

OVERCOMING OPERATIONAL MANAGEMENT PROBLEMS

WITH A SCHEDULER

by

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INTRODUCTION

In September 1977 the London Business School Computer Department installed a HP 3000 Series II Model 8 Computer System to provide replacement computing facilities to the research and administrative departments, who were previously dependent upon an ageing IBM 360/65, at University College of London, for providing their computing needs. The HP 3000 was to supply interactive and batch computer facilities to users in the following research areas: Economic Forecasting; Finance; Accounting; Marketing; Statistics; Quantitative Methods; Modelling. The system was also to provide a service to a mix of administrative, teaching and external users.

Initially, the first six month period was virtually devoted to the conversion of existing software from the IBM 360/65 with a substantial amount of new software being developed.

It was after this period and a great deal of system experience had been gained both by users and operations personnel, that it became apparent that the system lacked some desirable operational control functions in the following areas:

- Enforcing job CPU resource limitations
- Scheduling and providing notification of tape requests
- Cancellation of jobs by users prior to execution.

After careful deliberations in attempting to find a solution to overcome these system deficiencies it was decided that by implementing some form of automatic monitoring and scheduling system that this would provide the means of surmounting these problems.

OPERATIONAL MANAGEMENT PROBLEMS

In an effort to maximise the general batch job throughput and to evenly distribute batch CPU resources between users, during peak usage periods, it was decided that a realistic maximum CPU time obtainable would have to be placed on jobs during these periods. Unfortunately, we found that the system lacked any useful mechanism which could be adopted to enforce certain job CPU resource limitations within different time slots. (e.g. Setting a maximum CPU time of 300 seconds during Prime Shift). It is true that by using variations of different input priorities some form of control could be gained. This option though, was not totally secure as

some measure of trust has to be placed upon the users to submit work with the correct parameters. A side effect of introducing a batch CPU resource limitation, would be to encourage users to segment work into smaller packages in order to obtain the minimum turnaround time.

Due to our moderately active tape environment we found that our operations personnel needed some form of advance notification system of tape requirements prior to access. This would then enable tapes to be obtained from the tape library and scheduled for loading with the correct security status (read/write permit) and in the correct order. Providing the system to be adopted catered for obtaining tape details, up to the point of job termination, it would eliminate the confusion when handling volume tape sets that comprise of more than one tape.

As most HP 3000 system managers/operators will be aware that the console command =RECALL will not operate once the end of tape condition has been reached on the first tape, leaving the operator to guess what the next tape required is. Our experiences also showed that a great deal of errors and time were incurred in a free-for-all tape request/Mounting environment as requests frequently conflicted with available devices. In an attempt to eliminate these problems we felt that it would be necessary to prohibit all tape accesses from sessions. Initially it appears to place a great hardship upon the user but our experiences have shown that it is sometimes preferable to place tape work in the batch queue as in a heavily loaded system the session elapsed period can be very lengthy.

Lastly, one other drawback we found was that a user could not cancel a job once it had been streamed. Again, in our experience we found users often realise some alteration to the job file is necessary immediately after submission which meant the users having to interrupt the operators to effect the cancellation.

DESIGN PHILOSOPHY

Once agreement had been reached that a monitoring and scheduling system would provide the optimum solution in overcoming these problems, it was necessary to generate the general design philosophy to be adopted.

Primarily and foremost the total package would have to be easy to use for both experienced and inexperienced users. It was therefore essential that the package catered for both these types of users by incorporating

a dual mode operation with meaningful error messages and a general 'Help' facility. The package was to consist of common routines, for both users and operations personnel, utilising only standard features supported within MPE (i.e. Non-Privileged Mode). Since total monitoring and scheduling would be required it would be necessary to prohibit users from using the STPFAM command. Therefore identical facilities to that of the STREAM command would have to be supported within the package, including syntax checking on job statements. Jobs submitted via the scheduler would be vetted to ensure that the CPU resource limitations applicable were enforced, deferring any jobs exceeding the limitations. The scheduler would provide the means to schedule work on an immediate, specific time and date or every day basis. Users submitting tape work would be required to include 'COMMENT SETUP' statements, within their job files with the appropriate tape details coded in the remaining portion of the statement. These statements would be copied to an operator inspection file on submission of the job. Alternatively, these statements could be used to relay other pertinent information to the operator. Jobs submitted with embedded 'COMMENT SETUP' statements would automatically be placed into a hold status, pending release by operations personnel. Users would be allowed to cancel owned jobs or modify scheduling parameters on their jobs through the scheduler package. The same functions, would be available to the operations personnel, but with the ability to override scheduling limitations and ownership basis.

USER REACTION

On announcing to the users the proposed implementation of a scheduling system, the immediate feedback was that of scepticism and objection to change. To counteract this it was decided to introduce the 'Scheduler' in unison with the standard STREAM facility for a trial period and obtain feedback from users during and after this period. The package became available for use in December 1978. The initial transfer of users to the scheduler was at first very low but once reluctant users realised the benefits offered by the package a steady growth in numbers was seen. So much so, that it was decided to make the use of the 'Scheduler' mandatory from February 1979. Since the introduction of MIT 1906 software release we have replaced the STREAM command with a system wide user defined command which invokes the scheduler thereby preventing any user escaping the scheduling limitations.

User reaction and comments has reversed to that of being favourable since the initial design goals have been achieved and that the package provides flexibility over the previous operation.

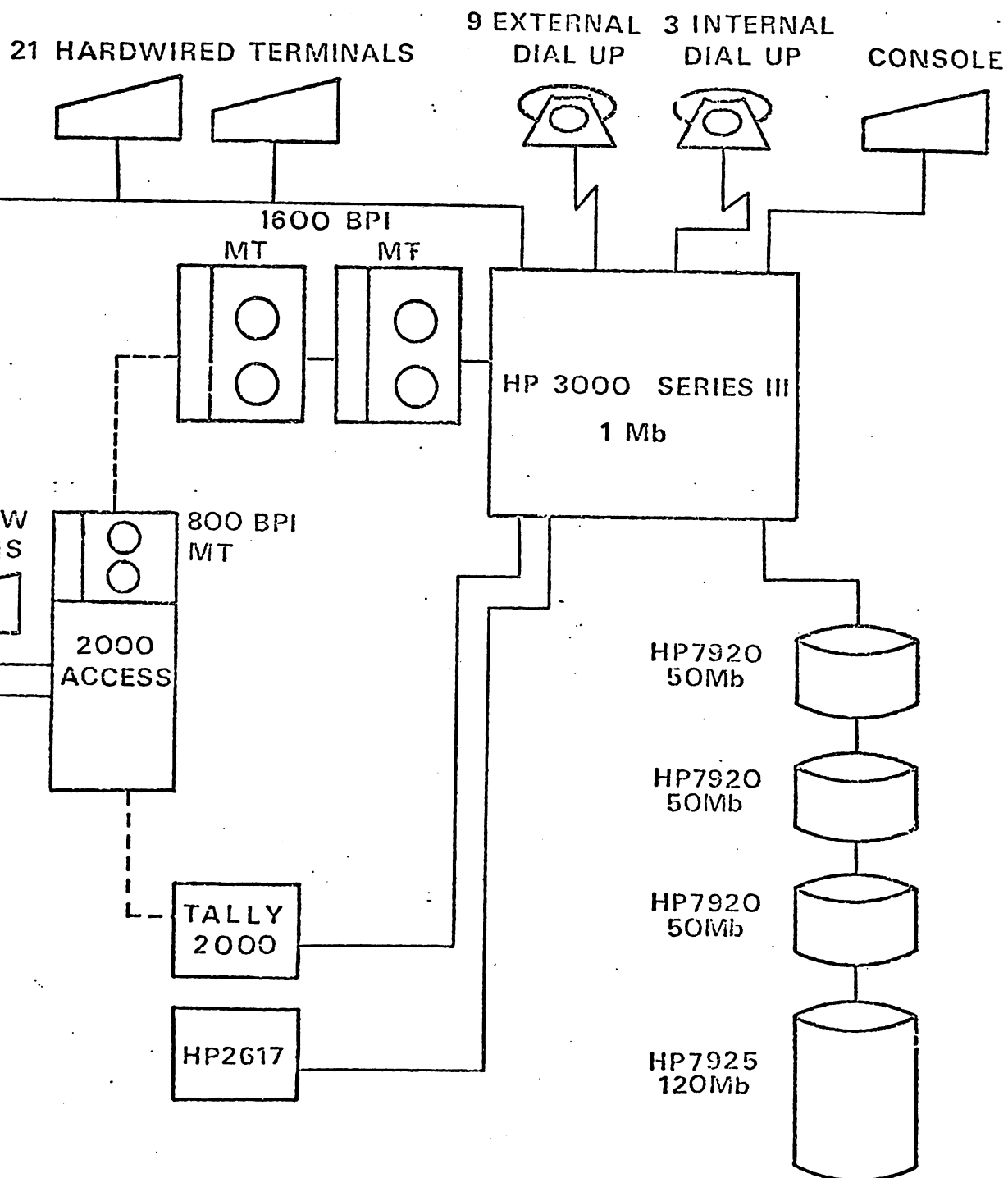
FURTHER BENEFITS

Additional benefits have been gained since the introduction of the 'Scheduler' package in that a large 'WAIT' queue is not built up which is subject to loss when the system cannot be successfully 'WARMSTARTED' after a system failure. A relatively new feature added to the 'Scheduler' package is in handling and scheduling of jobs to be transmitted via MRJE/3000 to a host-system. This has enabled us to provide the user with a common interface whether work is to be scheduled on the HP 3000 or via MRJE/3000. The user is not required to become familiar with the MRJE/3000 subsystem features and commands.

PROPOSED ENHANCEMENTS

Currently we are considering whether to implement further features in the form of job correlation and true resource scheduling. Although the present system provides a list of the previous twenty-four hours job statements and an hourly status report on input, output and execution queues, we feel the probable need for complete job correlation from the input stage to the final output stage. The true resource scheduling feature may be a requirement of the future where jobs are not scheduled according to a start time but scheduled when resources become available within various limitations. To date though no final conclusions have been reached whether these facilities will be implemented.

LBS COMPUTER CENTRE HARDWARE CONFIGURATION



SYSTEM OVERVIEW

- USERS:
- 25/30 Research/Teaching Faculty
 - 40 Doctoral Students
 - 10 "Computer-Related" personnel
 - 25/30 External Users

APPLICATIONS:

- Current:
- Economic Forecasting
 - Finance
 - Marketing
 - Accounting
 - Statistics
 - Quantitative Methods
 - Modelling

- Future:
- Expansion of several of the above
in particular:
 - Economic Forecasting
 - Financial Services

SYSTEM OVERVIEW

Continued

"TYPICAL" DAILY WORK-LOAD:

- Production Execution
- Fortran Program Development
- Basic Program Development

DURING "PRIME-SHIFT" A SYSTEM MIX OF:

- 10/15 Sessions
- 2 Executing Batch Jobs
- 1 Executing System Monitor

COMPILER USAGE:

- Fortran 80%
- Basic 19%
- SPL 1%

OPERATIONAL MANAGEMENT PROBLEMS

LACK OF OPERATIONAL CONTROL FUNCTIONS IN THE FOLLOWING AREAS:

- Enforcing Job CPU Resource Limitations
- Scheduling and providing notification of tape requests
- Cancellation of jobs by users prior to execution

ENFORCING JOB CPU RESOURCE LIMITATIONS TO:

- Maximise general job throughput during peak usage periods
- Evenly distribute batch CPU resources during peak usage periods

CONTROL BY:

- Prohibit users from using the STREAM command
- Imposing a maximum CPU time obtainable during peak usage period
- Deferring jobs exceeding limitations

SCHEDULING AND PROVIDING NOTIFICATION OF TAPE

REQUESTS TO:

- Provide operations personnel with advance notification of tape requirements prior to access
- Enable correct security status (Read/Write) to be applied to tape volumes prior to loading
- Eliminate the confusion arising when handling volume tape sets that comprise of more than one tape
- Reduce number of errors incurred through incorrect loading
- Reduce number of request conflicts for available devices

CONTROL BY:

- Prohibit all tape accesses from sessions
- Tape requesting jobs required to contain 'COMMENT SETUP' statements with appropriate tape details coded

CANCELLATION OF JOBS BY USERS PRIOR TO EXECUTION TO:

- Relieve interruptions on operations personnel by users

SCHEDULER DESIGN PHILOSOPHY

- Primary and foremost easy to use for both experienced and inexperienced users
- Dual mode operation for both these types of users
- Meaningful error messages
- General 'HELP' facility
- Common routines for both users and operations personnel
- Utilise only standard features supported within MPE (Non-Privilege mode)
- Provide identical facilities to that of the STREAM command including syntax checking on job statements
- Scheduler to impose resource limitations applicable, deferring any jobs exceeding the limitations
- Users to be able to schedule work on an immediate, specific time and date, or every day basis
- Jobs submitted with 'COMMENT SETUP' statements to be placed into a 'HOLD' status, pending release by operations personnel
- Users to be able to cancel owned jobs
- Users to be able to modify scheduling parameters on owned jobs
- Same functions available to operations personnel but ability to override scheduling limitations and ownership

USER REACTION

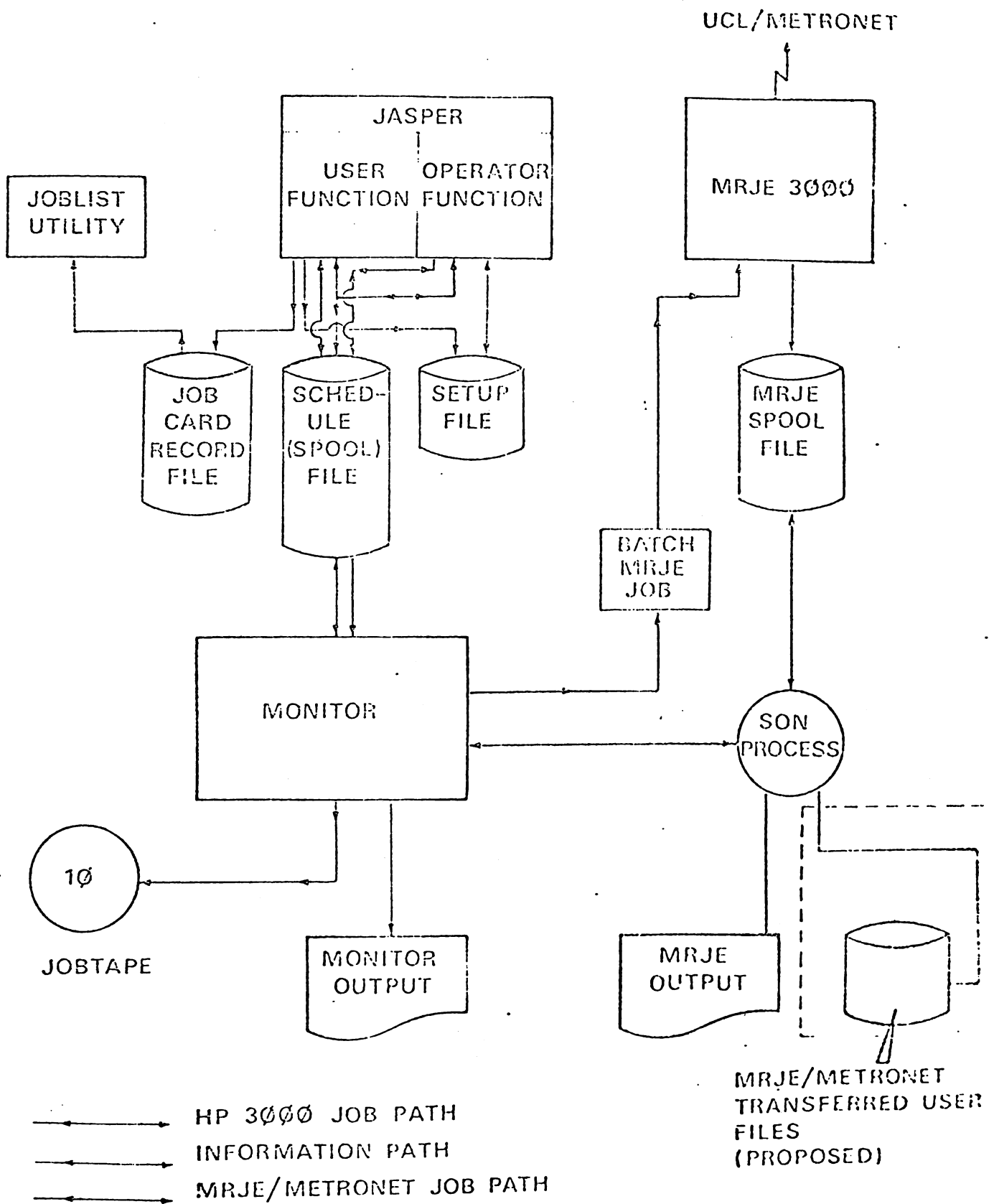
ON PROPOSAL OF IMPLEMENTING A SCHEDULING SYSTEM:

- Initial feedback, objection to change and scepticism
- To counteract this, Scheduler to be introduced in unison with standard 'STREAM' facility. December 1978
- Transfer of users to scheduler initially low
- Once reluctant users realised scheduler benefits, steady growth in numbers was seen
- Scheduler use made mandatory from February 1979
- Since introduction of MIT 1906 'STREAM' command replaced with UDC to invoke the scheduler
- User comments favourable of scheduler package

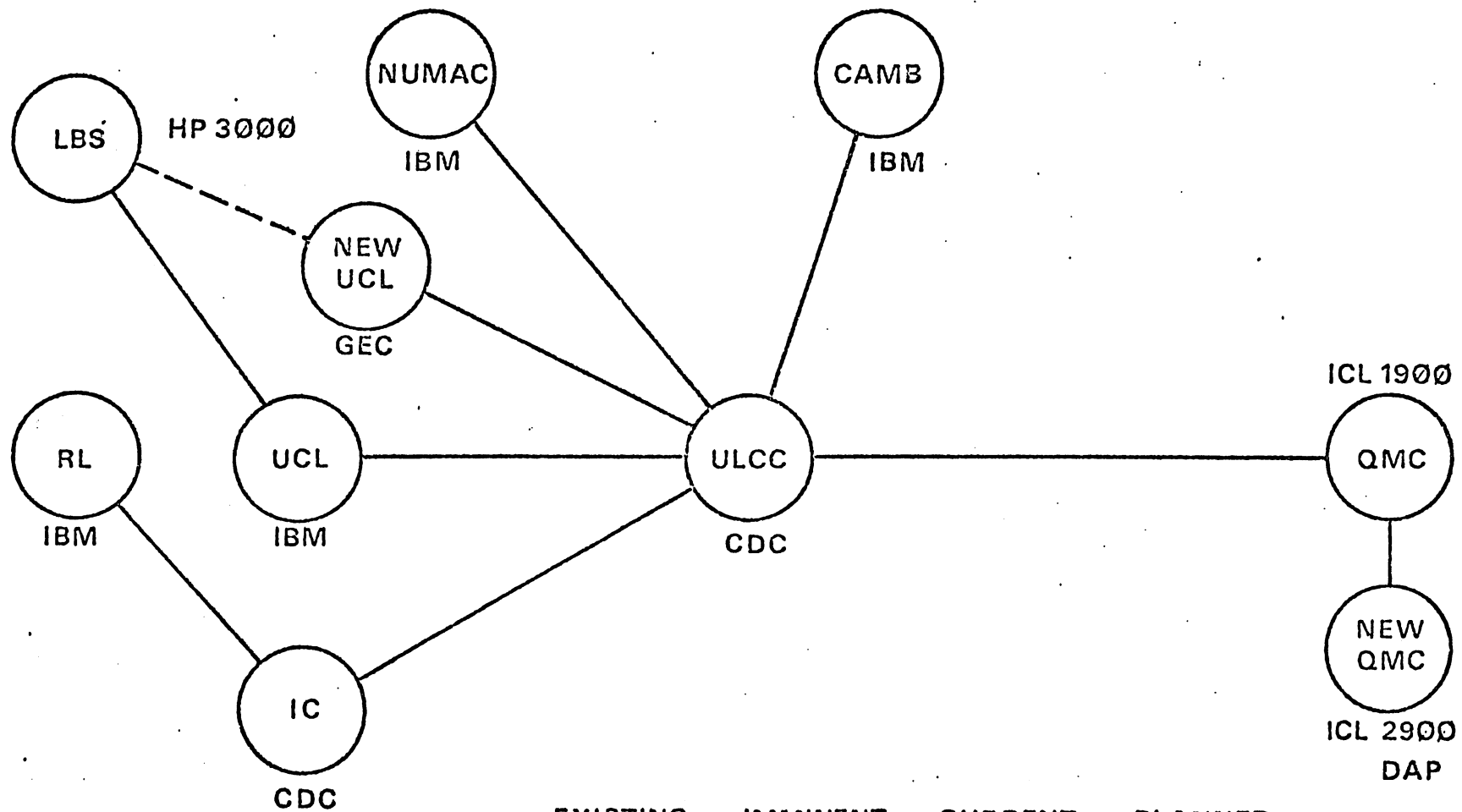
FURTHER BENEFITS

- Large 'WAIT' queues are not built up, which are subject to loss after a system failure
- New feature, where work can be submitted to HP 3000 or via MRJE/3000 to host system
- Common interface, users not required to be familiar with MRJE/3000 subsystem

LBS SCHEDULING SYSTEM



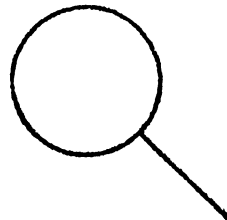
LONDON UNIVERSITY METRONET NETWORK



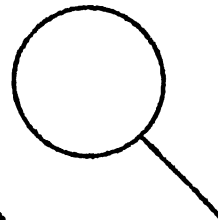
EXISTING



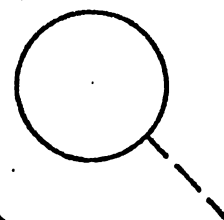
IMMINENT



CURRENT



PLANNED



:STREAM

JOB SCHEDULER .Version 03.40 .(c)1979 L.B.S. MON, JUL 16, 1979, 2:48 PM
COMMAND? HELP

These are the commands available under JASPER:

The parameters in {} are mandatory, those in [] may be defaulted.

ADD (A) {filename}[group][account][run-date][run-time]

MODIFY (M) {filename}[group][account][run-date][run-time]

LIST (L)

DELETE (D)

SHORT (S) {command}{filename}[group][account][date][time]

METRONET (MET)

BUILD (B)

HELP (H)

EXIT (E)

Which would you like a description of? 'EXIT' will return you to the scheduler.

ENTER COMMAND > ADD

ADD Adds a previously built Job file to the spool file.
You will be prompted for parameters filename, group,
account, desired run-date, and run-time.

ENTER COMMAND > LIST

LIST Enables selective listing of Jobs in the spool file:

- L - provides a list of your HP3000 Jobs
- L@ - provides a list of all users' HP3000 Jobs.
- LM - provides a list of your METRONET Jobs.
- L@M - provides a list of all users' METRONET Jobs.

ENTER COMMAND > EXIT

COMMAND? E

END OF PROGRAM

:

STREAM

JOB SCHEDULER .Version 03.40 .(c)1979 L.B.S. MON, JUL 16, 1979, 11:53 AM
COMMAND? ADD

NAME OF FILE? MCLOGS

GROUP?HARRIS

ACCOUNT?COMPUTER

MCLOGS.HARRIS.COMPUTER

IS THIS THE CORRECT JOB NAME (Y OR N) ? Y

DATE OF RUN?(DD/MM/YY)

ENTER HOUR OF DAY JOB IS TO BE RUN

BETWEEN 1 TO 24 OR ENTER 00 IF JOB CAN BE RUN AT ANY TIME

RUN DATE= 16/07/79 RUN TIME= 0 HRS

IS THIS CORRECT? Y

PRIME SHIFT RUN PROHIBITED

RESCHEDULED FOR 22 HRS

MCLOGS.HARRIS.COMPUTER

SUCCESSFULLY SCHEDULED

COMMAND? L

JOB	GROUP	LBS SCHEDULER ACCOUNT	RUN DATE	PAGE TIME	1 METRONET
COMMAND? L@					

JOB	GROUP	LBS SCHEDULER ACCOUNT	RUN DATE	PAGE TIME	1 METRONET
NIGHTJOB	LOGFILES	SYS	EVERY DAY	11:00PM	
REPORT20	PUB	LEASE	EVERY DAY	6:00PM	
ROYALCJ	LOGFILES	SYS	EVERY DAY	12:00AM	
MCLOGS	HARRIS	COMPUTER	16/07/79	10:00PM	
COMMAND? E					

END OF PROGRAM

:

:STREAM

JOB SCHEDULER .Version 03.40 .(c)1979 L.B.S. MON, JUL 16, 1979, 12:01 PM
COMMAND? A

NAME OF FILE? MCLOGS

GROUP?

ACCOUNT?

MCLOGS.HARRIS.COMPUTER

IS THIS THE CORRECT JOB NAME (Y OR N) ? Y

DATE OF RUN?(DD/MM/YY)

ENTER HOUR OF DAY JOB IS TO BE RUN

BETWEEN 1 TO 24 OR ENTER 00 IF JOB CAN BE RUN AT ANY TIME

RUN DATE= 16/07/79 RUN TIME= 0 HRS

IS THIS CORRECT? Y

PRIME SHIFT RUN PROHIBITED

RESCHEDULED FOR 22 HRS

MCLOGS.HARRIS.COMPUTER SUCCESSFULLY SCHEDULED

COMMAND? L

JOB	GROUP	LBS	SCHEDULER	ACCOUNT	RUN DATE	PAGE	TIME	1
MCLOGS	HARRIS		COMPUTER		16/07/79		10:00PM	METRONET

COMMAND? L@

JOB	GROUP	LBS	SCHEDULER	ACCOUNT	RUN DATE	PAGE	TIME	1
NIGHTJOB	LOGFILES		SYS		EVERY DAY		11:00PM	METRONET
REPORT20	PUB		LEASE		EVERY DAY		6:00PM	
ROYALCJ	LOGFILES		SYS		EVERY DAY		12:00AM	
MCLOGS	HARRIS		COMPUTER		16/07/79		10:00PM	

COMMAND? LM

JOB	GROUP	LBS	SCHEDULER	ACCOUNT	RUN DATE	PAGE	TIME	1
								METRONET

COMMAND? L@M

JOB	GROUP	LBS	SCHEDULER	ACCOUNT	RUN DATE	PAGE	TIME	1
DMP04	PUB		OPERATOR		13/07/79	*IMMED*		SENT
Q1941050	REQ		OPERATOR		13/07/79	*IMMED*		SENT
DMP08	PUB		OPERATOR		13/07/79	*IMMED*		SENT

COMMAND? D

NAME OF FILE? MCLOGS

GROUP?

ACCOUNT?

MCLOGS.HARRIS.COMPUTER

IS THIS THE CORRECT JOB NAME (Y OR N) ? Y

MCLOGS.HARRIS.COMPUTER DELETED

COMMAND? E

END OF PROGRAM

:STREAM

JOB SCHEDULER .Version 03.40 .(c)1979 L.B.S. MON, JUL 16, 1979, 12:09 PM
COMMAND? L

JOB	GROUP	LBS SCHEDULER ACCOUNT	RUN DATE	PAGE TIME	1 METRONET
Q1971204	HARRIS	COMPUTER	16/07/79	SETUP=1	

COMMAND? S

KEY PARAMETERS PLEASE D;Q1971204

Q1971204.HARRIS.COMPUTER DELETED

COMMAND? S

KEY PARAMETERS PLEASE A;MCLOGS

MCLOGS.HARRIS.COMPUTER

RUN DATE= 16/07/79 RUN TIME= 0 HRS

PRIME SHIFT RUN PROHIBITED

RESCHEDULED FOR 22 HRS

MCLOGS.HARRIS.COMPUTER SUCCESSFULLY SCHEDULED

COMMAND? S

KEY PARAMETERS PLEASE D;MCLOGS

MCLOGS.HARRIS.COMPUTER DELETED

COMMAND? S

KEY PARAMETERS PLEASE A;MCLOGS;99/99/99;02

MCLOGS.HARRIS.COMPUTER

RUN DATE= 99/99/99 RUN TIME= 2 HRS

JOB SCHEDULED FOR 2HRS

MCLOGS.HARRIS.COMPUTER SUCCESSFULLY SCHEDULED

COMMAND? L

JOB	GROUP	LBS SCHEDULER ACCOUNT	RUN DATE	PAGE TIME	1 METRONET
MCLOGS	HARRIS	COMPUTER	EVERY DAY	2:00AM	

COMMAND? S

KEY PARAMETERS PLEASE M;MCLOGS.HARRIS.COMPUTER;17/07/79;03

MCLOGS.HARRIS.COMPUTER

RUN DATE= 17/07/79 RUN TIME= 3 HRS

JOB SCHEDULED FOR 3 HOURS

JOB MODIFIED

COMMAND? L

JOB	GROUP	LBS SCHEDULER ACCOUNT	RUN DATE	PAGE TIME	1 METRONET
MCLOGS	HARRIS	COMPUTER	17/07/79	3:00AM	

COMMAND? S

KEY PARAMETERS PLEASE M;MCLOGS

MCLOGS.HARRIS.COMPUTER

RUN DATE= 16/07/79 RUN TIME= 0 HRS

PRIME SHIFT EXECUTION NOT PERMITTED

JOB SCHEDULED FOR 22 HOURS

JOB MODIFIED

COMMAND? S

KEY PARAMETERS PLEASE D;MCLOGS

MCLOGS.HARRIS.COMPUTER DELETED

COMMAND? E

P10-18

END OF PROGRAM

6

:STREAM

JOB SCHEDULER .Version 03.40 .(c)1979 L.B.S. MON, JUL 16, 1979, 12:03 PM
COMMAND? B

INPUT DETAILS OF JOB TERMINATED BY !EOJ

>!JOB TEST1,KIM.COMPUTER;INPRI=1
>!COMMENT SETUP TESTTAPE,WRITE/EXTERNAL/1600BPI
>!COMMENT THIS IS ONLY A TEST JOB
>!EOJ

LIST,DELETE,REPLACE,KEEP,IMMEDIATE RUN,OR SCHEDULE?I

Q1971204.HARRIS.COMPUTER
RUN DATE= 16/07/79 RUN TIME= 0 HRS
Q1971204.HARRIS.COMPUTER SUCCESSFULLY SCHEDULED
COMMAND? L

JOB	GROUP	LBS SCHEDULER ACCOUNT	RUN DATE	PAGE TIME	1 METRONET
Q1971204	HARRIS	COMPUTER	16/07/79	SETUP=1	

COMMAND? MODIFY

NAME OF FILE? Q1971204

GROUP?

ACCOUNT?

Q1971204.HARRIS.COMPUTER
IS THIS THE CORRECT JOB NAME (Y OR N) ? Y

DATE OF RUN?(DD/MM/YY)
ENTER HOUR OF DAY JOB IS TO BE RUN
BETWEEN 1 TO 24 OR ENTER 00 IF JOB CAN BE RUN AT ANY TIME

RUN DATE= 16/07/79 RUN TIME= 0 HRS
IS THIS CORRECT? Y

SETUP JOB SCHEDULED
JOB MODIFIED
COMMAND? L

JOB	GROUP	LBS SCHEDULER ACCOUNT	RUN DATE	PAGE TIME	1 METRONET
Q1971204	HARRIS	COMPUTER	16/07/79	SETUP=1	

COMMAND? E

END OF PROGRAM
:

:STREAM

JOB SCHEDULER .Version 03.40 .(c)1979 L.B.S. MON, JUL 16, 1979, 12:07 PM
COMMAND? B

INPUT DETAILS OF JOB TERMINATED BY IE0J

>!JOB KIM.COMPUTER;INPRI=2
>!COMMENT E0
>E
>IE0J

LIST,DELETE,REPLACE,KEEP,IMMEDIATE RUN,OR SCHEDULE?I

Q1971207.HARRIS.COMPUTER
RUN DATE= 16/07/79 RUN TIME= 0 HRS
SETUP JOBS MUST HAVE COMMENT SETUP CARDS
COMMAND? E

END OF PROGRAM

: