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OR-Library: Distributing Test Problems by Electronic Mail

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In this note we present a system (OR-Library) that distributes test problems by electronic mail (e-mail). This system currently has available test problems drawn from a number of different areas of operational research.

Key words: electronic mail

INTRODUCTION

One problem faced by research workers in operational research is the difficulty of comparing any algorithms that they develop with those of other workers. If a standard set of test problems is available, then algorithms can be compared on a more realistic basis (with regard to their performance on *exactly* the same set of test problems) than would otherwise be so.

In linear programming, for example, the problems available from NETLIB[1] have been widely used in recent research[2–7] into interior point methods for linear programming. NETLIB is a facility for obtaining linear programming problems via electronic mail (e-mail). A user merely sends an e-mail message to NETLIB specifying the particular test problems that they require, and NETLIB returns those problems to them via e-mail.

It is clear that e-mail is spreading rapidly amongst research workers in OR both within the United Kingdom and abroad. For example, within the United Kingdom there is the OR network/bulletin-board system (OR-Net) administered by the School of Computer Studies at the University of Leeds. Many letters from researchers overseas also now contain an e-mail address.

We felt that it would be of value if we made available via e-mail those test problems that we have collected and/or generated during our 15 years of research into OR. As these test problems are based on our own research experience, the areas covered are somewhat idiosyncratic. However, we believe that this note will encourage others to make their test problems accessible via e-mail in a similar manner. Hopefully, therefore, within a relatively short period of time, standard test problems accessible via e-mail will become established for many common OR problems.

Note here that whilst test problems can be (and often are) distributed by floppy disk, the method is time-consuming for the distributor (copying to disk the required files), expensive (cost of disks and postage) and slow (often taking weeks between the request being sent and the test problems being received). By contrast, distributing test problems via e-mail can be highly automated, is usually free to the users (as costs are met centrally) and is relatively quick.

OBTAINING TEST PROBLEMS

In order to obtain test problems, a user first has to establish an appropriate e-mail address for our system, *OR-Library*, for their particular e-mail network. Table 1 gives suggested addresses for OR-Library for a number of different e-mail networks. Clark[8] lists some 82 different e-mail networks, so it is clearly impossible to give a comprehensive list of addresses for OR-Library. It is hoped that Table 1 provides enough information for users (assisted by their local e-mail expert if necessary) to establish an e-mail address for OR-Library.

To test the address, the user simply mails to that address the message

info

TABLE 1

E-mail network	OR-Library address
Acsnet (Csironet)	umtsk99%vaxa.cc.imperial.ac.uk@munnari.mu.au
Csnet (Phonenet)	umtsk99@vaxa.cc.imperial.ac.uk umtsk99%vaxa.cc.imperial.ac.uk%nsfnet-relay.ac.uk@relay.cs.net
Ean	umtsk99@vaxa.cc.imperial.ac.uk
Earn (Bitnet/Netnorth)	umtsk99@vaxa.cc.imperial.ac.uk umtsk99%vaxa.cc.imperial.ac.uk@ukacrl
Internet (Arpanet/Darpa/Nsfnet)	umtsk99@vaxa.cc.imperial.ac.uk umtsk99%vaxa.cc.imperial.ac.uk@nsfnet-relay.ac.uk umtsk99%vaxa.cc.imperial.ac.uk@cunyvm.cuny.edu
Janet	umtsk99@uk.ac.imperial.cc.vaxa
Junet	as for Csnet above umtsk99%vaxa.cc.imperial.ac.uk@bitnet-relay
Uucp (Eunet/Uknet/Usenet)	as for Internet above umtsk99%vaxa.cc.imperial.ac.uk@ukc.uucp ...!ukc!vaxa.cc.imperial.ac.uk!umtsk99
X.400 environment	umtsk99@vaxa.cc.imperial.ac.uk
Other e-mail networks	umtsk99@vaxa.cc.imperial.ac.uk umtsk99%vaxa.cc.imperial.ac.uk@earn-relay.ac.uk umtsk99%vaxa.cc.imperial.ac.uk@nsfnet-relay.ac.uk umtsk99%vaxa.cc.imperial.ac.uk@ean-relay.ac.uk umtsk99%vaxa.cc.imperial.ac.uk@mhs-relay.ac.uk umtsk99%vaxa.cc.imperial.ac.uk@ukc.ac.uk

Note: Where more than one address is shown, addresses should be tried in the order given to establish which one will work correctly.

i.e. a one-line message consisting solely of the word 'info' (which tells OR-Library that the user is requesting the info file). If the address is correct, then the user will have the info file mailed back to him. Figure 1 gives the current version of this file. As can be seen from Figure 1, it outlines the areas for which test problems are available, and details the files that give further information about these test problems.

Welcome to OR-Library.

The following table gives the relationship between problem area and the appropriate file:

Problem area	File
Capacitated warehouse location	capinfo
Data envelopment analysis	deainfo
Euclidean Steiner problem	esteininfo
Linear programming	lpinfo
P-median	pmedinfo
Rectilinear Steiner problem	rsteininfo
Resource-constrained shortest path	rcspinfo
Set-covering	scpinfo
Set-partitioning	sppinfo
Steiner problem in graphs	steininfo
Two-dimensional cutting:	
assortment problem	assortinfo
constrained guillotine	cgcutinfo
constrained non-guillotine	ngcutinfo
unconstrained guillotine	gcutinfo
Uncapacitated warehouse location	uncapinfo
Vehicle routeing:	
fixed areas	areainfo
fixed routes	fixedinfo
period routeing	periodinfo
single period	vrpinfo

John Beasley, June 1990.

FIG. 1

As an example, suppose that the user is interested in test problems for the capacitated warehouse location problem. Then the user simply mails to OR-Library the message

capinfo

i.e. a one-line message consisting solely of the word 'capinfo' (which tells OR-Library that the user is requesting the capinfo file). Figure 2 gives the current version of this file, which will be mailed back to the user.

There are currently 40 data files.

These data files are the test problem sets IV to XIII and A to C in Table 1 of J. E. Beasley 'An algorithm for solving large capacitated warehouse location problems' *European Journal of Operational Research* **33** (1988) 314–325.

These test problems essentially (but see Appendix in the above paper) include the standard Akinc and Khumawala test problems for the capacitated warehouse location problem.

The following table gives the relationship between test problem set and the appropriate files:

Problem set	Files
IV	cap41, ..., cap44
V	cap51
VI	cap61, ..., cap64
VII	cap71, ..., cap74
VIII	cap81, ..., cap84
IX	cap91, ..., cap94
X	cap101, ..., cap104
XI	cap111, ..., cap114
XII	cap121, ..., cap124
XIII	cap131, ..., cap134
A	capa
B	capb
C	capc

The format of these data files is:
number of potential warehouse locations (m), number of customers (n);
for each potential warehouse location i (i = 1, ..., m): capacity, fixed cost;
for each customer j (j = 1, ..., n): demand, cost of allocating all of the demand of j to warehouse i (i = 1, ..., m).

For files capa, capb and capc (which are large files), in order to save file space, a single data file is used to represent four test problems. The word 'capacity' in these files should be replaced by the appropriate numeric value from Table 1 of the above paper in order to generate each of the four problems in problem sets A, B and C.

The value of the optimal solution for each of these data files is given in the file capopt.

The largest file is capc of size 1300 Kb (approximately).
The entire set of files is of size 5000 Kb (approximately).

FIG. 2

Suppose now that the user is interested in obtaining the files associated with problem set IV in Figure 2. Then the user simply mails to OR-Library the message

cap41
cap42
cap43
cap44

i.e. a four-line message consisting of the words cap41, cap42, cap43 and cap44 on separate lines (which tells OR-Library that the user is requesting the cap41, cap42, cap43 and cap44 files). These files will then be returned to the user as four separate e-mail messages. Potential users of OR-Library should note the following:

(a) Files will be returned with the subject field of the message being used to indicate the name of the file.

(b) Each line of any message sent to OR-Library should contain only one word (which should be a file name).
(c) As can be seen from the bottom of Figure 2, individual files (and the entire set of files) for a particular problem can be quite large. Users who have successfully contacted OR-Library (received the info file) but who are experiencing difficulty in receiving files are advised to check that their computer is capable of receiving large files (e.g. with respect to available file space and mailing software).
(d) OR-Library runs on a VAX 8600 under VMS V5.3, requires a minimum of human intervention, and we hope to return files to users within 2 working days (although we obviously cannot guarantee such a turnaround time).
(e) OR-Library maintains a list of all users who contact it in order to mail significant updates of the info file to them as appropriate.
(f) Messages concerning OR-Library (*other* than requests for files) should be sent to the author, either in writing or by e-mail (replace umtsk99 in Table 1 by umts020).

CONCLUSIONS

In this note we have presented a system (OR-Library) which distributes test problems for different OR problems. We hope that OR-Library will be of use to researchers and will encourage them to make their own collection of test problems available via e-mail.

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