the mesh elements.

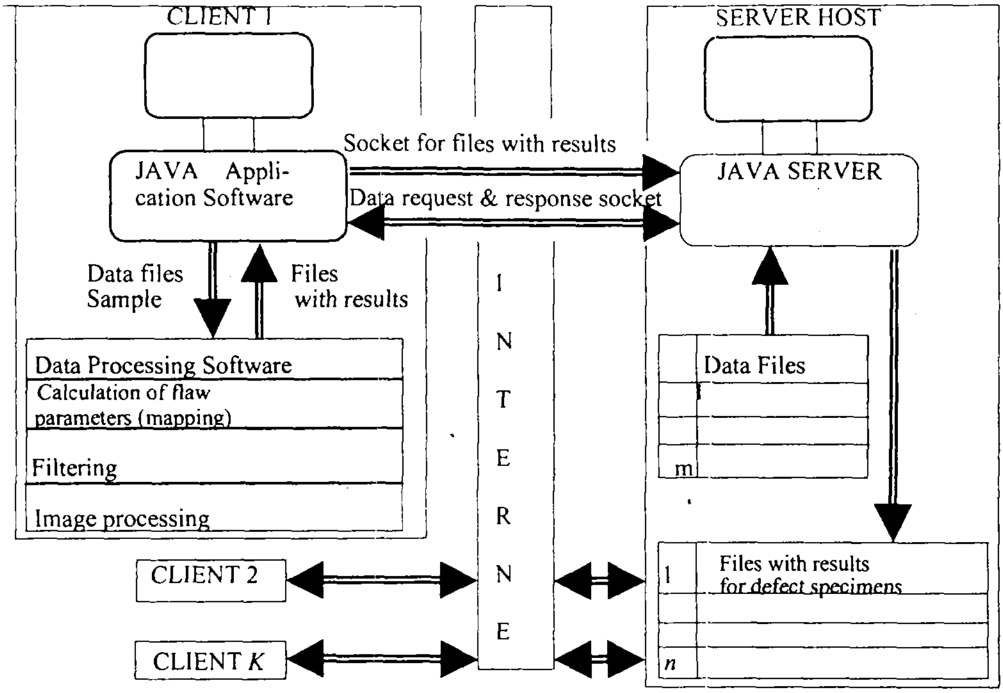

Figure 1: Design of the Distributed Data Processing System

Remark: *For the performance of step* 3. b), *additional measurement of the flaw region with lower step size may be necessary.*

An additional option in the system is the image processing. It uses software modules, which performance is described in [12].

The client computers send back to the host computer the obtained results concerning the flaw coordinates for each data array F_1, ..., F_n; from the current data sample.

The distributed system interface is created by means of the JAVA programming language packages JAVA.AWT and JAVA.LANG. The flaw parameters calculation (the mapping) is realized on FORTRAN and the image processing is based on MATLAB. The system is designed to perform under MS WINDOWS.

III. ILLUSTRATIVE EXAMPLE

The performance of the distributed system is facilitated by the user friendly interfaces, created for the client and for the server side. They serve the transfer of data files between the host computer and each of the client computers.

The client side interface is presented on Fig. 2. Initially the client side operator should type in the directory field the name of the client side directory, where the received data files will be stored. The left pane contains the names of the data files located in the server side directory (source directory). The right pane corresponds to the client side directory and is empty initially. After a click on the button, the names of the files selected by the client operator in the left pane appear in the right pane (Fig. 2.). The transfer begins after a click > on the button.

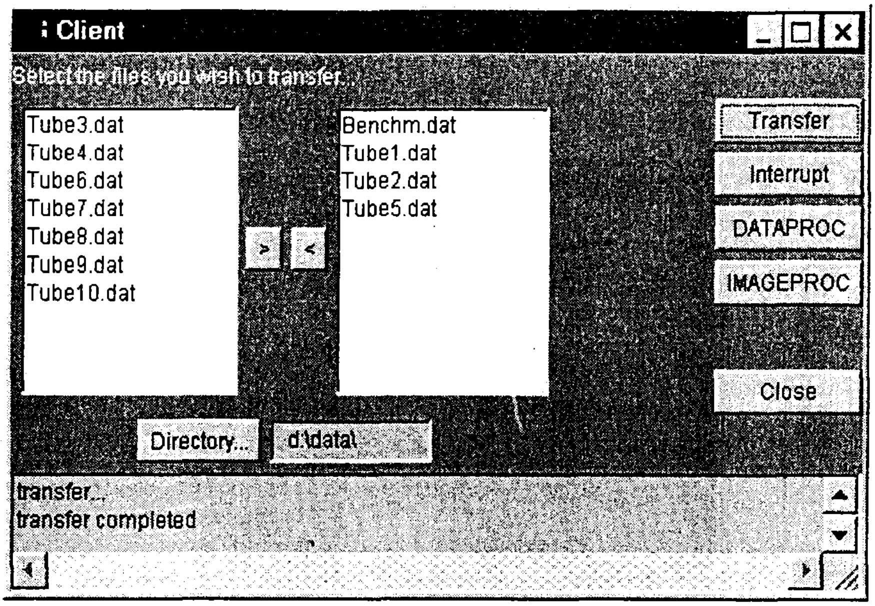

Figure 2: The Client side interface at the end of the transfer

The client operator can check the contents of the Directory field corresponding to the client side directory by a click on the DIRECTORY button and selecting the necessary directory. Then he can send his files with results back to the host computer by means of < button and of button (see Fig. 2). The data processing may be started by clicking the button and the image processing – by a click on the button correspondingly. An example of data processing performance is shown on Fig. 3.

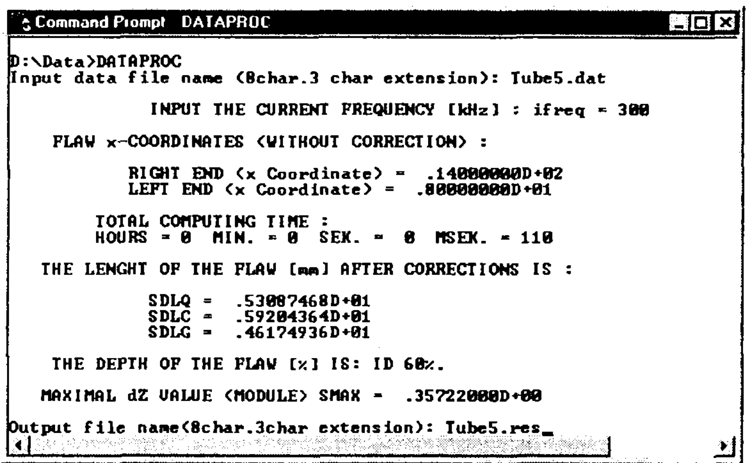

Figure 3: Example of data processing performance

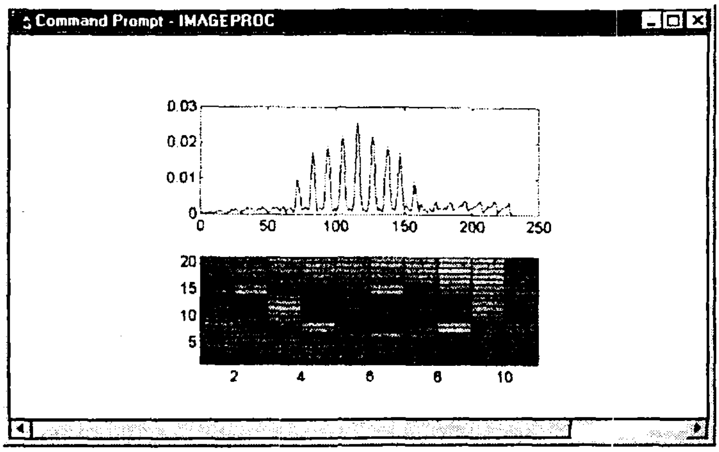

Figure 4: Example of image processing

On Fig. 4 is presented an example of image processing.

The server side interface is presented on Fig. 5. The server-operator can type the name of the current directory, containing the data files in the directory field. By clicking the button the server operator confirms that this directory will be used as a source directory during the data files transfer from the host computer to the client computers.

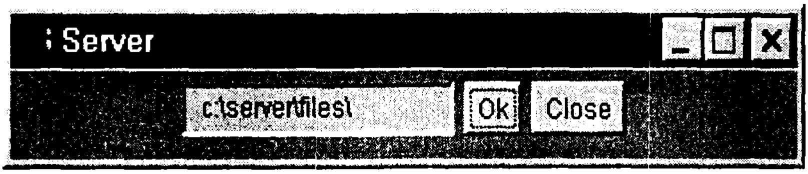

Figure 5: The Server side interface

It should be noted that the Runtime.exec( )method from Runtime class of JAVA.LANG package is used to run the executable files performing data and image processing (see [20]).

IV. CONCLUSION

The design and the development of a Distributed System for Parallel Data Processing of ECT Signals for Electromagnetic Flaw Detection in Materials could represent a basis for a multilateral project.

REFERENCES

[1] H. Bergsten, "An Introduction to Java Servlets", http://www.Webdevelopersjournal.com/articles/ intro_to_servlets.html,2000, pp.1-20.

[2] T. Berners-Lee and D. Conolly, "Hypertext Markup Language - 2.0", Internet RFC 1866, Nov 1995

[3] Z. Chen and K. Miya, "A Knowledge Based Approach for Fast Computation of ECT Signals", Proceedings of ISEM-Braunschweig, May, IOS press, 1997

[4] W. Cheng, K. Miya and Z. Chen, "Reconstruction of Crack with ECT Data", Applied Electromagnetics (Ed. By H. Yamashita, I. Marinova, L. Grcev), 1-st Japanese-Bulgarian - Macedonian Joint Seminar on Applied Electromagnetics JBMSAEM'98, Sofia, 14-15 September1998, pp. 133-138.

[5] E. Evans and D. Rogers "Using Java Applets and CORBA for Multi-User Distributed Applications", 1089-7801/97/S10.000, 1997, IEEE; http://computer.org/internet/

[6] S. Fukui, A. Kurokawa and H. Komatsu, "Progress of Verification Test Program of Eddy Current Inspection Technology for Steam Generator Tube of Nuclear Power Plant in Japan", Electromagnetic Nondestructive Evaluation, IOS Press, 1997, pp. 1-8.
[7] V. Gouliashki and Marinova G., "Fast 3-D ECT numerical analysis", Applied Electromagnetic (Ed. By H. Yamashita, I. Marinova, L. Grcev), 1-st Japanese-Bulgarian-Macedonian Joint Seminar on Applied Electromagnetics JBMSAEM'98, Sofia, 14-15 September 1998, pp. 139-144.
[8] V. Gouliashki., G. Marinova, "Algorithm FCD, Determining the Spatial Parameters of Flaws in Materials", Digest of the Joint Seminar'99, Hokkaido University, Sapporo, JAPAN, November -3, 1999, pp.42-43.
[9] N. Grcevski and L. Grcev, "Web Based Interactive Interface for Power Applications Using Java", Digest of the Joint Seminar'99, Hokkaido University, Sapporo, JAPAN, November 1-3, 1999, pp. 60-61.
[10] H. Huang, T. Takagi, H. Fukutomi and J. Tani, "Forward and Inverse Analysis of ECT Signal Based on Reduced Vector Potential Method Using a Database", presented at E'NDE Reggio Calabria, 1997
[11] Java Servlet API Specification 2.2, Public Release, Sun Microsystems, 1999
[12] G. Marinova, V. Gouliashki, "2D Eddy Current Imaging for Steam Generator Tubing Based on Spline Interpolation Mapping and Improved Statistical Filtering", Applied Electromagnetics (Ed. By H. Yamashita, I. Marinova, L. Grcev), 1-st Japanese-Bulgarian-Macedonian Joint Seminar on Applied Electromagnetics JBMSAEM'98, Sofia, 14-15 September 1998, pp. 145-150.
[13] G. Marinova, V. Gouliashki, "Distributed System for Research in Electromagnetic Flaw Detection in Power Plant Steam Generator Tubes", Digest of the Joint Seminar'99, Hokkaido University, Sapporo, JAPAN, November 1-3, 1999, pp. 44-45.
[14] M. Morgan, "Java TM 2 for Professional Programmers", Part I, II, Info-Dar, Sofia, 1999
[15] A. Napoli,E. Santini C. Santucci,"Algorithm, Database and Error Evaluation for Electromagnetic FEM of Moving Geometries", Proceedings of International Symposium on Theoretical Electrical Engineering, ISTET'97, 1997, pp. 283-286.
[16] Object Management Group, "The Common Object Request Broker Architecture and Specification-Revision 2.0", (OMG 96-08-04), Object Management Group, Framingham,Mass 1996; also available at http://www.omg.org/corba/corbliop.htm
[17] "Remote Method Invocation Specification", Sun Microsystems, Mountain View, Calif;1995;alsoavailableathttp://www.javasoft.com/products/jdk/1.1/docs/guide/rmi/spec/rmiTOC.doc.html
[18] D. R. T. Robinson, "The WWW Common Gateway Interface Version 1.1", Internet Draft http://wwww.ast.cam.ac.uk/-drtr/draft-robinson-www-interface-01.txt, IETF, Feb. 1996; also available at http://www.w3.org/pub/WWW/CGI/Overview.html
[19] T. Takagi, M. Hashimoto , H. Fukutomi, M. Kurokawa, K. Miya, H. Tsuboi, M. Tanaka, J. Tani T. Scrizawa, Y. Harada, E. Okana and R. Murakami, "Benchmark models of Eddy Current Testing for Steam Generator Tube", J. of Applied Electromagnetics in Materials, 5, 1994, 149-162.
[20] http://forum.java.sun.com/read/16791418/q_3U7vXZhyv8AAYyU

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