Description of IBM 360/67 and CP/CMS Software

The IBM System 360/67 was specifically designed to overcome the problems encountered in programming and operating a time-sharing application. The following features are considered necessary in an on-line computing environment:

1. CPU Speed - The 200 nanosec internal cycle time assures a fast response to console users. The necessity of a high-speed CPU in this environment is not to handle a few staggered demands for service, but to insure that when multiple instantaneous user's demands exist, the apparent terminal response is not degraded. Most computer systems designs are built around a turnaround criteria of hours; and job load averages in this spectrum of time can be analyzed to determine the best CPU cost vs. time tradeoff. In a time-sharing system this same system design technique is invalid. The on-line system which uses only response as a measure of its acceptability requires a high-powered CPU, a CPU which is excessive in regard to the computing demands of the on-line users. Any inefficiency in this type operation suggests that the system also accommodate another class of user, the background job. This low priority work must be available to absorb the excess CPU capability.

2. Dynamic Relocation - This feature on the Model 67 insures the security of user data and programs which co-exist in the same real memory. It also provides the control programs with the hardware necessary to overcome the core fragmentation problem; therefore, only programs and data which are actually in use require residence in high-speed memory.

3. Channel Architecture - The channels in Model 67 are self-contained; that is, they are not part of the CPU as they are on the less powerful models of the System/360. This arrangement has two advantages--first, a hardware error in the channel does not bring the system down completely; second, when this architecture is further extended by the inclusion of a channel controller IBM 2846 in the system configuration, the probability of interference between the channel and CPU memory demands is reduced.

4. Reconfiguration - In the Model 67 system equipped with a configuration console, the probability of extended system outage is considerably reduced. The operator need only switch out defective components and gracefully degrade system performance.

The real advantage of any computing system is, of course, its software. In this respect, the System 360/67 is unique. The CP/67 which is the time-sharing part of the system program has evolved from an earlier system CP/40 which was operational over two years ago.

The CMS (Cambridge Monitor System), which is one of the on-line programming systems available to the terminal user, is the same system that operated with CP/40 and therefore has benefited through two years of use.

The specific advantages of the CP/67 come from its creation in a dynamic sense of many "virtual computers." This technique allows the terminal user to regard his console as an operator's console, 1052, and he programs as if he is running on a 360 computer by himself. This organization permits the individual terminal user a multitude of already existant programs and lowers the cost of converting to an on-line programming environment.

The CP/67 system has the following attributes:

1. Compatibility - Most significantly by being able to run OS, it is completely compatible with the rest of the installation.

2. Openended - CP/67 allows execution in a virtual machine any 360 programs which are not timing dependent nor have data driven I/O.

3. Security - The virtual machines are accessed through a password scheme and since all memory and I/O references invoke mapping by hardware and software, the security of the individual's data is nearly absolute.

4. Maintainability - The system is easily maintained for two reasons; first, because it is relatively small; second, because it is very modular and the individual modules have very little dependence on one another.

5. Proven System - The system has been over two years in operational development and has been successful in operation in a customer site (Lincoln Lab) for over a year where it currently supports 30 terminals.

Questions and Answers on Model 67 and CP

1. What is CP?

   A Time-Sharing System for the Model 360/67 hardware.

2. What does it do?

   This software system, working in conjunction with the hardware, creates a unique environment called the virtual machine.

3. How does it compare with MFT and MVT?

   There is a functional difference between CP and other current operating systems. In CP, the common user functions usually called data management are separate from those functions necessary to perform multi-programming. Under the other systems, multi-programming and data management are combined and usually user directed.

4. Under CP on the Model 67, how many virtual systems can be "sysgenned" into the system?

   This is limited by the amount of space, I/O, and secondary storage which are available.

5. What is a virtual system?

   Virtual system is a simulated 360 environment in which all inter-user conflicts are resolved through mapping by either software of hardware, or both.

6. What systems can be operable under CP? (OS, CMS???)

   Any non-timing dependent/360 program is operable in a virtual system.

7. What is the limit to the number of users on line at the same time under CP?

   The limit on the number of users depends on the load conditions but currently there are 30 on-line users at the Lincoln Laboratory. Plans call for another control unit and then the number will double.

8. When are the bounds of each virtual system defined? Can they be altered at any time?

   The bounds of each virtual system are defined in the user directory. It can be altered by creating a new directory before start-up.

9. What device support is available under CP?

   A. 2260
   B. 2250
   C. 2741
   D. Disk drives 2314, 2311
   E. Drums 2301, 2303
   F. Large core storage is being implemented at Washington State.
   G. Printers--No restriction as to the number of printers.
   H. Card Reader-Punch--no restriction as to number.

10. Can one use RJE's with this system?

    Yes, current plans include 1130 support as an RJE terminal.

11. Would it be practical?

    yes

12. Is there much degradation to the system if they are all on at once?

    Degradation in a time-sharing paging environment is a function of the load of the terminals. In a correctly operating system, degradation should be linear as the load.

13. Can any one virtual system interfere with any other virtual system? Even deliberately?

    No

14. If data is written on a disk or other I/O device by one virtual system, can it easily be accessed by another virtual system?

    Access to I/O data is only achievable through the directory. Therefore, users can be prohibited or permitted access to one another's data by altering the directory before start-up.

15. Can remote terminals be used with this system?

Yes

16. Can the remote terminals be on-line with the batch?

Yes

17. Is there any chance that one remote terminal may retrieve data from another area other than the area he is using?

No

18. Does the remote terminal degrade much from batch performance? Even with a compute bound job?

Degradation in the time-sharing system is severe for jobs which misuse core even in a batch system. Jobs which are written to run well in the batch environment tend to perform well in the time-sharing environment.

19. What is CMS?

CMS is the Cambridge Monitor System. It is the Operating System used by the terminal user. It provides on-line capabilities such as FORTRAN, PL/1, context editing, SNO BOL.

20. How does it compare with OS?

In comparing CMS with OS, with CMS we have a subset of the OS data management functions and a subset of the languages available under OS and no multiprogramming facilities. CMS is comparable to FMS (Fortran Monitor System) for the IBM 7090.

21. Which types of jobs, I/O or compute bound, run best under the CP system?

I/O bound jobs tend to run best under the CP system.

22. Why?

Because there is a greater amount of time available for multi-programming with these type jobs.

23. Is there a significant increase in performance with faster data rate I/O (2311 vs. 2314 vs. 2303 vs. large core)?

System performance with regard to the I/O system depends heavily on the ratio of core space and CPU demands to I/O demands.

24. With only 444k bytes of physical core available, how can the machine act as if it has 1 meg. bytes available?

By the use of a hardware relocation device which maps all storage references, those pages (i.e., 4096 bytes) which are not in core are brought in from secondary storage and the relocation device is updated.

25. What is paging?

Paging is the artificial division of a user program's address space. In the 360/67, this space is divided into 4096 byte pages. Addresses generated by the CPU pass through and are acted upon by a hardware relocation device before reaching the execution store. Those pages which are not in the physical core store are retrieved from secondary storage devices (drum, disk). The entries for the relocation device are changed to reflect the swap from drum to core.

26. Is only part of the program stored in core at any one time?

The part of the program required for execution is in core.

27. If so, where is the rest of it?

On some secondary storage device (drum or disk).

28. If two small programs are operating under two virtual systems, might everything remain in core from both systems at the same time?

Yes, if the sum of the two active page requirements is less than or equal to the number of available pages in a physical core.

29. Under CP and the concept of virtual systems, how large can a program be before it runs out of core?

16 million bytes, i.e., the number of bits in the address field.

30. If one virtual OS systems fail, does it bring down the whole system?

    No

31. If CP fails, does it bring down the whole system?

    Yes

32. Does CP have both input and output spooling?

    Yes

33. How can the output from separate jobs be kept separate?

    By prefixing the printed output with a user ID.

34. Is there a way to direct certain job output stream to a certain printer?

    This facility is currently being implemented.

35. From the same system input device (i.e., card reader-punch) how does the input go to the intended OS virtual system?

    By preceding the user input cards with a user ID card.

ATTACHMENT I

26 April 1968

MEMORANDUM FOR: Computer Science Advisor

SUBJECT : Planning for IBM 360/50 Replacement

STATINTL

1. I would like you to form an ad hoc group within the Office to study the alternatives and recommend a course of action regarding the replacement of the 360/50 in the Computer Center. As you know, this computer [redacted]

2. In analyzing the alternatives, the following factors should be considered:

a. The system will be used principally in the time sharing mode. Background processing for efficient computer utilization is desirable but not mandatory.

b. I do not believe we can plan to move into a completely integrated software system including multiprocessing, multiprogramming, and time sharing as the standard Operating System in the Center. Compatibility with the software and hardware used in the Center is certainly desirable, particularly if main frame connections are feasible for passing tasks back and forth.

c. We should assume that by January 1969 the customer requirements and our experience with time sharing will be such that a stand alone production time sharing environment will be feasible and desirable.

d. Movement toward a production environment will make system experimentation and extension more difficult than it is now, but through judicious planning (and perhaps the use of IPRD facilities), we should be able to continue experimentation at a reasonable pace.

e. Costs must stay within current budget estimates. Supplementary funding could be justified only if major new requirements were surfaced.

f. Conversion to the new equipment should be as painless as possible.

g. We have no firm basis for projecting load other than what we know about existing applications and informal requirements. We should assume that the known requirements will constitute the minimum load to be expected.

3. The above factors tend to reduce the number of hardware alternatives that must be considered seriously. In my view, the following are the more obvious ones (in no particular order, with no comment):

a. A 360/50 starting with the configuration identical with the current one but expanding as needs arise (LCS, AMCS, 2314's, etc.).

b. Two stand alone 360/40's, one for Agency sensitive data, the other for everything else.

c. A 360/67 using a minimal configuration needed for TSMON (with or without CP67).

d. A 360/65 configured for time sharing.

e. A Spectra 70/46.

4. Software alternatives are perhaps the more difficult to evaluate. Some random thoughts: We have to assume that the programming talent that can be applied to time sharing software and related application services (in quality and quantity) will always be less than optimal. But I think the "shoe string" effort thus far can be expanded over the next year because we have encouraging tangible results. We should concentrate on building and expanding services peculiar to our installation, perhaps at the expense of building monitors or spending time making them more efficient. As the system becomes saturated, our first question should be whether modest increases in hardware would keep the system going rather than to immediately task our available programming manpower to squeeze more from the existing hardware. Only when serious overload is expected should we look to improved or new monitors. In this way, I would hope that we could keep the system going until efficient monitors that meet our needs become available from the outside, using our people in the meantime to build more and better application services.

5. Your findings should be available by 1 June so that a decision can be made and an order placed with sufficient lead time.

STATINTL

[redacted]
Deputy Director of Computer Services

cc: D/OCS
TRC Members

26 June 1968

ATTACHMENT J

MEMORANDUM FOR THE RECORD

SUBJECT: Trip to RCA on Spectra 70/46

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1. On 17 June 1968, [redacted] went to [redacted] New Jersey, to test the Spectra 70/46 and talk to systems personnel. (See attached for a description of Spectra 70/46 as written by Totaro of Auerbach and distributed by RCA.)

2. Meinstein, RCA, stated RCA's time sharing objectives as follows:

a. "To provide concurrent service to a large number of users at remote points."

b. "To supply the user with immediate access to a computer so that it appears to him that he is the only user."

He gave an overview description of the hardware which is included in the attachment. He explained that 524K of memory was rejected because of cost and thus the S-46 was a 262 byte machine. System design programs are separated into two classes.

Class 1 - that which is brought over, must be loaded in entirety, must be loaded contiguously, must use private volumes, must never be paged, and memory is not to be relinquished.

Class 2 - Program is created on S-46 with TDOS compilers, pages are pageable, certain pages are not to be moved, only the page with an entry point must be loaded to start, may share public and/or private volumes.

In data management, SAM and BDAM are available on all devices except RACE. BTAM (Basic Tape Access Method) is available. ISAM is available on all DASD except on RACE.

All code is re-entrant. Is this because of insufficient memory size? Is it worthwhile? This was rather unusual since there is a trend to forget re-entrant code on paging hardware. Cataloging is available by name.

JCL and TCL (Terminal Control Language) are a single language which is an excellent feature. The operator can designate number of pages limited to a class 1 program.

3. Performance Tests. In order to demonstrate that the S-46 works, an unofficial demonstration was given. One typewriter terminal was activated and then 39 copies of another program were simulated by attaching a S-45 to the S-46. Performance and response were impressive. However, as most time sharing implementers have discovered, a synchronous and perfectly interleaved load is not the same as humans asynchronously interacting with a system. Whether RCA really has a better time sharing technique than others could not be determined. If a machine as low powered and with as small memory as the S-46 can handle 40 users with 1-2 second response time, RCA has a winner. In conclusion, I am willing to go on record with my personal opinion that RCA is in for a rude awakening on performance. In my opinion, RCA on the S-46 will not provide 40-48 users with adequate response time. When load peaks and especially with complicated queries or calculations, I believe the response time will degrade to many seconds, or even minutes and customers will be dissatisfied. Unfortunately, RCA's system cannot be adequately exercised and measured.

4. Device support.

Data Cell. RCA offers its RACE; and even though direct access is not supported under S-46, they offered to help move SANCA over to the RACE.

Fast Direct Storage. RCA will not have its own large disk until 1970, but they offered to interface with a 2314.

2250. They can interface through an 1130. They have no comparable piece of equipment manufactured by RCA.

5. Language Support. RCA supports FORTRAN and COBOL. The statement was made that a S-46 could handle jobs as fast as the Mod 65, even in FORTRAN. OCS is supplying them with the 13 jobs from the benchmark test so that they can compare their times with a Mod 65. Several similar statements were very disconcerting and reminded me of performance claims for the S-70/45 before delivery. However, if what they are claiming is true (or even partially), OCS should immediately substitute RCA equipment for all IBM gear. Just to satisfy all parties concerned, RCA must complete the comparison testing of the FORTRAN programs.

6. Summary. Very interesting. RCA has very impressive technicians. They are making many ambitious claims. If these are really true, they should be given strong consideration in new time sharing equipment selection.

STATINTL