

UTS 1972: CONCEPTS AND CAPABILITIES

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SUMMARY

UTS is today a major competitor in the field of multiprogrammed/timeshared operating systems for medium- and large-scale digital computers. Its capabilities compare favorably with or exceed OS (IBM), GECOS (Honeywell), TOPS-10 (DEC), EXEC 8 (Univac), VMOS (RCA), MCP (Burroughs), Kronos (CDC), etc. A recent benchmark was extraordinarily comprehensive, consisting of 170 batch jobs, including major multi-sort business data processing jobs as well as student FORTRAN compile-and-run jobs, together with 40 on-line terminals. In this test, which ran nearly two and a half hours, UTS on a Sigma 9 was the price/performance winner over an IBM 370/155, a CDC 6500, a Univac 1106, and a Honeywell 6070. The important capabilities of UTS include the following:

- Multiprogrammed batch processing with resource control
- Comprehensive on-line (timesharing) services
- Peripheral symbiont (spooling) system for both batch and on-line users
- Remote batch terminal processing
- File management system for tape, pack, and RAD, including consecutive, random (direct), and keyed (ISAM) files
- Extensive reliability features, including automatic system recovery and error logging and displays
- On-line peripheral diagnostics
- Automatic system failure analysis
- On-line system debugging and performance measurement services

Current projects will add the following important features to the system for field delivery before the end of 1972:

- Utilization of the full 512K core memory capability of the Sigma 9
- ANSI format tape processing, including full label control
- Disk pack system (no RAD) for lower price entry
- The addition of EASY, the GE Mark II style of terminal command language, and TEXT, an ATS-like text editing and printing service

Those features which give UTS its unique place in the industry are the following:

- The extensive timesharing facilities (perhaps the best in the industry)
- The complete file compatibility of the batch and on-line environments
- The availability of all batch services to on-line users
- The use of the virtual memory map to use core memory economically, especially via the 40 shared processors
- The speed and reliability of the system
- The software and hardware maintainability features
- The extensive library of useful processors and programs supplied by both Xerox and the user group.
- Proven performance in environments including business data processing as well as timesharing/scientific applications.
- Absolute security protection of files and programs from accidental or malicious misuse.

UTS FEATURES AND FACILITIES

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1. GENERAL DISCUSSION

This section summarizes those system facilities and features which are common to all operating environments: multiprogrammed batch, on-line terminals, and remote batch jobs.

1.1 ON-LINE/BATCH COMPABILITY

Because multiple batch jobs and on-line user sessions are treated uniformly as users of the system, complete compatibility exists between the two environments for both program execution (any program may be run either on-line or from remote or central site batch inputs) and of the files used, created, or updated, including access to all peripherals (tapes and private packs as well as printers and card punches) by on-line users, assuming they are authorized for such access.

1.2 VIRTUAL MEMORY

Via the hardware memory map and software management routines, core memory is efficiently utilized; it changes as necessary from moment to moment, allowing all momentarily inactive memory to be available to the system for the highest priority jobs.

Use of the map to share the code portions of reentrant processors among concurrent users achieves savings in core, which results in added throughput. In conjunction with virtual memory management, the UTS swapper allows the total size of all running programs, both batch and on-line, to exceed the size of real memory by orders of magnitude.

1.3 UNIT RECORD DEVICE SPOOLING (SYMBIONTS)

Unit record devices such as card readers, line printers, card punches, plotters, and other devices so specified at SYSGEN time will be spooled via disk pack or RAD by the UTS "symbiont" routines. This buffering of I/O to the low-speed devices via the high-speed RAD or pack smooths the peaks and valleys of device-loading and provides for multiple simultaneous logical streams of I/O to these devices in the multiprogramming/terminal system.

1.4 DEVICE INDEPENDENCE

Sources and destinations are controlled by I/O assignments at execution time, which extends to the on-line terminals as well as peripheral devices and files. Standard defaults select the normal input and output units as either card reader and printer (if batch) or the terminal (if on-line) without any action by the user.

1.5 COMPREHENSIVE DEFAULT CONVENTIONS

System defaults are provided - and are dynamically changeable by installation management - for limits, I/O assignments, processor options, etc., making the required JCL and terminal commands especially simple for standard operations and job setups.

1.6 ACCOUNTING/MACHINE RESOURCE CHARGING

The UTS accounting facility is especially complete. The wide assortment of statistics accumulated during job operation are reported both to the user and to a system file for installation accounting accumulations. The installation may assign charge values to each of the machine resources used, and the system will calculate and report the total cost accordingly. In addition, facilities are available to allow each installation to augment system accounting with routines unique to its particular needs.

1.7 CENTRALIZED ERROR MESSAGE FILE

The text for system and processor error messages are carried in a standard system file so that they may be easily changed to satisfy individual installation needs. Clear text messages are provided rather than the harder-to-interpret code numbers. Code numbers are provided whenever a corresponding message is not on file. However, they may be inserted on-line using EDIT.

1.8 SYSTEM SERVICES

System services are detailed in Section 6 on User Control. Internal services in the form of requests to the monitor via CAL instructions are available to both batch and on-line programs without limitation. Broadly speaking, they may be categorized as follows:

| <u>Item</u> | <u>Types</u> |
|--|--------------|
| I/O requests for files or devices | 35 |
| Debugging services | 6 |
| Memory management | 9 |
| Control operations (traps, interrupts) | 8 |
| Program management | 5 |
| Privileged services | 7 |
| Miscellaneous services | 10 |

1.9 MODULAR IMPLEMENTATION

UTS has a well-organized and highly modular internal organization. The broad capabilities of the system allow many of its services to be provided by slave mode programs - some running as GHOSTS - which are simple to extend and debug as well as easy to add to the system, since a SYSGEN is not required. More than 40 processors supported by the UTS Section (which does not include any language processors) fall into this category.

The resident monitor is itself highly modular, as shown by its ability to extract significant portions and debug them separately under simulators, as discussed in Section 13 on Maintainability and Extendability. Major segments of the resident monitor cover functional sections as follows:

- a. Basic I/O enqueueing and device handlers
- b. Terminal I/O management
- c. Symbionts and cooperatives
- d. Scheduling and swapping
- e. Memory management
- f. Job step control
- g. File management
- h. Load-and-link services
- i. Batch debugging commands
- j. Initialization
- k. Operator communications
- l. Accounting and performance monitoring
- m. System recovery
- n. System debugging
- o. Error logging and diagnostic program interfaces
- p. Multibatch scheduling
- q. Remote batch terminal management
- r. File granule allocation

An example of the modular nature of the system and the strength of the interfaces occurred with the C00 release. In this case, IOQ and the handlers were extensively revised to add device (pack) pooling. This feature, after test under BPM, was inserted in UTS without error.

I.10

EXECUTION SCHEDULING

UTS provides a multilevel scheduler which uses 30 states that provide separate execution time priorities for external interrupts, terminal input and output interactions, file I/O, and compute-bound programs. This unique scheduler assures fast response to interactive users while, at the same time, providing for an efficient multiprogrammed mix of I/O and compute-bound programs. The scheduling states also control the swapping algorithm for the same purpose, in particular providing a meaningful outswap ordering. The scheduler adapts efficiently to the actual environment whether batch only, interactive terminal only, or a mixture.

I.11

EXIT CONTROL

A facility to allow a processor to acquire exit control in the event of any termination of the program, including inadvertent line disconnect or program abort for whatever reason.

2. MULTIBATCH PROCESSING

UTS provides up to 16 concurrent batch processing partitions and guarantees that the total resources, such as tapes, private packs, core, etc., used by active partitions do not exceed the physical resources of the machine and the limits set by the installation manager. UTS classifies jobs dynamically into one or more of the 16 partitions depending on the resources required and the stated resource ranges of the partitions. Each partition, through its resource ranges, represents a job class; however, UTS is unique in that it can and will run - in priority order - the job class for which resources are available. This feature results in greater than usual throughput when jobs are submitted in an arbitrary manner. Conversely, critical jobs may have their resource requirements and priorities established in such close match to a partition class that immediate execution of critical jobs is assured.

Partition definitions in UTS act as a screening process for job selection and do not define a fixed boundary partition in the traditional sense. Jobs acquire core dynamically as needed up to the specified limit. Any excess core is available for running other jobs. Batch jobs are not core-resident from start to finish but are scheduled and swapped as system load dictates, which assures maximum system utilization consistent with response time considerations. Resources may be released by a job at each job step, e.g., tapes unused in subsequent steps.

The installation may define a priority increment to be used to increase the priority of bypassed jobs, thus giving them credit for longevity in the queue. Special treatment is accorded an F priority job, i.e., it is guaranteed to be the next job to be selected, depending only on the availability of the required resources.

3. ON-LINE (TIMESHARING) CAPABILITIES

3.1 ON-LINE BATCH COMPATIBILITY

The total compatibility between batch and on-line programming mentioned in Section 1 means that all the programs and all the monitor service functions (CALs) are available on-line. While all programs will run on-line, the results may not be aesthetically pleasing if the program is not "interactive", i. e., if it does not assume that an intelligent person is available to answer questions and supply corrections. In the lists of on-line services listed below, only "interactive" programs are discussed.

3.2 SERVICE PROCESSORS

Processors which are of special importance to the on-line user are as follows:

| | |
|--------------------|---|
| BASIC | Programming language for small-to-medium arithmetic problems |
| FORTRAN | Comprehensive algebraic programming language |
| METASYMBOL | Sophisticated machine language assembler |
| APL | Functional programming language for science and business |
| TEXT | ATS-like text editing and printing |
| TEL | Terminal command executive |
| PCL | Combined utility package for information transfer |
| FDP | FORTRAN debug package |
| DELTA | Machine language symbolic debugger |
| EDIT | Text editor |
| LINK | Program loader |
| Terminal Manage | Interactive manager for business data: updating, retrieving, generating reports |
| COBOL | Business language compiler |
| EASY | GE Mark II-like access to FORTRAN and BASIC |
| GPDS | General purpose discrete simulator |
| CIRC | Circuit analysis: DC, AC, and transient |

3.3 ON-LINE DEBUGGING (DELTA)

The DELTA on-line debugger is a particularly useful aid that may be used to advantage with any program, including FORTRAN and COBOL compilations, though it is especially designed for machine language. Symbol tables are available directly from the source code. Line-at-a-time assembly of machine language, instruction breakpoints, data value-change breakpoints, instruction traces, and transfer traces are included. A variety of conversion routines are easily invoked for terminal input and output.

3.4 ON-LINE FORTRAN DEBUGGING

An exceptional facility for debugging of FORTRAN programs on-line or in batch is provided via the FDP library language. Breakpoints and displays are provided using the statement numbers and symbols of the source program. Automatic debugging is provided, including checking of routine calling and receiving sequences.

3.5 CENTRALIZED UTILITIES (PCL)

A single comprehensive processor (PCL) that may be used in either batch or on-line environments replaces the usual proliferation of utility programs. Transfer of files in any system format is accomplished between any two devices via this easy-to-use command language. Format conversion and record selection may be specified and files may be concatenated or split.

3.6 META-ASSEMBLER AND LINK-EDITING LOADER

The METASYMBOL assembler is procedure-driven according to definitions supplied by the user, allowing assemblies not only for Sigma equipment but for foreign machines. The loader complements the assembler with an unusually wide-ranging capability which, through the Sigma standard object language, eases the burden on compilers.

3.7 EASY

A GE Mark II protocol access to FORTRAN and BASIC is provided through use of a general command processor facility which allows an installation to define additional command processors (e. g., CCI, TEL).

4.

REAL TIME

Although full real-time services cannot be claimed for UTS in the established SDS sense, it has substantial real-time capability by virtue of its underlying design. The I/O enqueueing routines and device handlers are nearly identical to those for RBM, our most successful real-time system. The file management system had its genesis in and is compatible with BPM/BTM, our other real-time system. Throughout the design of UTS, real-time-oriented principles were followed in table design and coding practices. Recent measurements of monitor inhibit time, the main limitation on real-time response, have shown the majority of inhibits to be less than 350 μ sec. The few inhibit paths remaining at 750 μ sec and above are considered correctable anomalies rather than flaws in the basic design.

UTS still lacks the formal real-time service CALs which allow monitor-supervised connection to interrupts although a specification was prepared for these services in 1970. Certain of the more difficult real-time services are inherently easier in UTS than in batch processing systems because its built-in swapping mechanism obviates special requirements for checkpointing the background in order to introduce nonresident real-time tasks; recovery of real-time tasks would similarly be a natural extension in UTS.

The strength of UTS in real-time design and capacity is indicated by current and projected use: one real-time UTS configuration will be installed for CDC of Canada in mid-August 1972, with two other scheduled for later in 1972, one at Vandenberg Air Force Base and the other at Lockheed's Sunnyvale facility.

5. TELEPROCESSING

Compatibility of terminal access with file and card reader/printer access has been discussed in Section 1. It is central to UTS teleprocessing services, making them more like the advanced TCAM of IBM than the older TAM services.

5.1 TERMINAL COMMUNICATION ACCESS METHODS

Excellent terminal communication access routines provide support for a wide range of Teletypes (including all ASCII coding terminals) and 2741-type typewriters (APL and standard keyboards; EBCD and selectric code sets), and CRT terminals. The UTS installation at UCI is using a dozen or more different types of terminals

A unique feature is type-ahead (input message queueing), which allows a user to continue inputting commands without having to wait for the next computer prompt. Commands typed-ahead are synchronized with program output which assures a clear and meaningful output identical to nontype-ahead in form.

Efficient COC buffering techniques provides this support with extremely low core storage requirements (four words/terminal), including output message queueing asynchronously with respect to the user program.

Automatic page headings are provided, with formatting control over both page width and length.

Simple line-editing commands for erasing characters and lines are available with the handling routines and thus are available to all programs and processors.

Both half- and full-duplex paper tape input and output are supported from on-line terminals.

Untranslated input and output is provided via a "transparent mode", which allows preparation of paper tapes for milling machine control and control over special devices, such as plotters and vector-generating CRT displays.

A single program may control many terminals via the shared processor mechanism. The system automatically provides separate context areas for each terminal, thus vastly simplifying the programming problem for such uses, since the processor need act only as if it were dealing with a single terminal, i. e., no submonitoring is required within the processor. These processors may be written in any language - FORTRAN, COBOL, etc. Further, the system does not require that the processor be shared in order to operate many terminals, although system efficiency is increased thereby.

Prompt characters, if specified, are automatically supplied for each program read. A unique prompt has been chosen for the terminal executive and for each processor function to insure easy user identification of the requestor.

Tab simulation is provided if desired, with explicit control over the choice of spaces or tabs for the reading program and the logical beginning point of the carriage.

Miscellaneous other controls restrict input to upper case, allow input of lower case characters from Teletypes lacking them, provide for control transfer to the executive, acknowledge the presence of the system, allow re-typing of the current input. All terminal control modes can be established by use of control keystrokes or by the program using CALs.

5.2 REMOTE BATCH

The following lists the features and capabilities of the RBT support in the current (C00) release of UTS, which has been in the field since late May of 1972. Extensions are planned as listed under the heading IRBT in Section 15 for delivery in the second quarter of 1973.

All system facilities available to local batch jobs are available to remote batch jobs.

No modifications need be made to a job to run it from an RBT.

Printed output is automatically sent when ready without operator intervention.

Terminals can be operated in either the attended or unattended mode, i. e., with or without an operator. In the unattended mode, the terminal is disconnected if transmission errors forbid communication.

Workstations are authorized by the system manager dynamically with SUPER, which also allows him to define a maximum priority for input jobs and the right to use the system account.

Half- and full-duplex switched and unswitched communication lines are supported.

The remote operator may defer output of files and request that output later.

The remote operator may send and receive messages to and from the central site operator.

The remote operator may delete his input and output files and abort his running jobs.

The remote operator may obtain the status of any or all of his files.

The remote operator can adjust the parameters (e. g., paper size) of his peripherals.

Either the remote or central operator can switch output files from one workstation to another or from an RBT to the central site.

The complete format control capability of the remote printer is supported.

Central site batch or on-line jobs may direct their output to a remote batch workstation.

Form control is supported. The remote operator is informed of forms changes and can control registration.

Input decks too big for the card hopper may be sent in shorter segments.

Output files currently printing can be suspended by the remote operator; they can then be deleted, restarted either at the stopping point or the top of the form, or saved for later output. While an output file is suspended, jobs may be entered into the system.

A simple procedure is provided to recover from all transmission errors, and no output is ever lost even in the case of complete device failure at the remote site.

Full error checking is done on all control commands from the remote site; "message files" inform the remote operator of errors in his jobs and remote control commands.

The message file provides a record of all jobs submitted by the workstation and their status, if requested.

Remote batch may be added to a UTS system simply by defining remote batch devices during SYSGEN.

6. USER CONTROL

6.1 JOB CONTROL LANGUAGE

A batch job communicates its requests by means of the Job Control Language (JCL), a consistent language that allows for parameter sequence independence. UTS JCL is a compatible superset of BPM JCL. Monitor control commands written in this JCL are processed by CCI and provide the following functions:

- a. Specify resource requirements.
- b. Execute conditional job step.
- c. De-allocate resources.
- d. Send messages to operator.
- e. Assign a user's logical I/O (DCB) to a file or physical device.
- f. Provide heading information for the listing device.
- g. Set/reset pseudo sense switches.
- h. Specify debugging control commands.
- i. Modify existing load modules.
- j. Allows for reading of nonstandard binary cards.

6.2 TEL

TEL is a command processor that is the principal terminal language for UTS. TEL commands provide the following functions:

- a. Composing program and data files.
- b. Assembling and compiling programs.
- c. Linking object programs.
- d. Loading programs in any language and initiating their execution.
- e. Initiating debugging operations.
- f. Managing and backing up files.
- g. Submitting, status checking, and canceling batch jobs.
- h. Calling subsystems.
- i. Interrupting, continuing, and terminating execution.
- j. Logging off.
- k. Changing the log-on password.
- l. Checkpointing on-line sessions.
- m. Assigning I/O devices and DCB parameters.
- n. Determining on-line user status.
- o. Listing a file directory.
- p. Listing system load parameters.
- q. Setting simulated tab stops.
- r. Obtaining terminal status.
- s. Changing terminal status.
- t. Changing terminal type.
- u. Changing terminal platen size.
- v. Sending messages to operator.
- w. Printing or punching output.

6.3 MONITOR SERVICES

- 6.3.1 The debugging facilities of UTS are quite extensive. On-line users may call on DELTA when a program is loading or after execution begins. Although it was designed for use in debugging machine language programs, DELTA may also be used to debug programs written in FORTRAN, COBOL, or any other language. A special FORTRAN Debugging Package (FDP) is available. Postmortem dump and conditional snapshot dumps commands are available to facilitate batch debugging. If desired, they may be used on-line.
- 6.3.2 Memory management services are available to allow for dynamic allocation of memory. User programs may get and release common, dynamic, or virtual pages. Memory protection may be increased by a user on any page by the user.
- The Change Virtual Map routine allows certain processors and privileged programs to examine, display, or change data portions of real physical core, especially the resident monitor.
- 6.3.3 Trap control is provided for all users to transfer control to a trap routine for designated traps. An interval timer trap is available via M:STIMER and a console interrupt routine may be specified via M:INT.
- 6.3.4 Remote Job Entry (RJE) is available to an on-line user through a TEL command or use of the M:JOB procedure call. Files may also be submitted for printing or punching.
- 6.3.5 Program segmenting facilities are available by means of an explicit M:SEGLD procedure call within the program or use of the REF/BREF options on the LOAD command. This will automatically insert the M:SEGLD code whenever there is a branch type instruction to a DEF in a higher segment (BREF mode) or wherever there is an expression involving a DEF from a higher segment (REF mode).
- 6.3.6 Inter-program communication may be effected through use of M:LINK and M:LDTRC procedure calls. Communication is accomplished through the general registers or common dynamic storage.
- Privileged programs may also initiate any processor in the system account as a ghost job through a procedure call within the program.

6.4 CATALOGUED PROCEDURES

Through its BATCH command, UTS includes a catalogued procedure facility, which may be used by on-line terminals to submit jobs (RJE) or by batch jobs themselves to spawn other batch jobs. Each call submits one or more jobs which may be independent or order-dependent on each other through the LIMIT command ORDER parameter. The current version does not include parameter substitution. The procedure may be nested indefinitely, i. e., catalogued procedures may themselves include calls to execute other catalogued procedures. The facility is heavily used to submit SYSGENs, regression test jobs, and the Engineering Department's analysis programs, run during the third shift.

7. OPERATOR CONTROL

7.1 OPERATOR CONSOLE MESSAGE FORMATS

Four classes of messages are printed in different formats on the operator's console in order to provide functional and visual separation. These formats are outlined below:

- a. Messages without tabs are for operator's reference at a later time. They are typed at the left margin. Examples are the following:

```
id:ON
id:OFF
JOB acct, name, id, priority
```

- b. Messages preceded by a single tab are for symbiont operations. With normal tab setting, they are positioned one inch to the right of the left margin. Examples are the following:

```
_Syyndd ACTIVE
_Syyndd NOT ACTIVE
```

- c. Messages preceded by two tabs either concern specific users or are generated by batch or on-line users. (All terminals logged into the system have the capability of sending messages to the operator's console.) With normal tab setting, these messages are positioned two inches to the right of the left margin. Examples are the following:

```
id:  _ user message
id:  _ ndd DISMOUNT AND SAVE reel number
id:  _ MOUNT ndd, reel number
```

- d. Messages preceded by four tabs are for operator actions related to physical devices. With normal tab setting, they are positioned four inches to the right of the left margin. Examples are the following:

```
----_LPA02 MANUAL
----_CRA03ERROR
```

The operator may cancel the printing of any message by depressing the BREAK key.

7.2 OPERATOR FUNCTIONS

7.2.1 Job Control

Key-ins are available to cause an error exit from a job step or abort a job in progress.

7.2.2 Symbiont Control

The operator has a variety of commands providing for symbiont control. The operator may initiate or suspend activity on any symbiont device, including remote batch terminals. Both forms control and the ability to delete or change the priority of a waiting input or output file is provided.

7.2.3 System Control

The operator may control the maximum number of batch or on-line users allowed in the system and may also force an immediate and orderly shutdown of the system. Many other system control functions are available through the primary operator's console if CONTROL is initiated as a ghost job. These capabilities are normally provided by means of a Teletype adjacent to the primary console. Section 8 discusses these capabilities in detail.

7.2.4 Operator-User Communication

The operator may send a message to an on-line user or a remote batch workstation as well as establish a broadcast message for all on-line users or all remote batch workstations. Through use of the INT key-in, the operator may cause control of a user program to be transferred to a console interrupt routine.

7.2.5 Peripheral Device Control

Hardware errors requiring operator intervention are reported at the operator's console. The operator can cause an error status to be returned, a retry operation to be performed, or may choose to continue as before. Errors requiring an operator response will periodically prompt the operator (every 20 seconds) with an appropriate message to insure that the error condition has been brought to his attention.

7.2.6 Removable Volume Control

The operator may premount or respond to specific mount requests for magnetic tapes and private disk packs. In the case of disk packs, he may also indicate whether the pack is to be shared or used exclusively by a specific user. Unsatisfied mount requests are repeated every 20 seconds to insure that the operator has been notified.

7.2.7 Secondary Storage Control

The operator is informed of critical secondary storage conditions whenever available space falls below a threshold established by the installation. The operator can cause inactive files to be backed up on tape to regain file space.

7.2.8 Information Display

The operator may display system information regarding tape usage, private pack usage, job status, and symbiont file information. Output for large displays may be directed to the line printer or the operator's console.

8. INSTALLATION CONTROL

8.1 ON-LINE INSTALLATION MANAGEMENT

The programs that allow the installation manager to control his installations are available from on-line terminals as well as through batch. These programs may be accessed from several terminals to provide separation of functions usually crowded onto a single operator's console. The El Segundo installations of UTS use two consoles. One covers the device error and recovery messages, logs jobs on and off, and provides tape mounting requests, while the other console is used for installation management functions as reviewed below.

Since the management functions may be accomplished through batch jobs or on the operator console using ghost jobs, small batch-only UTS systems do not require COC terminal hardware.

8.2 SYSGEN

The installation manager defines the profile of his system through the SYSGEN process. Through a process called PASS2, he specifies the hardware configuration and a number of parameters to tailor the system to his specific requirements. Most of the parameters specified at SYSGEN may be adjusted during system operation through the use of CONTROL to dynamically tune the system. The PASS2 process requires less than one minute to define the target system; all that then remains to be done is to load the UTS monitor and its overlays and those processors which reference symbolic locations within the monitor. The entire SYSGEN process, including the writing of the bootable system tape, can be accomplished in less than 30 minutes.

8.3 CONTROL

The CONTROL processor provides control over system performance. It may be run as a batch, on-line, or ghost job, though normally it is run on-line. CONTROL may be used to display or change more than 80 system parameters as well as to redefine partition attributes of any of the multibatch partitions. It is the tool of the installation manager, comprising most of the operational control functions that would otherwise be performed by the operator. In this fashion, an on-line terminal serves as a secondary operator's console, allowing the primary operator's console to be used exclusively for basic operator functions.

8.4 UTSPM

UTSPM performs the five following functions:

- a. Displaying selected performance data on-line.
- b. Creating a statistical base of performance data which may be referenced to create a report.
- c. Creating a history file of performance data by collecting the data at specified intervals.
- d. Referencing one or more history files to generate a performance measurement report and to create chronological and sorted "snapshot" records of performance data.
- e. Referencing the statistical base to provide a report covering the interval from the time of the base creation to the time of the report.

8.5 SUMMARY

The SUMMARY processor provides a global view of UTS performance by formatting and displaying the statistical data collected by UTSPM.

8.6 SUPER

SUPER is used to authorize users' entry to the system and their access to available resources. A unique feature of SUPER is the ability to define an auto-call processor that is to be automatically associated with the on-line user at log-on time, which allows special terminal protocols such as those provided by EASY to be invoked automatically without the request of the user.

8.7 RATES: MACHINE RESOURCE USAGE CHARGING

UTS measures the usage of resources by each job - CPU time, pages, cards, core use, I/O requests, console minutes, tapes used, etc. At the end of the job, a "rate" table is accessed which contains multiplying constants. By applying the constants to the measured usage, a gross "charge units" number is calculated which is reported to both batch and on-line users on the summary supplied at job or session end. It is intended that a simple constant be used to transform charge units into charge dollars. A default set of charge rate tables is detailed in the UTS System Management Reference Manual, 90 16 74 , designed for 1,000 charge units to the penny.

An additional feature of the UTS charge scheme allows up to eight separate rate tables to be assigned to different classes of users. The default supplies one for batch users and one for on-line. Further, the tables may be changed dynamically via a processor called RATES to provide differential charging, say by time of day - prime shift versus nonprime.

9. FILE MANAGEMENT

9.1 GENERAL DESCRIPTION

UTS includes a comprehensive file management system that is compatible with BPM/BTM for files carried on RADs, disk pack (both public and private), and magnetic tape. The following three organizations are included. They are equivalent in function, although different in name, to the offerings of other manufacturers.

Random (direct)

A contiguous pre-allocated set of 512-word granules accessed by relative granule number. Content is managed entirely by the user program.

Consecutive

A collection of variable-length logical records physically blocked into granules by the system. Access is tape-like: sequential, forward, reverse or spacing. Allocation is dynamic, and is limited only by the size of physical devices on the system. Control information is carried with the data blocks for fast access to this heavily used file organization.

Key-indexed (ISAM-like)

A collection of variable-length logical records, each of which has an associated key (name). Access is either by key or sequentially or a mixture of the two. A tiered tree index provides for fast access by key to any record (for example, the file may be positioned using a keyed read, then read sequentially). Allocation is dynamic, limited only by the size of physical devices on the system. A program coded for consecutive files may access keyed files sequentially without program change. Keyed files may be created with records supplied in any order, although the storage packing will be more efficient if they are supplied in sort order. Any copy operation or backup and restore compacts the file to its most efficient storage format. Sequential access is also improved if the file is created in sorted order.

9.2

FILE ACCESS INDEPENDENCE

Access methods are upward-compatible, i.e., a program which uses sequential access may read a keyed (ISAM) file without program change. This means, for example, that the editor can use keyed files for the power of their update capability and then pass this file to a processor, say COBOL, which will access it sequentially. The file need not be copied in order to remove the keys from the data. Thus the sequentially reading COBOL need not be aware of whether its inputs come from file (keyed or consecutive), from the card reader (via the symbionts), or from an on-line terminal.

9.3

AUTOMATIC FILE ALLOCATION

Space on secondary storage is automatically allocated to files as the need arises (automatic extends). No preallocation or extension specifications are required on the part of the user except for RANDOM files (direct). This centralized pooling of secondary storage for consecutive and keyed files makes for especially efficient use of storage when compared to preallocation of space at file creation time.

Statistics of use support the efficiency of the automatic granule-at-a-time allocation. A recent study of the sizes of files on the El Segundo Sigma 7T machine under UTS shows that, of 6000 files, 50% used two or fewer granules (512 words) and an additional 20% used three to five granules.

9.4

FILE SECURITY

Access to user files is controlled through both passwords and explicit authorization lists of users who may read and may write in each file. Automatic file backup facilities secure the files against disaster, and automatic purging of files is accomplished using creation, backup, expiration, access, and modification dates carried with each file.

10.0 PERFORMANCE

10.1 MONITORING AND TUNING

UTS provides a significant set of performance tuning and monitoring services via the processors CONTROL and UTSPM. SUMMARY provides for performance data reduction presenting averages, histograms, and cross-correlations of the data. These tools are described in Section 8.

10.2 TEXAS BENCHMARK

A recent benchmark run for the University of Texas provides a comparison between UTS and the machines and operating systems of major manufacturers. The benchmark was of extraordinary completeness, covering the business data processing applications of the university as well as student and research problems. The more than 170 jobs included in the test were submitted from remote batch terminals and at the central site. Thirty-eight TTS simulated lines were run concurrently using APL and BASIC and interacting once each ten to fifteen seconds, a particularly heavy rate. The 40-terminal on-line load was completed by University of Texas personnel at two other terminals doing timing and testing runs in a variety of languages. The batch stream, multiprogramming in four simultaneous streams, was unusually comprehensive. Several sorts, some on tape and some on pack, were included. One particularly heavy business job included seven sorts and seven interspersed COBOL program runs. This job ran about 1 1/2 hours in total processing time. In addition to many COBOL business programs and FORTRAN student programs, some programs were included for the SNOBOL, ALGOL, MIX, and RPG languages. In total the mix was about 75% business data processing.

The preliminary results, tabulated below, show UTS on the Sigma 9 to be an outstanding price-performer against major competition.

| Firm | Machine | Operating System | Price In \$1000 | Bench-Mark Time min. | Bid Price, Adjusted For Performance |
|-----------|-----------------|------------------|-----------------|----------------------|-------------------------------------|
| Xerox | Sigma 9 | UTS | 2201 | 165 | 2201 |
| IBM | 370/155 | OS/MVT | 3209 | 150 | 3046 |
| CDC | Cyber 73 (6500) | Kronos | 3754 | 105 | 3068 |
| UNIVAC | 1106 | EXEC8 | 3066 | ? | ? |
| Honeywell | 6070 | GECOS III | 2966 | ? | ? |

Benchmark results are not known for Univac and Honeywell, but according to the sales office in Dallas they also do not compete with UTS. Price includes machine maintenance, conversion, and software costs. The configuration benchmarked differs from the configuration bid in that current tapes and packs were used while new 1600 bpi tapes and disk A's will be delivered. Presumably these higher performance devices will increase the performance of UTS for this highly I/O-bound benchmark.

10.3 COBOL COMPILATIONS

Recent carefully conducted tests run by the COBOL development group are reported in PDS3-72-236, dated August 3, 1972. They compare COBOL compilations under BPM, UTS, and XOS. The principal results for the six compilations which ranged in size from 500-10,000 cards are as follows:

| | |
|-----|-------------------|
| BPM | 1178 cards/minute |
| XOS | 1817 cards/minute |
| UTS | 2055 cards/minute |

In addition to the 10 percent performance advantage of UTS over XOS, the study also shows the effects of the file allocation strategies of the two systems. Significantly higher temporary storage is required in XOS than in UTS. The effect is more pronounced for small compilations. The ratio of storage required ranges from 3.6 to 1.4.

10.4 IMPROVEMENT BY UTS VERSION

UTS has shown a steady increase in throughput capability for each new version. The table below summarizes this steady improvement. Features have been included in C01 and are underway for D00 which will continue the established trend. All data are taken from the 128K Sigma 7F, are averages over periods of 3-10 days, and consist of the heavily loaded prime shift only.

| UTS Version | Number of Users | Non- Wait CPU % | Number of CALs/ Minute | Interactions Per Minute | I/O Per Minute |
|----------------|-----------------------|-----------------------|------------------------------|-------------------------------|----------------------|
| A00 | 29 | 84 | 3100 | 25 | 830 |
| A03 | 24 | 83 | 3000 | 24 | 830 |
| B01 | 27 | 80 | 4200 | 27 | 1100 |
| C00 | 46 | 76 | 5600 | 48 | 1430 |

Service provided by UTS has increased satisfactorily, particularly with C00 as measured by (1) the number of users serviced, (2) CALs (monitor service requests), (3) terminal interactions, and (4) I/O rates per minute. The small cost in CPU utilization is not proportional to the work done, which reflects improvements in operating system efficiency. Most of the waiting time, which is for I/O, can be regained by use of larger memories and/or faster I/O devices provided for in D00.

11.0 STATISTICAL DATA

11.1 CONFIGURATION

The minimum-cost configuration for UTS consists of the following:

- a. Sigma 6 CPU with map, memory protect, two interrupt levels, decimal and floating arithmetic, and one extra register block
- b. 64K words of core memory
- c. System and file RAD
- d. One 9-track tape
- e. Operator's console, card reader, and line printer
- f. COC gear and lines as necessary to the application

The need for COC gear, extra register block, and interrupt levels may be eliminated if a batch-only system is desired. (A configuration of this sort has been ordered by Memphis State University for delivery this fall.) At minimum software cost, the COC routines may be removed from the resident monitor to release core for jobs.

In the minimum-cost installation, more file storage is usually required than is available. In this case, the RAD may be replaced by a disk pack for combined system residence, swapping, and file storage.

11.2 MONITOR SIZES

There are many ways to measure the "size" of a system. The following subsections provide several different breakdowns which describe the "size" of UTS; all of them relate to the parts of the system as maintained by the UTS Section except as noted.

11.2.1 Source Code

System source code (including comments) in compressed form for the C00 version of UTS is contained in 283 files comprising 1.2 million words.

11.2.2 Execution Form in the System Account

The system account, :SYS, contains the ready-to-run load modules for the UTS system, all of the language and other processors, error logs, accounting files, authorization files, etc. In total much more than just UTS system modules are included. The system account for C00 UTS on the Sigma 7T in El Segundo contains 1.6 million words in 175 files.

11.2.3 Resident Monitor

The UTS fixed resident monitor for the C00 version of UTS ranges from 24.5K to 32K words. Improvements for D00 will result in a batch-only resident monitor of about 22K words.

11.3 RESTRICTIONS AND LIMITATIONS

The attached appendix lists the current restrictions and limitations of UTS. Many of these limits are so wide as to constitute recommendations rather than limitations.

12. RELIABILITY AND AVAILABILITY

12.1 Memory Access Protection

All programs are divided into procedure and data areas which are separately protected with execute-only and read/write access codes. Access codes and write locks together are used to protect users from one another, to protect the system code from the user, and to prevent the system from writing in its own procedure area.

12.2 Device Error Recovery and Reporting

Error and fault detection, correction and reporting facilities provide for automatic re-try of device errors and machine faults. In the event of an uncorrectable error the effect is confined to a single user. Error log entries capture pertinent data to use in analyzing errors and in predicting problems by observing rising error rates. This technique has been used by Field Engineering to provide excellent up time on El Segundo on UTS machines.

12.3 Automatic Recovery

System malfunctions resulting from either software or hardware problems cause automatic recovery and restart of the system. The process closes all open files to preserve the most recent updates of each, updates accounting information, and provides a system dump for automatic analysis. Recovery takes one to three minutes depending on the current user load. On-line users are immediately notified by recovery of the interruption of service. Batch jobs in the queue waiting to run are preserved and run on restart. Output for completed jobs is preserved and printed. Lines remain connected and users are automatically provided with the logon sequence when the system is restored.

12.4 Critical System Table Protection

The granule allocation tables for the file system and symbiont queues are maintained on secondary storage. Even a complete loss of core memory does not affect file integrity. Re-booting from the system RAD recovers the critical tables without need for a costly file reconstruction process. A file reconstruction facility does exist; it can be activated at a convenient time to recover the small loss of unused granules recorded in the stacks at the time of loss core.

12.5 Consistency Checks

The operating system performs internal consistency checks throughout its operation. A complete user state/event matrix governs the scheduler's operation, thus insuring that inconsistent events are immediately detected and appropriate recovery initiated. The file management system is protected

by comprehensive flink/blink (forward and backward disk address links) checks which discover file system errors before they have a chance to propagate. The I/O system performs tests on the reasonableness of each I/O request, refusing to perform patently outrageous requests. Options are available to check-write each RAD or disk write operation as well as invoke a software read check on swap operations by including a unique "serial number" in each page written. Comprehensive tests are performed on all user requests to insure validity of the request and authorization. Near-absolute protection is provided against both accidental and malicious misuse of the system.

12.6

File Backup

The FILL processor backs up user files according to a schedule supplied by the installation or an explicit user request. Three levels of backup are provided by the SQUIRREL, INCREMENTAL, and SAVEALL functions.

These three file saving modes provide for a hierarchy of file backup tapes which contain the most recently modified files.

Saveall - saves all files in the system providing the basic backup point.

Incremental - saves only files which have been modified since the last Incremental or Saveall. This consolidates the files saved by Squirrel onto a single tape so that the individual Squirrel tapes may be released.

Squirrel - saves recently modified files for the most detailed form of file protection. Squirrels may be run each hour for especially high safety of the files.

FILL also controls the purging of expired and, if necessary, inactive files insuring that the files are saved on tape prior to deletion in order to release file storage space.

A media dump facility exists which saves all RAD and disk storage on tape by fast cylinder mode transfer. Only active tracks and cylinders are saved. A combination of the media dump tapes with FILL, squirrel and incremental tapes can be used to insure rapid recovery in the event of a complete file system loss. Media dump may also be used to create an exact copy of a private pack onto another pack.

12.7

FAST SAVE/RESTORE. A device speed file save/restore facility is provided. The file system is copied to tape on a file by file basis thus providing for a selective restore and the ability to transfer to a different system.

12.8

Maturity and Field Experience

UTS has two years of field experience, much of it in extremely demanding environments. Its roots are in BCM, RBM, BPM, and BTM so much of the code and the internal design has up to seven years of experience.

UTS is currently installed in more than 25 locations: 19 are running it full-time production, 6 part-time, and 7 are to be installed in the next 90 days. UTS has many excellent reference accounts, and will have 30 to 50 sites in 1972.

Seven new sales have been made this year because of UTS-- 4 Sigma 6s and 3 Sigma 9s.

13. MAINTAINABILITY AND EXTENDABILITY

UTS includes extensive and proven capabilities for maintaining itself both in El Segundo and in the field. Its features and facilities are powerful tools for extending its own capability. These features and facilities have been developed through experience gained in development of UTS and its ancestors - BTM, BPM, RBM, and BCM - over the past seven years. Items of specific importance follow.

13.1 SOFTWARE CHECKOUT AND REPAIR

13.1.1 Automatic Crash Analysis

Explicit internal tests detect most software and some hardware problems and activate the system recovery routines. A dump taken at this time is submitted to a ghost job that provides an analysis of the problem, including the immediate symptoms and formatted presentations of system tables and job-dependent information. About 20 specially formatted tables are presented in terms of well-known system symbols, permitting fast and accurate isolation of the problem either by home office experts or by field analysts. The analysis and repair of problems is thus especially prompt.

13.1.2 Remote System Analysis

The same routines used for automatic analysis may be used during system operation from any remote or local terminal to isolate system problems in a crash dump on file or in the running system itself. Further, the language DELTA may be used to examine and repair the running monitor, again from a remote terminal. This facility has proved especially valuable as a fast, money-saving aid to solving problems at several UTS installations; it allows several home office experts to combine their various talents to solve a problem within hours rather than making long, expensive trips to the customer's site. McDonnell Automation, DREV, Memphis State University, NYIT, Bucknell, and others have been helped with remote techniques. In these cases our people in the home office have logged onto the customer's system, gathered information, analyzed it, and dynamically applied the correcting patch.

13.1.3 Executive DELTA

For especially difficult problems which require hands-on control, the executive debugger, XDELTA, provides for complete total control of the operating system. Breakpoints may be set to stop the system for examination at crucial points using the symbols of the system for accurate, easy-to-read displays.

13.1.4 Symbolic Patching

XDELTA is also used to patch the system at boot time. The same symbolic patch format is used for both debugging and for patching. Patches are generally relocatable so that patch decks may be applied without change to all systems regardless of the SYSGEN configuration.

13.1.5 Boot-Under-the Files

When it is necessary to apply patches to a production system, UTS provides for rereading the patch deck without disturbing the permanent files of the system and its users, which avoids the necessity of saving and restoring an extensive file system in order to apply critically needed patches.

13.2 HARDWARE CHECKOUT AND REPAIR

13.2.1 Error Log

UTS provides a log of all recovered hardware errors as well as unrecoverable faults. Analyses of this log have consistently provided Field Engineering personnel with a prediction of faults through increasing error rates. Thus they are able to repair devices in nonprime time, before the device becomes unusable.

13.2.2 On-Line Diagnostics

Within the system, diagnostics are provided that may be used from either local or remote terminals to analyze and repair card readers, card punches, line printers, magnetic tapes, RADs, and disk packs. These run during system operation without disturbing on-line users or batch job throughput (except, of course, for jobs requiring the down device). Full direct access to the device is provided, and all hardware status information - TDV, TIO, AIO - for the read or write operation is returned to the diagnostic.

13.3 DOCUMENTATION

Use and maintenance of UTS is supported by the following documentation. Five user manuals relate directly to the use of UTS:

| | | |
|----------------------------|----------|-------------|
| Batch Processing Reference | 90 17 64 | (203 pages) |
| Time Sharing Reference | 90 09 07 | (135 pages) |
| System Management Guide | 90 16 74 | (236 pages) |
| Operator's Manual | 90 16 75 | (49 pages) |
| User's Guide | 90 16 92 | (107 pages) |

Five other user manuals relate to operations under UTS of language processors:

| | |
|------------------------------|----------|
| BASIC Operations Manual | 90 15 46 |
| Metasymbol Operations Manual | 90 09 52 |
| FORTRAN Operations Manual | 90 11 43 |
| FORTRAN Debug Reference | 90 16 77 |
| COBOL Operations Manual | 90 15 01 |

UTS internals are extensively and completely documented in the following software technical manuals:

| | | |
|--|----------|--------------|
| UTS Technical Manual | 703029 | (2500 pages) |
| BPM Technical Manual (for Compatible Items) | 90 15 28 | (350 pages) |
| Overlay Loader Tech. Manual | 90 18 03 | (122 pages) |
| SYSGEN Technical Manual | 90 18 77 | (321 pages) |
| DELTA Technical Manual | 90 18 79 | (39 pages) |
| EDIT Technical Manual | 90 19 11 | (105 pages) |
| PCL Technical Manual | 703027 | (100 pages) |

13.4 DEVELOPMENT AND TEST

Several programs and procedures facilitate the development of new versions of UTS, including the required extensive regression testing.

- a. On-line SYSGEN: provides for quick, accurate and convenient production of new systems for regression test.
- b. DRSP: provides for the replacement of shared processors with new versions without need for SYSGEN.
- c. System simulators: portions of the operating system are isolated for test under simulators and thus may be debugged from on-line terminals. UTS file management and Terminal I/O routines are checked out in this manner.

The C01 merge of ANS tapes (3000 lines), 120 SIDRs, and other C01 development, a total of 1000 lines, was brought up within one week to the point of successfully running regression tests. The reason was that ANS code had been thoroughly checked out in simulation on-line on the production Sigma 7T.

- d. Listing library: a centralized listing library provides accurate, complete, and available documents for analysis of each version of the system.
- e. Centralized definitions: certain system-wide definitions are carried in common packages (DATADEF-like) provided for accurate reference from any module.
- f. Automatic regression testing: the program QUAC makes it possible to submit the entire regression test library automatically.
- g. TTS: the Sigma 3 timesharing simulator and the library of UTS test cases allow fast easy regression testing of the on-line services.

- h. UPDATE: a program which merges and compares update packages for a given module to facilitate integration of separate development efforts.
- i. CROSSREF: a program which provides a complete cross-reference of all symbols used in the monitor, showing where it is defined and all the places it is referenced.

13.5 EXAMPLES OF EXTENDABILITY

UTS has shown an accelerating development pattern over the last year and a half. It becomes easier and easier to add new features to the system. Two factors are probably responsible for this: first, the solid fundamental design of the system. Much long range planning was done in the early days. Second, for the last year and a half the system has been solid enough to support its own continued development, becoming an important tool in the development process.

Several recent features are examples of system extensions which required an unusually short development time.

Most features specified for XMS are in the current system; they were put in place with disarming ease.

Major enhancement to remote batch support went into the system smoothly, release C00 was ready ahead of schedule.

The general command processor interface for EASY was added to the system with only one and a half months of effort.

Exit control has been designed, coded, and is ready to go into the system at a cost of one and a half man/months.

The system features which have made this possible are the modular division of the monitor by function, the simplicity of the interfaces between functional modules and the generalized functions performed by the memory management, execution scheduler, and the swapper. These same hooks allow and facilitate a number of natural extensions to UTS.

Interprogram communication - by making use of existing event-reporting logic in the execution scheduler, it is possible to write two new CALs which permit message transfer from one program to another.

Transaction processing - the combination of exit control, interprogram communication, and the shared processor feature of UTS provides very naturally for the generation of transaction processing applications. These applications can be based as well on keyed files or on DMS random files.

Demand paging - the potential addition of demand paging to UTS is facilitated by the existing swapper and memory management code. This existing code would require minimal change. An enhanced trap handler to detect and analyze page faults and alter the swap or working set through existing memory management facilities is the only new code required. While permitting large (virtual size greater than physical size) users to execute, this approach retains the efficiency of UTS swapping for small users. The modularity of UTS would permit even demand paging to be a SYSGEN option.

14. AVAILABLE LANGUAGE AND APPLICATION PROCESSORS

14.1 CLASS A1 PROCESSORS

| | |
|-----------------------|---|
| <u>Manage</u> | Generalized file management system including update, retrieval, and report generation. Terminal-oriented Manage (TOM) is available for on-line use. |
| <u>CIRC-DC</u> | DC circuit analysis. Batch or on-line. |
| <u>DMS</u> | Generalized data management system. Batch or on-line. |
| <u>CIRC-AC</u> | Provides frequency domain analysis of electronic circuits. |
| <u>SL-1</u> | Real-time hybrid continuous system simulation language. |
| <u>GPDS</u> | General purpose discrete simulator. Batch or on-line. |
| <u>CIRC-TRANSIENT</u> | General purpose time-domain analysis of electronic circuits. Batch or on-line. |

14.2 CLASS B1 PROCESSORS

| | |
|--------------------------------|---|
| <u>META-SYMBOL</u> | Meta-assembler. Batch or on-line. |
| <u>SORT/MERGE</u> | Generalized file sorting and merging. |
| <u>1400 SIMULATOR</u> | Used to execute 1400 series object programs. |
| <u>BASIC</u> | Interactive algebraic compiler. Batch or on-line. |
| <u>EXTENDED XDS FORTRAN IV</u> | FORTRAN compiler and libraries. |
| <u>ANS COBOL</u> | COBOL compiler. Batch or on-line. |
| <u>TEXT</u> | ATS-like on-line document processing system. |
| <u>APL</u> | Interactive functional programming language. |
| <u>EASY</u> | The GE MARK II-like system for BASIC and FORTRAN. |

15. FUTURE COMMITTED FEATURES

This section lists only those features which are explicitly committed for development by marketing announcement or approved field request. Many other enhancements are feasible in UTS and have received some design attention.

15.1 OCP, 2Q73. Support for the XEROX Optical Character Printer as a symbiont device.

15.2 IRBT, 2Q73.

IBM HASP multileaving, record compression/decompression

IBM Bi Sync communication protocol

2780 support

Facility for computer-to-computer communication between
UTS systems

Multiple peripherals at remote stations

Forms control at IRBT

Support for remote operator consoles

Flexible control over the priority of input and output files

Multiple copies and routing of copies to remote terminals

Comprehensive backup control over printed output

Workstation accounting

15.3 NO-WAIT I/O, 2Q73. No-wait I/O will provide substantial performance improvements for many applications. The support will include automatic double buffering and I/O independent of the user. That is the user may swap while his I/O is in progress.

15.4 1600 BPI TAPE, 2Q73. 1600 BPI tape support will include resource control for mixed density systems.

15.5 TAURUS, 1Q74.

15.6 RMA, 4Q72 → 4Q73. On-going improvements for RMA are scheduled through the fourth quarter of 1973. Improved error logging, error analysis, and on-line diagnostic support will be provided.

16. SPECIAL FEATURES

16.1 COMPATIBILITY WITH BPM/BTM

UTS is entirely compatible with BPM/BTM. Files are transferable, programs are executable, and the terminal protocol is, for practical purposes, identical. This means that UTS can run without change not only all processors developed for BPM/BTM, but also programs from the comprehensive user group library, which includes SNOBOL, LISP, APT3, ADAPT, MIX, SOL, ALGOL, ECAP, FLOPLOT, and other programs listed in Section 14.

The 32K BTM system provides UTS with its low entry system. Compatibility provides for upgrade to UTS without conversion. The process has been accomplished in a matter of a few hours or a few days.

16.2 SHARED PROCESSORS

The procedure portion of most processors, libraries, and monitor overlays is shared among all concurrent users. For example, if four FORTRAN coded programs are running concurrently, only one copy of the library is required. This yields a savings of 13.5K words--enough core to run another job. About 40 processors and overlays are shared in UTS, which results in particularly efficient uses of core memory. Using DRSP, these shared processors may be replaced during system operation with updated versions without disturbing on-going work. Current users of the replaced processors continue to use the old version until they terminate. Installations may take advantage of this core-efficient facility by adding their commonly used processors and libraries to the system as shared processors either at SYSGEN or dynamically, via DRSP.

16.3 FACILITIES FOR INSTALLATION DEVELOPED COMMAND PROCESSORS (SUB-EXECUTIVES)

UTS provides in its standard release the batch command processor, CCI, the general-purpose terminal command processor, TEL, and the special-purpose GE MARK II-like command processor, EASY. Installations may use the facilities provided for these processors to develop their own command processors (also called "sub-executives") to satisfy special needs. A command processor is a shared processor that is given control on all exits, errors, aborts, breaks, and hang up conditions resulting from programs executing under its control. When coupled with

the SUPER specified auto-call-at-log-on facility, it can therefore provide an isolated environment for a particular class of users that may be separately charged for the restricted services provided. If desired, one command processor may pass control to another, thereby granting a greater range of service up to the full set of system services.

16.4

GHOST JOBS

Ghost jobs are independent tasks which, rather than entering the system through a card reader or on-line terminal, are initiated at program request by the operator, the system, or by a current job. Many system tasks (e.g., crash analysis, performance monitoring, secondary storage allocation, multi-batch scheduling, remote batch support, and system initialization) take this easy-to-add and easy-to-maintain form and thus do not add to the resident or nonresident system overhead. Any program may be called as a ghost job for the specific needs of a particular installation. Ghost jobs form a "parallel" class of jobs which may be called into execution by the operator. Newport News, for example, runs a subset of the CPU diagnostics via a ghost job during lightly loaded periods. The number of ghost jobs allowed in execution at any one time is a SYSGEN parameter.

16.5

CENTRALIZED UTILITIES

A single comprehensive processor (PCL) that may be used in either batch or on-line environments replaces the usual proliferation of utility programs. Transfer of files in any system format is accomplished between any two devices via an easy-to-use command language. Format conversion and record selection may be specified for the transfer and files may be concatenated or split.

16.6

VIRTUAL MEMORY MANAGEMENT AND SWAPPING

This important UTS facility is discussed in Section 1.

16.7

ON-LINE BATCH COMPATIBILITY

This is also discussed in Section 1.

UTS OPERATIONAL RESTRICTIONS
AND LIMITATIONS

1. File System
2. DCBs
3. Assignments and Sets for DCBs
4. Symbionts and Cooperatives
5. Physical Core
6. Virtual Core
7. Lines, Jobs, and Users
8. Devices
9. Terminal I/O
10. Other

1. File System

- a. File names are limited to 31 characters, except for:
 1. Names supplied via TEL where the limit is ten characters.
 2. ROM names which are limited to ten chars.
- b. The number of accounts allowed is limited by requiring a printable name of eight characters or about 40^8 .
 $\approx 64 \times 10^{11}$
- c. The number of files per account is limited by requiring expression in 31 characters which is greater than 40^{31} .
- d. The size of a keyed-file record Key (name) must be ≤ 31 characters.
- e. The maximum number of records per keyed file is greater than 40^{31} .
- f. The number of records in a consecutive file on RAD must be less than 2^{31} .
- g. There can be no more than seven levels in a keyed file multi-level index. (Implies a limit of more than $22 \cdot 57^6$ records.)
- h. No public file may total more than 32767 granules. $\approx 16 \times 10^6$
- i. No private pack file may exceed 65535 granules (somewhat less than six packs).
- j. There can be no more than 399 files per private pack.
- k. The minimum allocation unit for private pack files is 30 granules.
- l. The size of records in a file is limited by the requirement that the record be entirely contained in core memory when written.

2. DCBs

- a. Length of an individual DCB is limited to 255 words.
- b. The number of DCBs is limited by the rule that the total space for DCBs and buffer pools (POOL command) may not exceed 11K words. Individual DCBs must not overlap page boundaries - this is enforced by the Loader so some "breakage" space results in packing of DCBs into memory.
- c. The DCBs M:UC, M:OC, and M:XX do not require space in the DCB area. An M:DO DCB is always supplied by LINK; LOAD supplies and M:DO DCB except when NOTCB is specified.
- d. If an M:PRINT CAL is used, then an M:LL DCB is generated and included in the DCB area. If the program LOAD specifies SEG, REF, or BREF, then an M:SEGLD DCB is supplied through which the overlay I/O is accomplished.
- e. For LINK loaded programs only a limit of two pages of DCBs applies.

3. ASSIGN and SET Commands for DCBs
 - a. Total number of active SET commands is limited to 12. Unneeded SETs may be removed with a SET DCB 0 command.
 - b. Total number of ASSIGN commands is limited by the size of the associated FPTs (sizes as if M:OPENs had been issued for the ASSIGN information). Total size of FPTs may not exceed 490 words or about 40 ASSIGN commands (12 words for a typical entry).
 - c. Serial numbers for tapes and private packs are limited to four characters.

4. Symbionts and COOPeratives
 - a. A maximum of three COOP devices may be open at any one time during program execution.
 - b. The number of symbiont input and output files is limited only by resident memory size. Two words per output file and 6-3/4 words per input file. The resident memory requirement for input files is lifted in a 2Q72 UTS release.
 - c. Space for symbiont input and output files is taken from the sysgen set values but PFA granules are used if PER is entirely used.

5. Physical Core

- a. Total memory allowed is 128K for Sigma 6/7; memory to 512K is allowed on Sigma 9 with a later UTS release (4Q72).
- b. The resident monitor may not exceed 32K (to the beginning of the module JIT).
- c. No monitor overlay may exceed 3K.
- d. Minimum memory is 64K.
- e. Minimum resident monitor is about 24K.

6. Virtual Core

- a. No program may exceed 63.5K (extended to 76K in 4Q72), including program, data, DCBs, and buffers but excluding associated shared processors.
- b. The minimum requirement for DCBs and buffers is 1.5K.
- c. No special shared processor can exceed 16K.
- d. Combined size of DCBs and buffer pools may not exceed 11K.

7. Lines, Jobs, and Users

- a. The total number of concurrent active jobs (users) in UTS (batch plus on-line plus ghost) may not exceed 255.
- b. The total number of terminal lines connected to a UTS system may not exceed 512 (7611 hardware limit).

8. Devices

- a. The total number of I/O devices - tapes, packs, RADs, card readers and punches, line printers, 7611's, 7601's, plotters, paper tape readers and punches, etc., - may not exceed 255.
- b. The minimum configuration requires line printer, card reader, 7232, 7611, and operator's console.
- c. The total number of packs plus tapes may not exceed 32.
- d. The largest record that may be written to a device (as distinguished from monitor-managed files) is 32K-1 bytes.

9. Terminal I/O

- a. An individual M:READ or M:WRITE may not specify more than 140 characters of length.

10. Other

- a. A FILL SAVEALL must be contained on eight tape reels (36 in a later release).
- b. There can be no more than 255 CFUs.
- c. A SNAP may not specify more than 255 linked FPTs.