THE HARWELL LOW LEVEL MEASUREMENTS LABORATORY MICROCOMPUTER NETWORK

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1. Introduction

The Research Centre for Computer Archaeology has been associated with the Low Level Measurements Laboratory at Harwell since 1979. Originally set up to measure Tritium for hydrological applications, the laboratory later extended its services to the measurement of Carbon-14 and certain stable isotopes, for applications in archaeology, hydrology and environmental fields. It is now one of the most active laboratories for service measurements of Carbon-14, handling around 400-500 samples per year, the greater proportion of which are for archaeological dating applications. The laboratory is also involved with certain research and development programmes including: the measurement systems employed, areas of application and field study support projects. The staff complement includes full time, part time and temporary staff, post graduate research and undergraduate industrial experience students. The project management and administrative services are situated in a different building some 500m away, a point which is relevant in the discussion of hardware implementations below.

Until recently the laboratory was served exclusively by the Harwell IBM 370 mainframe computer, using programs written in FORTRAN, with input mainly from punched cards, but with some papertape originating from teletypes connected to the liquid scintillation counters (Otlet and Walker, 1981a and 1981b). The increasing throughput of samples and the need for greater overall business efficiency has initiated a programme leading to major modernisation and extension of the electronics, computer data gathering and processing facilities in the laboratory. The new small-sample gas counting system is the first example of this, employing microcomputer data gathering from many counters, spectrum display and analysis (Otlet et al., 1982). This equipment, the original software for which was developed with RCCA support, is now in routine operation for Carbon-14 measurements using miniature gas counters for very small samples, down to 10mg of Carbon content.

The current involvement of the Polytechnic began with the decision, in 1980, to reorganise completely the computing procedures, and in particular to integrate the data processing, commercial management and administration requirements into a microcomputer based system with links to the group office and the Harwell mainframe. The current implementation uses two independent networks based on Research Machines Limited (RML) 480Z and 380Z equipment, linked by low-loss coaxial cables within the buildings and by existing terminal lines between buildings. Mainframe links are not yet established but are planned to be implemented via Harwell's Gandalf PACX line switching system, when this becomes fully operational.

This paper discusses the design requirements, the development of the hardware and software components and mentions briefly, the proposed implementation of the Harwell and Council for British Archaeology (CBA) radiocarbon databases, now in the pilot stage.

2. System requirements

Analysis of the system requirements showed four main functional categories:

a) General administrative functions, including letter writing, project files, internal "electronic mail", standard reports and letters, resource management, etc.,

b) Customer liason, including management of laboratory customer files, sample progressing and scheduling, generation of measurement reports, circulars, etc.,

c) Data processing, including equipment control, assimilation of experimental data, calculation of results and graphical representation, etc.,

d) Research and development, including preparation of research reports and technical data sheets, automatic preparation of formatted sample data for publication in Radiocarbon, storage of laboratory publications, references and the management of radiocarbon databases, etc.

3. System planning

At the core of almost all the computer operations is the need to access databases containing customer details, addresses, previous dealings, sample whereabouts, progress, measurement data and results. Integration of these was planned using a database management system with the prime databases held either locally or on the Harwell mainframe. The local database, held on the microcomputer system would enable rapid access to customer or sample details for telephone or written enquiries, while the mainframe system would be used for logical searches of various types required on a longer term basis, e.g. for results certificates, or for publication in Radiocarbon or CBA approved styles.

Although most data collection is at present by manual methods, in the future the quantity collected by automatic means, direct entry via keyboard or even hand-printed character recognition devices, will inevitably increase. Automatic data collection, before the small counter facility, was confined to the use of teletypes, as papertape punches, on the liquid scintillation counters, so the planned use of intelligent, direct data acquisition techniques is seen as an important advance.

Use of a microcomputer as an intelligent terminal to mainframe facilities is an attractive solution to the problem of transferring data between the microcomputers and the mainframe as well as allowing interrogation of the mainframe databases.

For the efficient integration of all these requirements a network of stand-alone microcomputers configured as user stations was decided upon, and to accommodate the geographical separation of the two sections of the group, two linked, but otherwise autonomous, networks were planned. The two buildings would have their own networks linked both to each other and to the Harwell mainframe. The use of distributed processors (the stand-alone microcomputers) offers greater reliability of the system in that failures of individual stations do not lead to a one-out-all-out situation and even a server failure does not necessarily prevent at least limited operations from continuing.

Other design features relating to the system's use by laboratory staff and the safeguarding of the data handled, are listed below:

a) New procedures should save staff time and not just generate new tasks: for example, work carried out by mainframe computer staff should not be transferred to microcomputer operation by laboratory staff unless clear benefits could be shown.

b) The system should be as robust as possible to the effect of user induced errors, i.e. they should be readily recognised, intercepted and easily recovered (ideally automatically).

c) Backup systems should be very safe, i.e. accidental irrecoverable loss of data through operator errors should be fully guarded against.

d) Sensitive data should be protected from unauthorised access.

4. Hardware solutions

An outline schematic of the solution proposed for this project is given in Figure 1. The achievement of the full scheme is planned in four development phases, building on the existing pre-network installation, listed as phase 0 below.

4.1 Phase 0 - 1979/1980

This first system was primarily introduced to serve the small counter Carbon-14 measurement facility. It consisted of a NASCOM 1 single board microcomputer to capture counter data and an RML 380Z with minifloppy discs, high resolution graphics, papertape reader and a QUME daisy wheel printer. The RML 380Z was essential for the periodic processing of data collected by the NASCOM but, when not so engaged, was also available for general purpose laboratory computing requirements.

4.2 Phase 1 - 1982

The first expansion updated the 380Z to a prototype network server, with full-sized floppy-discs and a number of 480Z microcomputer stations. One of these stations replaced the original 380Z and continued to support the small-sample gas counter set-up via the NASCOM 1. The original network hardware and system software were developed by Research Machines Limited, based on Digital Research's CP/NET and Zilog's ZNET, and Harwell was established by Reseach Machines Limited as a field trials site.

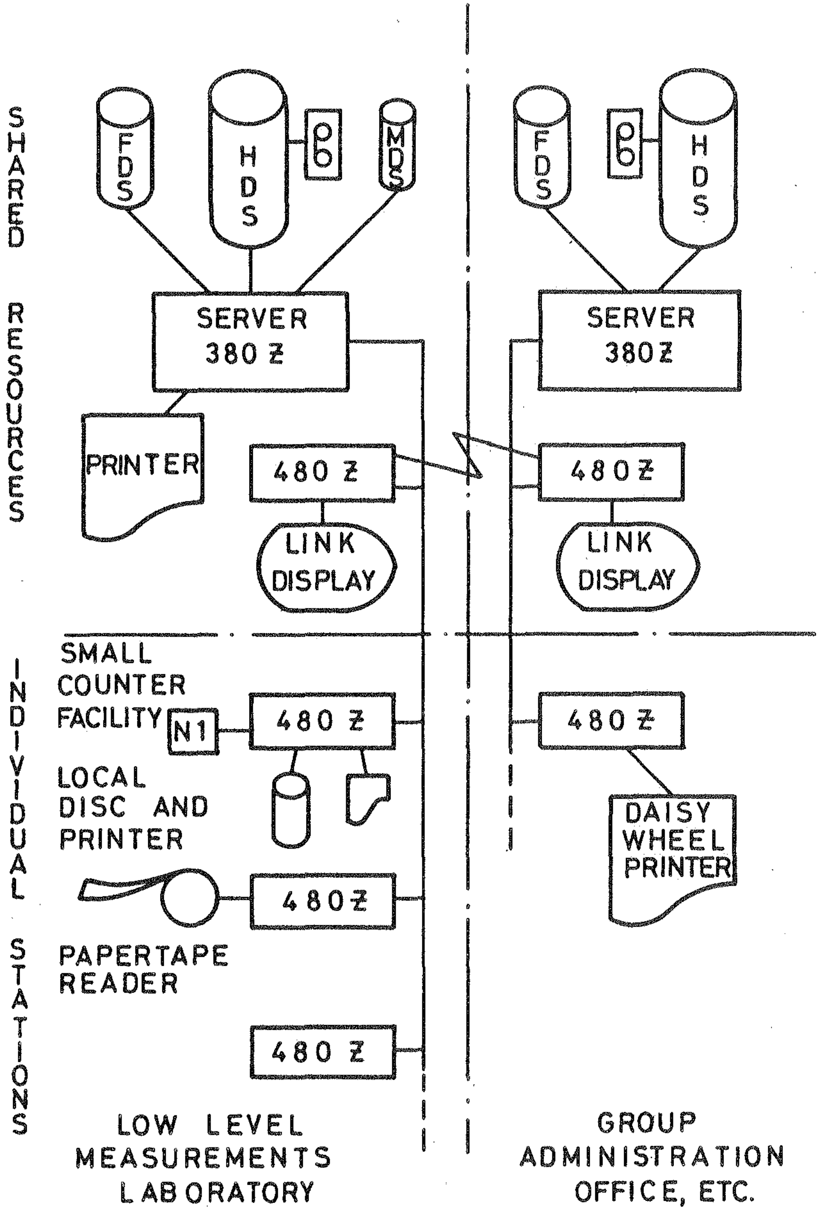

FIGURE 1. SCHEMATIC OF LINKED TWIN NETWORK SYSTEM.

4.3 Phase 2 - 1982/1983

The main expansion in this stage was the installation of equipment in the group office, to form the core of the second network, and its link to the laboratory system. The main problem preventing its immediate implementation was how to achieve signal transmission between the separated locations, approximately 500m apart. It was originally proposed to link the two servers using a direct coaxial server-to-server cable, giving all stations access to both networks. While this was, and still is, technically possible, to lay the low-loss coaxial cable between the two locations proved impractical on the Harwell site and use of this method would also have had certain disadvantages for security. It was therefore necessary to find an alternative solution. The current implementation uses two dedicated 480Z stations as communication supervisors, allowing both secure access and a central display (by analogy a type of airport arrivals/departure board) to attract users' attention to waiting messages as shown in fig 2.

4.4 Phase 3 - 1983

Work is starting on this phase, the major part of which is the expansion of the group office system into a full network. Initially this will involve the provision of more 480Z's on both networks together with suitable software.

4.5 Phase 4

Further expansion is planned but some of it depends upon development progress by Research Machines Limited. Particular features it is hoped to include are:

a). Local discs.
For stations producing large amounts of unreduced data not required by any other station the use of local discs will free space in the common area, reduce unnecessary time overheads on the server and thereby improve response times on the network. It will also help maintain operation in the event of server failure.

b) Additional storage capacity on the server.
Although initially this will probably be done by changing to double recording-density and double track-density on the existing drives, addition of more drives and/or hard discs is also being

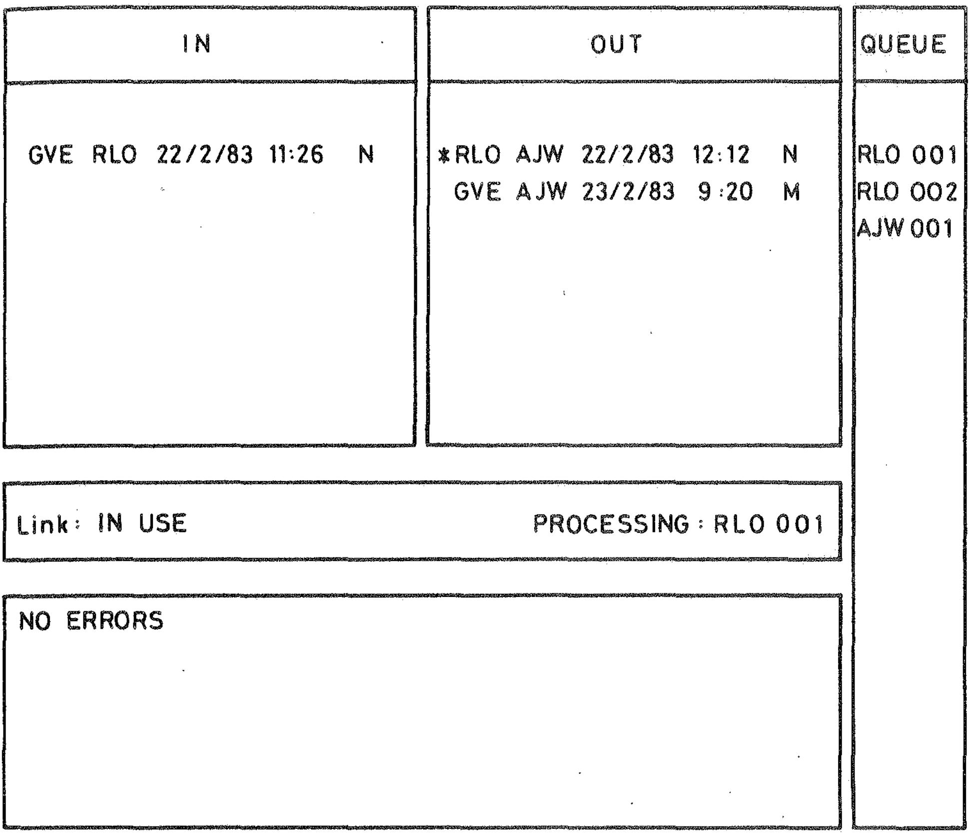

FIGURE 2. EXAMPLE OF DISPLAY BOARD FORMAT

considered. This will allow expansion of the scope of the local databases and enable more detail to be immediately available for telephone or written enquiries.

c) Faster shared-facility printers and local printers. This will also help to reduce time and disc space overheads on the server, again improving the response times of the network.

d) Direct connections to all the data producing equipment in the laboratory.
This will help reduce the numbers of operator-induced errors and remove tedious jobs such as the input of papertape.

e) External network and mainframe interfacing.
This will increase the flexibility and number of facilities that can be used in the laboratory, eg. Colour graph plotting and access to the Harwell CRAY 1.

5. Software Development

The software development is discussed under three categories: already established, currently under development and future plans.

5.1 Established Software

This is all related to the small-sample gas counting facility. It includes software developed for graphical display, analysis and long term storage of energy spectra, as well as proprietary packages for word processing and normal facilities for program development.

5.2 Current Development

As an introduction for the staff, some isolated packages concerning the administration procedures have been implemented. These include the post management system, various network versions of data reduction and summary programs currently running on the mainframe, and some word processing utilities.

The most crucial part of the software, now in the final stages of development, is the inter-network communications system and this will now be described in more detail.

As mentioned previously, it is technically possible to support the two servers on a single cable network over a distance of up to a couple of kilometres, but there were two main reasons for choosing to make them two independent networks with a link to each other via two dedicated, supervisory 480Z's.

The first and major reason was the physical difficulty of having a low loss coaxial cable laid between the two buildings, and although this is still not impossible, other considerations dissuaded us from attempting this solution.

The second reason, related to the operational aspects of the link, refers to the fact that transfer of information should not be totally transparent and unannounced, by analogy a telephone without a bell.

The solution, having passed through the flashing lights and beeper stages, was to adopt the "arrivals/departures board" approach, and to have a central display from a dedicated communications station on each network. Fig 2 shows the format of the proposed display "board". It is divided into five windows in which are displayed the labels of the messages awaiting users' attention (From/To/Where/When etc.), labels of messages awaiting transfer to the remote network, link status information, any error messages and progress on messages in the queue for transfer. This meant that in order to generate a fully addressed announcement, both the originator and the addressee had to be identified to the system. To do this, it was decided to adopt the usual mainframe procedure of logging in to a "session", requiring a user identifier and password, before the communications facilities can be initiated. Once logged in the users would then be able to see any messages addressed to them, to originate new messages or to initiate inter-network file transfers, with access controlled by passwords where necessary. In addition to direct user operation it should also be possible for applications programs to request unannounced inter-network transfer of certain system files, for routine processing functions, eg. the post management system.

Information retrieval strategies for the sample information databases have also been investigated. Plans for translating existing mainframe databases into a high-level structured format similar in concept to that used by the Museum Documentation Association are well under way, and it is proposed that this or a similar, high-level format should be offered for use for international communication between existing radiocarbon databases. This is the subject of a paper to be given at a forthcoming conference (Wilcock, Otlet and Walker). A prototype program exists that translates Harwell and CBA radiocarbon records into this format.

5.3 Future Plans

Systems analysis has been completed for the following applications packages:

a) Microcomputer database for ephemeral customer records, sample progressing, and customer records. The database has information on customers, customer communications, finance groups, samples, laboratory runs, and field sites, with appropriate relational links.

b) Mainframe database comprising detailed customer and sample information again with appropriate relational links.

c) Data capture sub-systems for automatic data acquisition from the laboratory equipment, with both short and long term storage.

d) Administrative sub-systems for full post management, personal diaries, general departmental planners, memoranda, and archiving.

6. Conclusions

The Harwell Low Level Measurements Laboratory microcomputer network is already contributing to the operations of this active Carbon-14 measurement laboratory. Although its primary purpose is to increase efficiency of running the service, the use of the computer allows ready access to much of the information not directly related to the measurement process, eg. archaeological documentation, which was originaly only added at a much later stage just for report publication. The network approach will allow integration of these data handling requirements without the need for bulky and expensive equipment but still offer a reasonably robust and reliable system for use throughout the laboratory.

Although the system has been designed specificaly around the needs of the Low Level Measurements Laboratory, it may find wider application in installations involved in similar commercial/scientific operations, where the commodity is analytical measurements from sophisticated scientific apparatus and especially where this and other data are required for reference purposes.

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