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Software Section

Obtaining Test Problems via Internet

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Abstract. In this paper we detail a number of sources of test problems accessible via Internet. We also outline a number of ways by which such test problems can be obtained, for example by electronic mail (email), anonymous file transfer protocol (anonymous ftp), Gopher, Veronica and via the World Wide Web (WWW) using browsers such as Mosaic and Netscape.

Key words: Test problems, Internet.

1. Introduction

One problem faced by developers of algorithms is that of obtaining test problems which can be used to compare their algorithms with those of other researchers. In this paper we outline a number of ways by which test problems can be obtained via Internet. We first detail the test problem library (OR-Library), accessible via Internet, maintained by the author. We then outline different ways by which Internet resources can be accessed and finally go on to consider different sources of test problems.

2. OR-Library

OR-Library has details of test problems available for a large number of optimisation problems. Specifically it has details of test problems for assignment, crew scheduling, data envelopment analysis, generalised assignment, integer programming, linear programming, location (capacitated, p-median and uncapacitated), matching, maximum clique, multiple knapsack, network flow, quadratic assignment, resource constrained shortest path, scheduling (flow shop, job shop and open shop), set covering, set partitioning, Steiner tree problems (Euclidean, rectilinear and in graphs), time series forecasting, travelling salesman, two-dimensional cutting (assortment, constrained guillotine, constrained non-guillotine and unconstrained guillotine) and vehicle routing (fixed areas, fixed routes, period routing, single period and sparse feasibility graph). OR-Library is maintained by the author of this paper and researchers with publically available test problems are invited to

contact him (*j.beasley@ic.ac.uk*) so that a reference to their test problems can be included in OR-Library.

3. Internet Resource Access

As readers may be aware there has recently been a rapid increase in the number of users of Internet, as well as continuing evolution in the software tools used to access Internet resources. In this paper we *briefly* outline a number of such tools and illustrate their application by reference to OR-Library. More information about these tools and their general use can be found in [1,2].

Electronic mail (email) is the simplest Internet resource access tool. Typically the user simply sends an email message requesting certain files/information to an email address and the required files/information are sent by return email. For example emailing the message *info* to *o.rlibrary@ic.ac.uk* returns information about the current contents of OR-Library.

Anonymous file transfer protocol (anonymous ftp) is a more complex Internet resource access tool. With it the user accesses (as an anonymous user) another computer and transfers files. Figure 1 illustrates an anonymous ftp session, with appropriate annotations, for OR-Library.

Email and anonymous ftp require relatively technically sophisticated users. There are a number of tools for accessing Internet resources that are more menu-driven and which attempt to hide technical complexities from the user, among these tools are Gopher, Veronica, Mosaic and Netscape.

Gopher is an interactive system that offers menu-based capabilities for accessing Internet resources. A related tool is Veronica which offers a keyword search of the Internet resources known to Gopher.

Readers of this paper may well have Gopher and Veronica available on their own systems. If not, then a publically available Gopher/Veronica system can be reached by telnet (the Internet tool that allows a user to log into a remote computer). Simply *telnet* to *ux1.cso.uiuc.edu* and login as *gopher.*

The World Wide Web (WWW) is an emerging linking of Internet resources via hypertext documents–documents (files) with explicit links to other documents (wherever they may reside on Internet). One specific tool for accessing WWW documents is Mosaic. Mosaic is a graphical, mouse driven, tool (as opposed to the previous mentioned tools, Gopher and Veronica, which are essentially command line driven menus). Such graphical tools are typically known generically as *browsers*. Netscape is another popular browser. Readers without Mosaic (or any other WWW access tool) available on their own systems can access information about the WWW and available WWW access tools by *telnet* to *telnet.w3.org.*

```
ftp mscmga.ms.ic.ac.uk            ... use the ftp command to access the appropriate computer
Connected to mscmga.
220- Imperial College of Science, Technology and Medicine
220-
220-                    Management School
220-
220-     This computer system is operated on behalf of
220-                 Imperial College
220-
220- Only authorised users are entitled to connect and/or
220- log in to this computing system. If you are not sure
220-    whether you are authorized, then you are not and
220-           should DISCONNECT IMMEDIATELY.
220-
220 mscmga FTP server ready.
Name (mscmga.ms.ic.ac.uk:jebl): anonymous                      ... login as an anonymous user
331 Guest login ok, type your name as password.
Password: smith                                     ... enter any name as a password
230-
230-
230- Welcome to OR-Library
230-
230- All files are stored in the pub directory and have a .txt extension
230-
230- The file info.txt in that directory gives further information on
230- the files that are available
230-
230- J.E.Beasley
230-
230-
230 Guest login ok, access restrictions apply.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp> cd pub                                        ... change to the appropriate directory
250 CWD command successful.
ftp> ls                                            ... use the ls command to list files
200 PORT command successful.
150 Opening ASCII mode data connection for '/bin/ls'.
total 569892
-rwxr-xr-x  1 jebl     6653      16564 Jan 13  1994 area1.txt
-rwxr-xr-x  1 jebl     6653      25466 Jan 13  1994 area2.txt
                                        ... lines of file listing deleted for clarity
-rwxr-xr-x  1 jebl     6653        875 Mar  9  1994 vrpfeasinfo.txt
-rwxr-xr-x  3 jebl     6653       1359 Oct 21 11:14 vrpinfo.txt
226 Transfer complete.
ftp> bin                                           ... set to binary mode for file transfer
200 Type set to I.
ftp> get vrpinfo.txt                               ... get a particular file, namely vrpinfo.txt
local: vrpinfo.txt remote: vrpinfo.txt
200 PORT command successful.
150 Opening BINARY mode data connection for 'vrpinfo.txt' (1359 bytes).
226 Transfer complete.
1359 bytes received in 0.05 seconds (29.18 Kbytes/s)
ftp> quit                                          ... finish the session
221 Goodbye.
```

Figure 1. Anonymous ftp session for OR-Library.

```
DIMACS
     ftp: address: dimacs.rutgers.edu
          directories: pub/netflow & pub/challenge/graph
     WWW address: http://dimacs.rutgers.edu/


ELIB
     email:    message: send index
               address: elib@zib-berlin.de
     ftp: address: elib.zib-berlin.de
          directory: /
     telnet:   address: elib.zib-berlin.de
               login: elib
     WWW address: http://elib.zib-berlin.de/


MIPLIB
     email:    message: send catalogue
               address: softlib@rice.edu
     ftp: address: softlib.cs.rice.edu
          directory: pub/miplib
     WWW address: ftp://softlib.cs.rice.edu/pub/miplib


NETLIB
     email:    message: send index
               address: netlib@ornl.gov
     ftp: address: netlib2.cs.utk.edu
          directory: /
     WWW address: http://www.netlib.org/index.html


OR-Library
     email:    message: info
               address: o.rlibrary@ic.ac.uk
     ftp: address: mscmga.ms.ic.ac.uk
          directory: pub
     WWW address: http://mscmga.ms.ic.ac.uk/


QAPLIB
     ftp: address: ftp.tu-graz.ac.at
          directory: pub/papers/qaplib
     WWW address: ftp://ftp.tu-graz.ac.at/pub/papers/qaplib


TSPLIB
     can be contacted via ELIB as detailed above
     can be contacted via MIPLIB as detailed above (directory
     pub/tsplib)


Note: for all ftp addresses login as anonymous
```

Figure 2. Access details for test problem sources.

4. Test Problem Sources

Below we outline a number of test problem sources accessible via Internet. Details of how to access these sources are given in Figure 2.

DIMACS has test problems available for cliques, colouring, matching and network flow. It also has available a selection of computer codes for such problems.

ELIB has test problems available for assignment, clustering, linear programming, integer programming, matching, maximum flow, minimum cost flow, set partitioning, Steiner tree problems, travelling salesman, transportation and vehicle routing. It also has available a wide selection of computer codes for various problems.

MIPLIB has test problems available for linear and integer programming.

NETLIB has test problems available for linear programming and unconstrained optimisation. It also has available a wide selection of computer codes for various problems.

QAPLIB has quadratic assignment test problems and TSPLIB has travelling salesman test problems.

5. Appeals

It is possible to make an "appeal" in order to solicit information about test problems in a particular field. By this we mean broadcasting a general request for such information to a large number of people.

This is best done using Usenet newsgroups. Readers with access to Usenet (typically those with Internet access) can appeal to the subscribers of any newsgroup. Relevant newsgroups for readers of this journal might include *sci.op-research*, *sci.math.num-analysis*, *sci.math*, *sci.math.research* and *sci.nonlinear*. For more about newsgroups see [1,2].

6. Conclusion

In this paper we have outlined a number of ways by which test problems can be obtained via Internet.

References

1. Dern, D. P. (1994), *The Internet Guide for New Users*, McGraw-Hill, New York.
2. Krol, E. (1994), *The Whole Internet User's Guide and Catalog*, 2nd edition, O'Reilly & Associates, Sebastopol, California.