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Guidelines

FOR THE MEASUREMENT OF REMOTE BATCH COMPUTER SERVICE

CATEGORY: ADP OPERATIONS
SUBCATEGORY: COMPUTER PERFORMANCE MANAGEMENT

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Foreword

The Federal Information Processing Standards Publication Series of the National Bureau of Standards (NBS) officially publishes standards adopted and promulgated under the provisions of Public Law 89-306 (Brooks Act) and under Part 6 of Title 15, Code of Federal Regulations. The Brooks Act and subsequent OMB policy guidance designate the Department of Commerce as responsible for providing scientific and technological advisory services for the management of Federal ADP procurement and usage, including computer networking. These legislative and executive mandates have given the Department of Commerce important responsibilities for improving the utilization and management of computers and automatic data processing systems in the Federal Government. To carry out these responsibilities, the NBS, through its Institute for Computer Sciences and Technology, provides leadership, technical guidance, and coordination of Government efforts to assist in the development of guidelines and standards in these areas.

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Abstract

These guidelines are primarily directed to people who operate or consume remote batch computer service.

The evaluation of Remote Batch [Computer] Service (RBS) is dependent on several factors, including the nature of the service provided, the RBS equipment and its staffing, the criteria and metrics which are deemed applicable, and the measurement methodology. These guidelines present these factors in a unifying context which should introduce increased orderliness into management and selection of RBS.

Key words: Analysis; computer; evaluation; Federal Information Processing Standards Publication; measurement; performance; remote batch; selection; service.

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ANNOUNCING THE

GUIDELINES FOR THE MEASUREMENT OF REMOTE BATCH COMPUTER SERVICE

Federal Information Processing Standards Publications are issued by the National Bureau of Standards pursuant to the Federal Property and Administrative Services Act of 1949, as amended, Public Law 89-306 (79 Stat. 1127), Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 Code of Federal Regulations (CFR).

Name of Guideline: Guidelines for the Measurement of Remote Batch Computer Service.

Category of Guideline: ADP Operations, Computer Performance Management.

Explanation: These guidelines define measures and describe methodologies for measuring remote batch computer network service.

Approving Authority: Department of Commerce, National Bureau of Standards (Institute for Computer Sciences and Technology).

Maintenance Agency: Department of Commerce, National Bureau of Standards (Institute for Computer Sciences and Technology).

Cross Index: See bibliography.

Applicability: These guidelines are a basic reference document to inform Federal agencies of current approaches to evaluation techniques related to remote batch computer service (RBS). These guidelines are primarily oriented toward the person who will be operating a computer system which supports RBS. They should also aid both consumers and providers of RBS in the specification of RBS and in determining whether promised services have been delivered.

Primary Service Attributes: Availability, reliability, timeliness, and correctness are identified as the primary service attributes.

Implementation: These guidelines may be used by a Federal agency which has a need to measure and evaluate the delivery of network services. The methodology and procedures described provide a starting point for such network related activities.

Specifications: Federal Information Processing Standard 72 (FIPS 72), Guidelines for the Measurement of Remote Batch Computer Service, (affixed).

Qualifications: The recommendations provided in these guidelines are based on the research and experience of not only the National Bureau of Standards, but also other Federal organizations and private sector groups. In the future these guidelines will be modified to reflect new developments in network performance evaluation.

These guidelines represent recommended good practices for the specification, measurement, evaluation, and selection of remote batch computer network services. These guidelines acknowledge, but *do not* address, other portions of the procurement process such as functional demonstrations, contractual safeguards, procurement regulations and policy, or other ADP procurement considerations. Thus, in order to be consistent with overall Federal policy, the user should seek current guidance from applicable Office of Management and Budget and General Services Administration policy and procurement directives.

These guidelines are not procedural steps that can be followed as a "recipe" with successful results. Instead, they are intended to be a systematic presentation of good practices. Nor are they "clauses" which can be simply inserted into specifications or other contractual documents. In this sense, guidelines are useful as a checklist and as a means to identify areas where special competence, expertise, or particular attention is indicated.

These guidelines will need to be expanded and/or modified as further knowledge is gained of the techniques involved. Comments, critiques, and technical contributions directed to this end are invited. These should be addressed to the Associate Director for ADP Standards, Institute for Computer Sciences and Technology, National Bureau of Standards, Washington, D.C. 20234.

Where to Obtain Copies of the Guideline: Copies of this publication are for sale by the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161. When ordering, refer to Federal Information Processing Standards Publication 72 (FIPS-PUB-72) and title. When microfiche is desired, this should be specified. Payment may be made by check, money order, or deposit account.

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Specifications for

GUIDELINES FOR THE MEASUREMENT OF REMOTE BATCH COMPUTER SERVICE

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Executive Overview

The need to measure remote batch computer network service arises in the selection, operation, evaluation, and testing of such services. Availability, reliability, timeliness, and correctness are identified as the primary service attributes to be measured and/or evaluated. Other Federal documents are referenced to direct the reader to related Federal procurement and other ADP policies and procedures.

These guidelines are designed for use by Federal officials and other employees who have responsibility for the specification, measurement, operation, evaluation, or selection of remote batch computer service. The functional performance measures presented in this document can be used to evaluate the delivery of remote batch service from Government-operated computer systems.

The current state-of-the-art in the evaluation of computer service makes it necessary to perform comparative rather than absolute evaluation. It is always necessary to qualify measurements by a description of the measurement environment and methodology. Measurement may be done under controlled conditions, implying a test environment where it is desirable, if not absolutely necessary, that tests be repeatable.

The selection of measurement methodology must incorporate consideration of the conditions under which measurement is conducted and the functional performance measures by which the interactive computer service is to be judged. Cost, complexity, and accuracy must weigh in the selection. The methodologies available include measurement automatically by the central host computer, the remote batch device, and manually employing printing time clocks. The statistical methods used for analyzing the data and generating reports must be carefully designed and tested.

Throughout these guidelines, specific summary guidance is set in boldface italic type so that it is easily identified and located. ***This is boldface italic type.***

A glossary provides definitions and discussion of terms and a bibliography is provided.

Summary Guidance

Objectives of this Guideline: These guidelines should aid both consumers and providers of remote batch computer services (RBS) in determining whether promised services have been delivered. *Availability*, *reliability*, *timeliness*, and *correctness* are identified as the primary service attributes to be measured and evaluated.

Applicability of this Guideline: The definitions of remote batch service quality should be agreed upon and published in advance of any attempt to measure that service. These guidelines will assist the user of remote batch services in establishing formal metrics which define remote batch service quality.

Where service levels are important, they should be contractually agreed upon and stated in a manner so that they can be monitored.

Specifying Metrics Which Define Remote Batch Service Quality: A remote batch service should be measured on criteria involving functional and performance characteristics. The performance characteristics should be evaluated in terms of metrics that are meaningful to the consumer and that are measurable. Consumers' interests are in whether the remote batch service is available when they need it, whether it operates without interruption, whether it provides their results when they need them, and whether the outputs are correct. These attributes are termed *availability*, *reliability*, *timeliness*, *and correctness*. The evaluation of a remote batch service must be on the basis of its handling of individual submissions.

Availability: Availability can be specified in terms of the portion of a selected time interval during which the remote site is capable of performing its functions. Availability must be specified for each remote site individually. If a metric is required for the RBS as a whole, the appropriate one is the portion of all specified remote sites that meet the requirements for availability.

Reliability: The reliability of an RBS involves the ability of the remote batch device to operate without the consumer's corrective intervention through a complete input or output operation. When each of the operations performed by a remote terminal device has a different set of hardware that can impact reliability, the required level of reliability can be specified for each.

Timeliness: Timeliness is usually equated to "turnaround," the elapsed time between the moment of submission and the instant that output is returned. Timeliness objectives should be stated as the portion of instances in which specified timing objectives are met. When two or more output devices are employed, timeliness metrics must identify which devices are applicable to each. Specification or measurement of a remote batch system's timeliness requires the identification of events signifying the submission time and the completion time.

Three main RBS inputs exist: Provider Operated, Consumer Operated, and Interactive Terminal. Output from the remote batch service may be Immediately Transmitted to the remote batch device, it may be Held Until Requested by the consumer, or it may be Delivered to the consumer by a courier.

Given the various input, processing, and output alternatives, the submission and completion phases must be carefully defined for metrics to be clear. For immediate output the completion time is the instant when the last record of output is printed. For request output the completion time is the instant when the user is notified of output availability, or when the last record of output is available for transmission upon request. When the provider employs a courier service for voluminous or special output, appropriate metrics should be employed to measure the effect on the delivery of output. For database updates the completion time is the instant, upon completion of the database update, when the revised data can be accessed.

Correctness: The current state-of-the-art for measuring correctness largely depends on rerun rates for determining correctness levels. Agreement is needed on the mechanism for determining that a job must be rerun because of the provider's actions. Required levels of service should be specified in terms of the portion of all submissions that may be affected by these conditions.

Selecting the Measurement Methodology: The decision to measure RBS must incorporate a selection of appropriate measurement methodology. The need to perform statistical analysis on the measured data strongly favors a measurement methodology which provides its data in machine processible form. Data acquisition and analysis must be specified in advance. The statistical criteria and sample size should be chosen in advance of any measurement of service quality.

In most situations, evaluation will be made under partially controlled conditions where the analyst enters submissions in addition to the normal workload on the remote batch service. Measurement under partially controlled conditions may require measurement under uncontrolled conditions in order to provide comparison values for detection of uncontrolled changes. Measurement under total control is available to the provider of the RBS. It should be pursued only if partial control is inadequate and only after thorough design of the experiment.

Performing the Remote Batch Service Measurement: Even though measurement technology could stand some improvement, there is presently a sufficient basis for remote batch service measurement. The recommended approach consists of the four steps outlined below.

1. Identification of provider and consumer: The first step in RBS measurement is the identification of the provider and consumer. This is not necessarily trivial when dealing with groups of consumers who may belong to different organizational units and who may deal with the provider through different spokespersons.

2. Selection of descriptive scenario: The second step is selection of the scenario descriptive of how the consumer obtains RBS. The scenarios presented in this report should serve as a starting place. Both provider and consumer should agree on the representativeness of the scenario.

3. Selection of Metrics: The third step is the selection of RBS metrics. This selection must be done in concert with the fourth step, selection of measurement methodology. The problem is to determine what should be measured and what can be measured. The consumer group should be kept aware of and educated about the selections of metrics and methodology and the logic which led to that selection.

4. Implementation: The final step is implementation. RBS performance evaluation may be employed to settle disputes, to contractually establish definitions of satisfactory RBS, to support negotiation or litigation when agreed-upon service criteria are violated, to alert provider management when service levels are out-of-bounds, or to help consumers select a new RBS.

GUIDELINES FOR THE MEASUREMENT OF REMOTE BATCH COMPUTER SERVICE

1. Introduction

These guidelines should aid both consumers and providers of remote batch computer services in determining whether promised services have been delivered. Availability, reliability, timeliness, and correctness are identified as the primary service attributes to be measured and evaluated. There are specific recommendations distributed throughout the text. These recommendations are set in boldface italic type.

1.1 How to Read and Use These Guidelines

The major sections of this document discuss measurement of remote batch service in terms relevant to providers and consumers. The phases of input, processing, and output are defined in context. Metrics are defined and meaurement methodology developed, with consideration of the measurement environment.

An overview of each section is followed by specific recommendations and discussions of salient points. Throughout the document, specific summary guidance is set in boldface italic type. This document is organized into five major sections each of which contains subsections which address specific topics in increasing depth. The reader is advised to read the document in its entirety before attempting to apply the guidance for a particular purpose.

1.2 Applicability

Application of the metrics suggested in this document can usually be applied to lend rigor to the analyst's "intuitive feel" that is so often incorrect. ***Formal metrics should be applied to situations where the issue is:***

Setting contract terms,

Selection of one remote batch service from among many,

Performance improvement or performance projection,

Performance management system design.

The application of these metrics is not an adequate solution to all the problems that are typically encountered in dealing with these issues, of course. In each situation a mix of skills is required; for example, setting contract terms in a formal contract requires the skills of a contracting officer or attorney. Properly applying the metrics, however, can improve the results in these situations when a remote batch service is of concern.

1.2.1 Setting Contract Terms

A contract for remote batch service from a provider typically sets the charging rate for usage, but does not provide incentives for exceptionally good service or set minimum levels of service. ***Where service levels are important, they should be contractually agreed upon, and stated in a manner so that they can be monitored.***

1.2.2 Remote Batch Service Selection

A remote batch service should be selected on criteria involving both functional and performance characteristics. The performance characteristics should be evaluated in terms of metrics that are meaningful to the consumer and that are measurable. A good starting place is the metrics given in this report.

The evaluation of competitive remote batch services should be based on satisfactory performance unless added utility is associated with performance above this minimum level. In most situations, evaluation will be made under partially controlled conditions where the analyst enters submissions in addition to the normal workload on the remote batch service.

1.2.3 Performance Improvement and Performance Projection

Determining ways and means to improve performance is an exercise with much similarity to forecasting system performance. In both cases analysts must hypothesize relationships and then test these hypotheses. In both cases measurement under no control, partial control, or total control may be required.

The results of performance improvement efforts should be evaluated in terms of their utility to consumers—employing metrics that are meaningful in those terms. Similarly, the objective of a performance projection study should be to establish values of metrics that indicate service levels to consumers.

1.2.4 Performance Management System

A performance management system [6] employs measurement to compare realized values against previously-established values. The previously-established values may involve utilization of system resources, the level of loading, and the achieved levels of service from the computer system. In the case of remote batch services,

the level of service is in terms of the metrics described in this document.

A performance management system, like most other applications of metrics for describing service levels on remote batch services, requires explicit efforts to choose both the appropriate metrics and their values. In fact, this is probably the most difficult part of designing a performance management system; an organized approach is needed to ensure that comparisons are meaningful and do not lead to unjustified attempts to change the RBS.

1.2.5 Setting Service Level Metrics and Objectives

Setting timeliness objectives is a challenging process due to the variety of possibilities (including submission events, completion events, turnaround objective, deadline, and level of achievement). Generally the most appropriate approach is to set from two to ten turnaround time objectives with a different deadline for each submission for which such an objective is appropriate. Since some submissions will not meet the objectives, the level of achieving each objective can be measured and compared with nominal values. Alternatively, the number of submissions meeting and failing different objectives can be combined when this technique matches the needs of the remote batch service's provider and consumers.

The steps to set the objectives for a particular regular submission are as follows:

1. Pick the events indicating submission and completion times. The submission event might be, for example, the instant the first record is read through a card reader that is part of a remote batch device, and the completion event might be the last line of printing produced for the submission.
2. Choose whether the timeliness objective should involve deadline or turnaround time.
3. Determine the value for turnaround time, or the times for submission and completion deadlines.
4. Select the portion of all such submissions that must meet the timeliness criterion (e.g., 90%).

The improved rigor of well-defined, specifically-designed metrics for a remote batch service can reduce confusion in performance analyses and reduce disputes about achieved service levels in operational systems. Choosing metrics and selecting their nominal values is feasible and rewarding. If the service level is worth arguing or worrying about, it is worth defining and measuring.

1.3 The Relationship Between Providers and Consumers

Although there is much advice available on procuring remote batch service (RBS)* (c.f. [2, 3, 4]), consumers of an RBS have few indicators of poor service other than late outputs. The common metrics of service (e.g., turnaround time within the computer averaged over all submissions) do not indicate how well the remote batch service is actually serving the consumers. Lack of indicators also hampers RBS providers from assessing and improving the quality of the service provided. This objective data about RBS can help bridge the gap between consumers and providers of remote batch services and provide a common ground for communication between the two groups.

An organization's ability to carry out its operations under budgetary constraints is often dependent on the results from the remote batch service. Many organizations have successfully improved communication between provider and consumer by setting explicit service level objectives.

1.4 Special Problems of Remote Batch Service Metrics

Measurement of RBS is complex because of the variability of the communications facility, and the limited input and output capabilities available to serve individual consumers. Each of these factors has to be considered in developing metrics appropriate for describing the remote batch service. The effect of these factors in developing specific metrics for all phases of RBS is explained in section 2.

For example, consumer actions affect measurement of device availability. In many remote batch services the consumers operate the remote batch device to input their submissions. In addition, they may operate the device to allow the return of their output. On the input side, consumers become immediately aware if the device refuses to accept their submissions. This may occur if the communication facility cannot accept the submission and no capability exists for the device to store the submission for later transmission. This situation can also occur when the device itself is inoperable and maintenance is required at the remote site. Metrics describing availability of the service must recognize that the consumers with submissions will sometimes remain at the device to be able to employ it as soon as possible after failure to submit input.

Output from the RBS may also be dependent on consumers' actions. As an example, the consumer's failure to load paper in a printer at the remote site will delay delivery of the output through no fault of the provider. In

*Terms specific to the subject of this publication are defined in the glossary.

addition, some services hold output until it is requested by the consumers. If the consumers do not take action to request the output, then the recorded turnaround time of the submission will be very high in spite of the providers' exemplary services. ***Therefore, metrics describing timeliness of the service must reflect the potential impact of the consumers.***

Similarly, the cost and reliability of the communication facility affect service delivery. Since these facilities have specified maximum transmission capabilities, the return of voluminous output can require a considerable time. If consumers have chosen a particular line capacity or transmission rate and have large volumes of output, the most appropriate measure of turnaround time may be one that does not include the output transmission time.

Even with a high-speed communication line, the input or output capacity of a remote batch device may cause the time for these operations to dominate the total time for responding to a submission. In addition, the delay experienced in printing one consumer's output may affect other consumers dramatically. Excessive output from one consumer can cause subsequent consumers to wait for long periods before their output even begins to be printed. Output production in a conventional batch system is less of a problem due to the economic viability of high capacity printers and computer output to microfilm (COM) equipment. When the demand for output production is spread among a number of remote sites, these high speed printers are not economically viable: as a result, a few very large jobs can have an adverse impact on consumers' service levels.

2. Remote Batch Scenarios

The first step in developing effective measures of RBS is identification of the phases of RBS and the tasks involved in each phase. A consumer may employ a remote batch service several times in the course of solving a problem or editing some data. The consumer's overall objective is to complete the work task, not to obtain output. Specifying each work task and evaluating a remote batch service by task completion time would be ineffective due to the dependence on highly variable human problem-solving capabilities, the inordinate effort required to specify the task and its completion time, and the difficulty in separating human from computer effects. ***Therefore, the evaluation of a remote batch service must be on the basis of its handling of individual submissions.***

Scenarios of RBS usage begin with some specific act of submission and end with (or before) the return of all output.

A scenario for using a remote batch service can be divided into three general phases—input, processing, and output. The specifics of each of these phases may indicate widely different applications of the RBS, and suggest that different metrics are applicable. Since different activities and queues exist in various systems, the consumer perceives different system characteristics. However, common features of the three phases can be used to facilitate comparisons of services though these phases may not be applicable to all systems.

For example, the functional phases below may not describe a specific RBS exactly because some new products can function as remote batch devices, and as interactive terminals and stand-alone minicomputers as well. The general RBS phases are blurred as a result of these enhanced capabilities.

In addition, different orientations (both applications and degree of service) may apply to remote batch services. Therefore, the description of each of the general phases begins with discussion of the more important differences that may influence the mapping from actual RBS activities to the functional phases.

2.1 Input

Input to a remote batch service can be a relatively simple action, such as a consumer placing a stack of punched cards into the hopper of a remote batch device and pressing a button. Input may also consist of several sequential steps, with the consumer only executing a few of them. Three main remote batch service input environments exist, differing in the degree to which the provider takes responsibility for elements of input operations. These are identified below as Provider Operated, Consumer Operated, and Interactive Terminal.

2.1.1 Provider Operated Input

In this environment, the provider of the remote batch service furnishes the remote batch devices and maintains personnel to operate them. The modes of input are as follows: the consumer may physically place the input submission media into a designated area; the consumer may notify the provider-supplied personnel that data have been input through a data-entry device; or the consumer may actually hand the submission to the provider-supplied personnel at the remote site. The actual time of input is when the consumer takes the necessary actions to signify transfer of control. While the consumer will perceive that this type of service is virtually always available, the provider does not have an automatic means of determining the time of input.

In the absence of automatic means to record the time of input, the RBS provider may need to maintain appropriate manual records to record input time. Since the consumer has completed all the actions to initiate the input process, and control of the submission has been effectively transferred to the provider, successful input to the remote batch service is completed. Provider-supplied personnel

have control of the consumer's submission media and must now perform additional intermediate actions to transmit the submission to the central site and to ensure its acceptance there for processing. These actions may include some delays while equipment and/or personnel are involved in activities for other submissions.

2.1.2 Consumer Operated Input

In this environment, control of the submission is not transferred to the provider until the consumer's attempt to do so is successful. This attempt may consist of pressing the START button on a remote card input device, initiating a communication line after loading a floppy disk, or entering a command to initiate the transfer of records. The submission time is the instant when the first record is read.

The equipment at the consumer-operated remote site might be provided by the same organizational unit which operates the central computer. Alternately, it might be provided by the consumer's organization, or even by a third party.

2.1.3 Interactive Terminal Originated Input

An interactive device can be used to input records to storage media at a central site, and subsequently to command that those records be interpreted as a batch submission. Remote batch systems usually include this capability when the computer at the central site supports an interactive service as well as the RBS.

The submission time for interactive terminal origination is the time of successful request for batch submission, i.e., when the RBS command transaction is accepted by the RBS. Submission may be indicated by the completion of printing on a printer, the availability of results on a terminal, or some other possibility that an inventive provider creates.

2.1.4 Input Functional Phases

A remote batch submission may go through several functional phases, each of which introduces the possibility of a delay or an error. Figure 1 represents these phases:

I1—Queue for Provider-Supplied Personnel Pickup
I2—Queue for Input Device
I3—Input of Physical Media or Command
I4—Queue for Transmission
I5—Transmission

The phases that may exist for the three classes of input situations are:

Interactive Terminal:	I5	(Transmission)
	. . . . .	
Consumer Operated:	I2	(Queue for Input)
	I3	(Input of Physical Media)
	I4	(Queue for Transmission)
	I5	(Transmission)
	. . . . .	
Provider Operated:	I1	(Queue for Pickup)
	I2	(Queue for Input)
	I3	(Input of Physical Media)
	I4	(Queue for Transmission)
	I5	(Transmission)
	. . . . .	

Each of the three input environments includes the three functional phases, but the implementations of these functional phases may be quite different in each actual system.

The primary importance of identifying these phases is to facilitate measuring the timeliness of the remote batch system. Accordingly, the descriptions below emphasize the elapsed time between transition of the phases.

Queue for Pickup—If a clerk is busy with other activities, a submission may await pickup for a long time. For this reason many remote sites maintain sign-in logs or they time stamp job submission cards so that the consumer can record the time of submission.

Queue for Input—After pickup, a submission may remain outside the automated system waiting for the input device to be available. Usually, the duration of the wait in this queue is quite small. If this queue delay is not small, it may be an indication that the remote batch device and/or the transmission rate is inadequate. When the device is provider operated, the attendant should note this queuing delay and report it to the appropriate manager. When the device is consumer operated, the consumers need to have established norms for queuing delay and need to know to whom to report excessive delays.

Input of Media—The most obvious media for input are punched cards. However, advancing technology has led to rather widespread use of more sophisticated media such as floppy disks. In some remote sites a key-to-disk system is employed to enter data for remote batch services. In other cases the data is entered as a disk which is then transferred to the remote batch device.

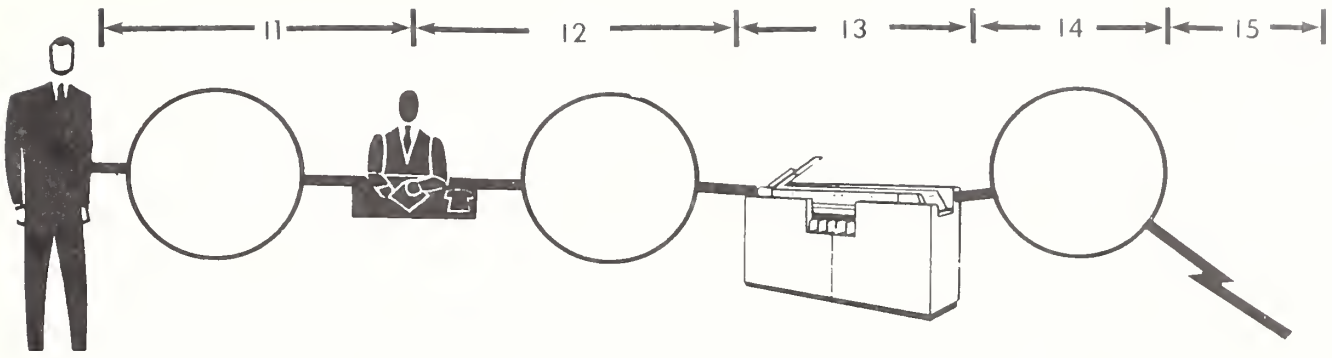

Figure 1. Input phases

Queue for Transmission—The communication line may be inoperable or already in use at the instant the new submission arrives. In this case, the submission will await the availability of the line. Queuing for transmission usually occurs when the communication capability is temporarily dedicated to send output back to the remote site.

Transmission—If the communication line is of relatively low bandwidth and the submission includes relatively large quantities of data, the time for transmission of the submission will be large. If consumers are operating the remote batch device, they may be particularly sensitive to transmission time if they are required to remain at the remote site to ensure correct transmission of their submissions.

2.2 Processing

The input phase begins when the provider gains control over the consumers' submission. The processing phase begins when the submission is available at the central site.

2.2.1 Initiation Delays

Since most data processing installations cannot process jobs instantaneously upon arrival, the actual processing of the consumers' submissions is typically delayed in a central site initiation queue. ***The consumers should be unconcerned about the mechanisms the providers have established for classifying and processing submissions, as long as the system operates as expected. However, the providers must consider both the mechanisms and the effects in order to meet their commitments to the consumers.***

2.2.2 Processing Objectives

The objective of processing may be to obtain the output from executing a job, or it may be to update a database. In the first case the completion time of the remote batch submission is when the output is returned. In the case of database update the completion time may be the instant that the database has been updated and the results are available for retrieval.

Although the objective of a database update submission may be fulfilled at the instant the results are available for inquiry, a second objective may be equally important: to notify the consumer of the completion of processing so that further processing can be initiated. ***In cases where the objective of a submission is database update, two measures of timeliness may be required to reflect both the completion of the update and the notification of the update's completion.***

2.2.3 Functional Phases

The functional steps in the processing phase of a remote batch system are not as apparent to the consumer as the input steps. Figure 2 portrays these phases:

P1—Queue for Processing
P2—Initial Processing
P3—Database Update
P4—Final Processing

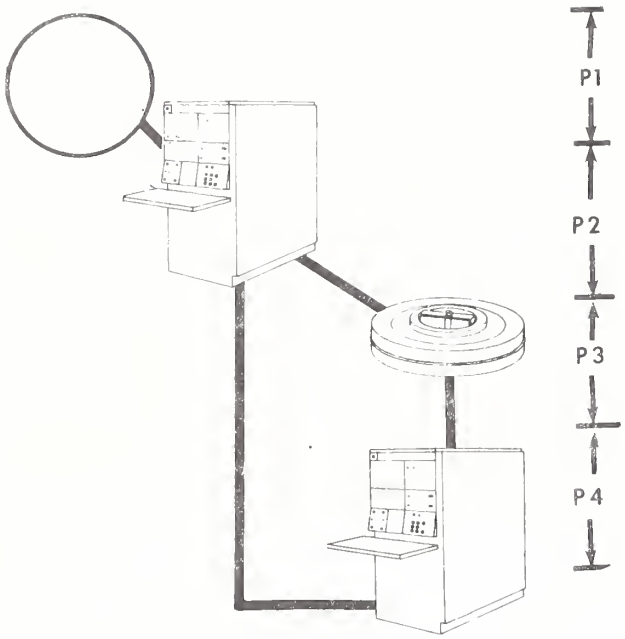

Figure 2. Processing phases

These phases are more general than usual descriptions of processing steps. Details of processing steps are of little interest to the remote batch consumer other than for their effects on the completion of the requested task.

Queue for Processing—This phase begins at the instant the entire submission arrives at the central site. Submissions may be sorted so that they will begin processing in an order different from their arrival order. Both the beginning and end of this phase can usually be determined automatically by the provider through the operating system or the communications monitor.

Initial Processing—This phase includes all processing except database updates. Although completion of this phase may be difficult to determine when a database update phase follows, its completion time is automatically recorded in most operating systems when it is the final processing phase.

Database Update—For submissions requiring a database update, this phase begins with the first modification to the database; it ends when the last modification is completed and the database is available for accessing. The beginning and ending times for this phase are not always recorded automatically, so application programs may be required to collect the timing information.

Final Processing—This phase occurs only for submissions that include a database update. It includes all processing that takes place between the completion of the update and time when all output is available.

2.3 Output

Consumers usually regard their output as the objective when making a remote batch submission. (Only in a few cases such as database update is no output produced.) Most remote batch devices either have a printer associated with them or they may share a printer with other devices (e.g., interactive terminals used as remote batch devices). In some cases output may be prepared at the central site and delivered to remote sites.

2.3.1 Delivered Output

The primary advantage of supplementary delivered output service is that large volumes of output can be produced without the expense of high speed communication lines and multiple, high speed remote printers. Special media conversion may also be required for the consumer's output; central conversion is typically the only economically feasible technique. For example, multiple copies may be required or microfiche may be needed. In such cases the output is processed centrally and the resultant media are transported to the remote site.

When the provider employs a courier service for voluminous or special output, appropriate metrics should be employed to measure the effect on the delivery of output.

2.3.2 Immediate vs Request Output

The difference between immediate and request output affects measures of *timeliness* (discussed in 3.3 below). Production of immediate output usually employs a first-in-first-out scheduling discipline. The output is sent to the remote site as soon as it is available, the communication line is free, and the remote batch device is able to operate.

Very often request output techniques are more effective for the consumer. This means that the output is held on storage media where it is available for the consumer as soon as processing is completed. If the consumer does not request the output, output from other consumers can be printed. In addition, the consumer may be able to review the output with an interactive terminal prior to having it

printed and then decide whether it should be immediately discarded rather than printed. Although the output capability of the remote batch service is used less efficiently and is idle more frequently, the service level provided by the remote batch service may be higher due to the reduction in total output printed.

Timeliness metrics for immediate output usually begin with the submission, and end when all the output has been printed. Employing these metrics for request output can be deceptive because the output may never be printed. ***Assignment of arbitrary completion times for output never printed provides little information and may, in fact, interfere with timeliness measurements. The proper completion time for a submission employing request output is the instant that output is available for its printing to begin.***

2.3.3 Functional Phases

The functional phases in output may be executed several times for a single submission in order to provide several modes of output. For example, a consumer might have some output immediately transmitted to the remote site, with the bulk of the output physically delivered to the site. On the other hand, some output may be produced by only a subset of the phases shown in Figure 3.

O1—Queue for Transmission
O2—Transmission
O3—Queue for Output Process
O4—Output Process
O5—Queue for Courier
O6—Courier Transfer
O7—Output Return

The detailed phases O1 through O4 occur within the automated processing system of the computer and the communication systems, so data on the timing of submissions passing through the phases can be collected by automatic means. Phases O5 through O7 are manual processes, so manual means must be employed to collect data on the time of their initiation and termination.

For request output, none of these phases is executed, but for other cases at least O3 and O4 are performed.

Queue for Transmission—Output remains in this queue until it can be transmitted. If the output is to be printed or otherwise processed at the central site, it does not enter this queue.

Transmission—Transmission time is determined mainly by the volume of output and the capacity of the communication line. In some cases transmission and printing are performed simultaneously; in this case phase O4 (Output Process) is identical with the transmission phase, and the duration is at least the longer of the two.

Queue for Output Process—Output processed at the central site nearly always enters this queue in modern systems. In addition, output transmitted to the remote site may enter this phase if transmission and printing are separate phases.

Output Process—All output goes through this phase in its production. In some cases this output process may be quite complex as forms are changed, output is written to floppy disk, and a printer operates.

Queue for Courier—If output is printed at the central site, it must be transported to the remote site (even if

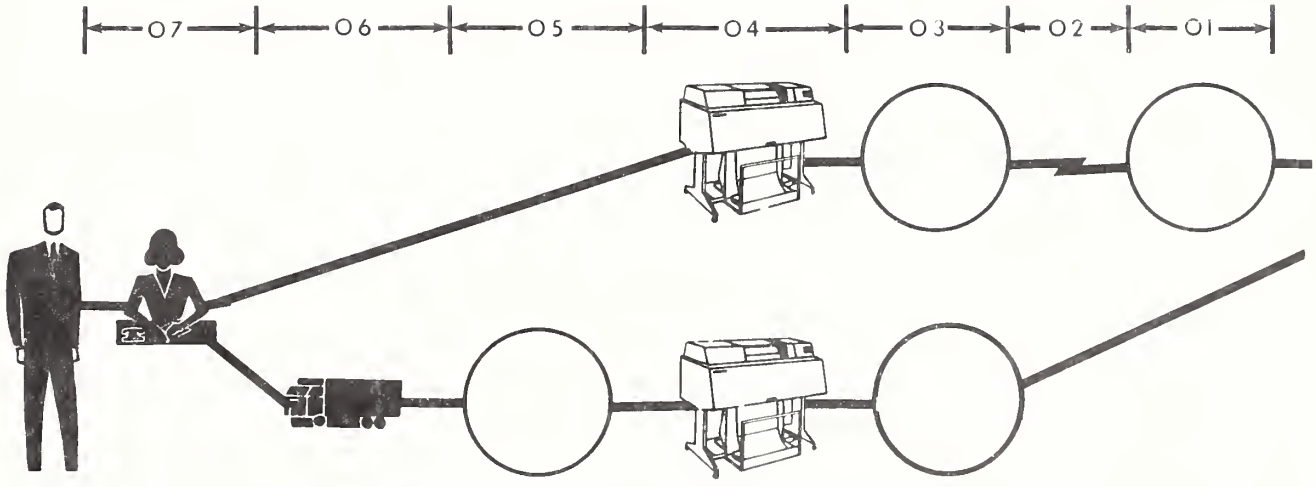

Figure 3. Output phases

the central site and the remote site are physically quite close). This queue occurs between the time the output is produced and the time the courier removes it for transfer to the remote site.

Courier Transfer—The actual transfer of the output from the central site to the remote site may be by special courier, a routine courier, or the mail. The time for this phase is sometimes quite variable, and sometimes is several times longer than all the rest of the processing.

Output Return—When the RBS provider supplies personnel to operate the remote batch device, the consumer does not obtain the output until these personnel return the output. The duration of this phase should be small.

2.4 Phases of Interest to the Consumer

Consumers need not be concerned with the vast majority of the 16 phases listed for Input, Processing, and Output. They are usually only interested in two or three of them—the phase in which they input their submissions, and the last one or two phases in which the work is completed. ***Given the various input, processing, and output alternatives, the submission and completion phases must be carefully defined for metrics to be clear. This definition is necessary to eliminate ambiguity in employing the metrics for evaluating the remote batch service.*** Figure 4 gives an overview to aid in this definition.

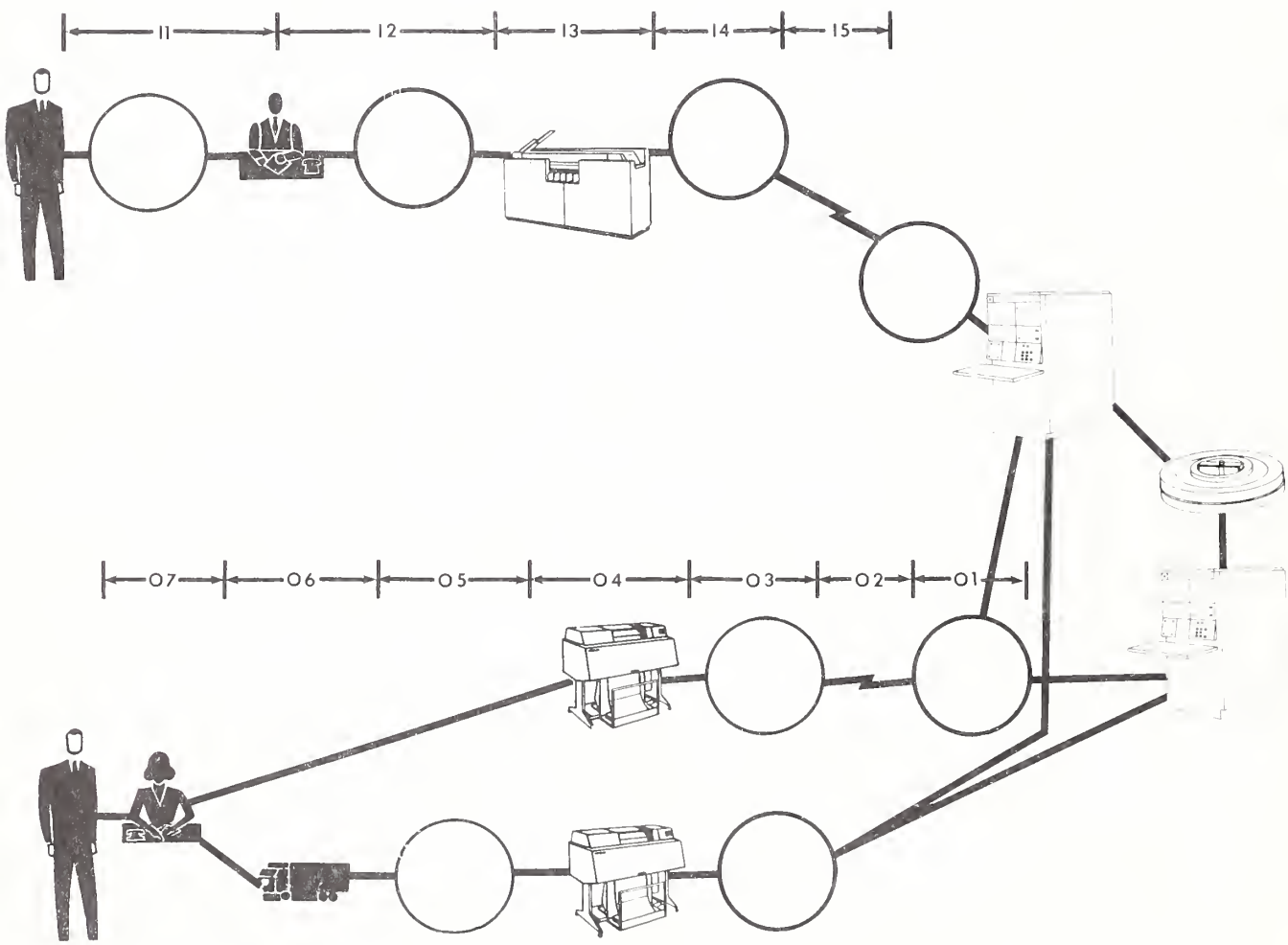

Figure 4. Overview of phases

3. Consumer-Oriented Remote Batch Service Metrics

Consumer-oriented metrics measure the RBS service characteristics that are of concern to the consumer. The average utilization of computer system resources is of little interest to the consumers of a remote batch service, except to the extent that it influences the level of service they receive. Consumers are interested in whether the remote batch service is available when they need it, whether it operates without interruption, whether it provides their results when they need them, and whether the outputs are correct. These attributes are termed availability, reliability, timeliness, and correctness. They are derived from the functional phases of the RBS process that are described in section 2. The consumer is, of course, concerned with the overall RBS process and how it affects delivered service. The provider must consider the detailed components of the process in efforts to improve services or diagnose service problems.

3.1 Availability

The availability of a remote batch service must be specified in terms meaningful to the consumer. If the consumer walks up to a remote batch device that is not operating, then the service is unavailable. How well the central site or other remote batch devices may be processing other jobs is unimportant. Therefore, ***availability must be specified for each remote site individually.***

Availability can be specified in terms of the portion of a selected time interval (e.g., 8:00 a.m. to 5:30 p.m.) during which the remote site is capable of performing its functions such as accepting submissions and producing output. ***If a metric is required for the RBS as a whole, the appropriate one is the portion of all specified remote sites that meets the requirements for availability.***

The interpretation of the term "availability" varies across different types of remote sites. For example, a remote site that is operated by provider personnel is available when the operator is there to receive submissions although another consumer may also be there at the same time. If the remote site is consumer operated, then availability implies that the remote batch device is able to communicate with the central site computer. In this case, availability includes consideration of the central site computer and the telecommunications facilities. If any component is unavailable, the RBS is unavailable.

Measurement of availability must be performed with recognition of the tendency of consumers to emphasize periods of unavailability. If consumers find a remote batch device inoperable (perhaps due to a failed communication line), they will likely make repeated attempts to use it in the following few minutes. Therefore, the portion of attempts that fail will be far higher than the portion of time that the device is actually inoperable.

In some remote sites the input and the output equipment can fail independently of each other. In these cases ***the provider and consumer must decide whether they wish to specify different availability criteria for input and output, or to specify the required availability of BOTH capabilities.***

If a remote batch device is able to begin an input, but then fails during processing of the submission, its computed availability will be affected by the failure. However, the effect on the consumers will be larger than if the failure condition occurred during a period when the device was not active. In this case the consumer must determine the status of the submission, output and the system before reprocessing the submission. This problem involves reliability as well as availability.

3.2 Reliability

The reliability of a remote batch service includes the reliability of the central site to the extent that a failure there interrupts operations at the remote batch device. The reliability of an RBS involves the ability of the remote batch device to operate without the consumer's corrective intervention through a complete input or output operation. For the consumer operated remote batch device, corrective actions might include restarting a transmission, reloading a card deck, rekeying a command, reinitiating a communication line, or other actions outside normal ones such as loading a new box of paper. With the increase in sophistication of remote batch devices, many of these actions can be undertaken automatically when necessary. Automatic correction results in increased reliability. When the remote batch device is provider operated, consumer intervention would be required and possible in much more limited circumstances.

A variety of different capabilities may be associated with remote batch devices connected to a remote batch service. For example, a device might accept keyed input for storage on a floppy disk, transmit the information automatically at a specified time, receive output back onto the floppy disk, and subsequently print it. ***When each of the operations performed by a remote terminal device has a different set of hardware that can impact reliability, the required level of reliability can be specified separately for each. Some remote devices, however, fail as one unit. When this happens, a single metric for reliability should be employed for the device.***

Computation of reliability of the different operational modes of a remote batch device involves determining the total time that the device successfully operates for each mode, and the number of times that corrective consumer

action is required during that operation. A ratio of average successful operation time to number of required corrective actions can be calculated. If the remote batch device halts operation after a failure and does not restart until corrective action is taken, the time between the failure and the corrective action must not be included in the time of successful operation. Elapsed time is often reported as Mean Time Between Failures (MTBF).

3.3 Timeliness

Timeliness is usually equated to "turnaround," i.e. the elapsed time between the moment of submission and the instant that output is returned. Timeliness can also be specified in terms of a deadline, when completion of the processing of submissions is required. However, if only the deadline for completion is specified, the providers may have an impossible job. The consumers must input their submissions early enough to allow processing to occur before the deadline, so ***agreements regarding service level in terms of deadline must include specification of submission time.***

A computer installation that can *always* ***fulfill all its timeliness objectives*** *probably* ***has far too much hardware. At some time in its life, the load is certain to peak to an unusual level and result in underfulfillment of some consumers' objectives unless a luxurious surplus of capacity exists. The normal case is for a remote batch service to fulfill reasonable goals most of the time, but to fail some portion of the time. Therefore, timeliness objectives should be stated as the portion of instances in which specified timing objectives are met.***

Specification or measurement of a remote batch system's timeliness requires the identification of events signifying the submission time and the completion time. Special hardware or software may be needed for this identification.

3.3.1 Submission Time

The time of submission is the start of any turnaround measure. In general, the submission time is the instant that the consumer transfers control of the submission over to the RBS provider. The three input environments have different events signifying submission times:

Provider Operated. When the provider supplies personnel to operate the remote batch device, the submission time is the instant when the consumer turns over the media with the submission. Because it is usually small, the delay when the operator is busy with another consumer is ignored.

Consumer Operated. When the remote batch device is a conventional one that accepts card or other physical media input, the submission time is the instant that the first record is read.

Interactive Terminal Originated. When the remote batch device is a terminal also employed for interactive services, the submission time is the instant that the RETURN key or the ENTER key is depressed on the terminal.

In some remote batch systems more than one of these types of input may be employed. ***When more than one type of input is employed, the applicability of criteria must be specified by type.***

3.3.2 Completion Time

Several types of output may be employed for one consumer. In such cases the choice of completion time may make a dramatic difference in the value of the metric. For example, a common approach is to provide summary output to a terminal used for interactive output on an immediate basis with more extensive output printed subsequently. The delay in printing the extensive output may exceed the time between submission and initial output, so choosing one completion time rather than the other could change the turnaround time by a large factor. ***When two or more output devices are employed, timeliness metrics must identify which devices are applicable to each.***

Output from the remote batch service may be immediately transmitted to the remote batch device, or it may be held until requested by the consumer. The completion time is associated with the final output operation. ***For immediate output the completion time is the instant when the last record of output is printed. For request output the completion time is the instant when the user is notified of output availability, or when the last record of output is available for transmission upon request.***

In some cases the objective of a submission is to update a database rather than to produce output. ***For database updates the completion time is the instant, upon completion of the database update, when the revised data can be accessed.*** When both a database update and a set of outputs have separate timeliness objectives for a single submission, the two criteria should be specified separately.

3.3.3 Intermediate Times

Consumers may only be interested in the level of service received, but their actions can significantly influence the level received. If the consumers served by a single remote batch device increase their volume of output,

for instance, they will likely experience degraded timeliness. The providers will be interested in the cause of this degradation because they may need to take corrective action. The consumers may also be interested, however, because simple actions on their part (e.g., reducing output volume) may result in improved timeliness without increased cost. Each of the stages of flow through the RBS scenarios in the previous section can be measured and reported to aid in determining whether changes are appropriate.

The functional definitions of submission and completion times provided above have general applicability because they describe the effects that the consumer observes about the RBS rather than the techniques employed in its implementation. The definition of intermediate times, however, is dependent on the particular implementation characteristics of the remote batch system. ***For maximum utility, intermediate times in the flow of submissions must be defined for each remote batch system as a special case. These intermediate times should be employed in performing studies on timeliness.***

3.4 Correctness

The remote batch service consumer has the same problems related to correctness as the on-site batch consumer. In addition, there are errors which could be introduced by the telecommunications facility and the remote batch device. Undetected transmission errors may cause software errors and compromise the correctness of the data processing. Identifying the source of such errors is practically impossible.

The current state-of-the-art for measuring correctness largely depends on rerun rates for determining correctness levels. Although internal balancing controls can ease this job considerably, identifying a submission as a rerun due to provider actions usually requires human review of output. This identification is frequently subject to dispute between the providers and consumers because of differing interpretations of events and the potential impact on payments from the consumers to the providers. Therefore, ***agreement is needed on the mechanism for determining that a job must be rerun because of the provider's actions.***

Specifications for correctness have to take into account problems that might arise as a result of the kind of service provided. For example, the operational problems and the difficulties with obtaining the correct data are sometimes less important than inadequate disk space (or other resource) for the execution of a particular submission. Some types of problems (e.g., support software such as compilers) may be far more difficult to detect or correct, and may have more important effects (e.g., a late payroll), than others (e.g., one more test run). Therefore, ***required levels of service should be specified in terms of the portion of all submissions that may be affected by these conditions.***

To the consumer, detected failures in correctness are costly to the degree to which they affect timeliness.

4. RBS Measurement Methodology

The four attributes applicable to RBS—availability, reliability, correctness and timeliness—cannot be measured equally well. Techniques for measuring timeliness are the best developed.

4.1 Timeliness Measurements

The measurement methodology which can be applied to remote batch service depends on the scenario which best describes the way in which the RBS is provided to the consumer. As pointed out in section 3, different activities and queues exist in different scenarios. Consequently, the consumer's perception of the quality of service differs. This differentiation, in turn, requires that different measurement methodologies be employed according to the way in which the RBS and the consumer interact.

4.1.1 State-of-the-Art

The most common way of measuring remote batch service is by the central-site computer which is providing the service. Times are associated with a job when it enters the central-site computer and when it leaves. There is great variability among operating systems as to the exact step in the queuing of input and output associated with these times. In many cases, this information is not available and can only be determined by a systems programmer reading the instructions in the front-end and/or central processor concerned with communications.

For consumer operated and interactive terminal input, measurement of input times, and of request and immediate output times, can be done by the central site computer. Measurement within the central-site computer is conditional on ignoring delays within the data communications system. The validity of this assumption appears to be based on the relative brevity of data transmission as compared to processing. When there is an interruption to data transmission due to failure of some component in the data communications system, this assumption is violated, but the central-site computer may not be programmed to modify its timing accordingly.

Another way to measure RBS is to use a "job submittal card" with each job submitted for remote batch service. Along with other functions, the job submittal card provides a place for a time stamp when the job enters and leaves the system.

In a provider operated remote batch service, the consumer could time stamp the job submittal card when

passing the job to the attendant. The attendant could time stamp the card when output was ready to be claimed by the consumer. In the case of a consumer operated remote batch service, the time stamp could be employed for job submission only.

4.1.2 Extensions to the State-of-the-Art

A printing clock could be added to the printer at a remote batch site which would automatically print the time on the output. This timer could be set to print at a fixed interval which would provide satisfactory granularity. This timer would be useful in the case of a consumer operated remote batch service; the time stamp closest to the end of the printout would identify when the output was ready for the consumer.

If the remote batch device could associate a unique identifier with each job, it could participate in the timing. The presence of such a unique identifier is dependent on the operating system; it is not universally available. When a unique job identifier was available, the remote batch device could associate a time with the beginning of job input and the end of job output. This timing would be useful in the case of consumer operated remote batch service.

4.1.3 Data Acquisition and Analysis

The coverage of the methodology described above to the scenario descriptive of the remote batch service is shown in Tables 1 and 2. ***Any acceptable pair of methodologies may be selected as the basis for analysis, one for input and another for output. The need to perform statistical analysis on the measured data strongly favors a measurement methodology which provides its data in machine processible form.*** Thus data acquired in the host computer and in the remote batch equipment is well suited for analysis.

If the manual time stamp could also provide information in machine readable form, its potential usefulness would be increased. If the stamp characters

Table 1. Input Measurement Methodology Related to Service Scenario

Service Scenario	By Host Computer	Manual Time Stamp	Job Timing In Remote Batch Device
Provider Operated	N:5	C:2,8	N:5
Consumer Operated	C:6	C:2,6,7,8	A:8
Interactive Originated	A	C:2,8	X:4

Table 2. Output Measurement Methodology Related to Service Scenario

Service Scenario	By Host Computer	Manual Time Stamp	Printout Time Stamp	Job Timing In Remote Batch Device
Delivered	N:1,3	A:2,8,9	N:1,3	X:4
Immediate (provider operated)	N:1	A:2,8,9	N:5	N:5
Immediate (consumer operated)	C:2,6,7	A:2,8,9	A:2,8	A:8
Request	C:6	A:2,8,9	A:2,8	A:8

Key

- A - Acceptable.
- C - Conditionally acceptable.
- N - Not acceptable.
- X - Not applicable.
- 1 - Excludes time outside host (central site) computer.
- 2 - If a means exists for automating data analysis.
- 3 - Excludes period when output is not available to consumer.
- 4 - Remote batch device not involved.
- 5 - Excludes time outside computer/communications system.
- 6 - If there is no significant delay in transmission.
- 7 - If there is no significant delay between time stamping and transmission.
- 8 - If a means exists for associating input and output of each job.
- 9 - Time stamp applied when output becomes available to consumer.

were optical character recognition (OCR) or magnetic character recognition (MICR), then machine input would be possible. Another possibility is for the time clock to punch the job submittal card so that it could be read into a computer.

Data acquisition must be planned. In fact, ***data acquisition and analysis must be specified in advance. If contractual guarantees of service are employed, these specifications must be part of the contract.*** Data acquisition could be performed by sampling actual RBS utilization. The sampling interval and rate would have to be selected so as to be statistically valid. Benchmarking, [5] especially the running of a specified benchmark under normal operating conditions, is another data acquisition technique [6].

Meaningful reports describing remote batch service will require statistical analysis. The number of observations to be taken must be sufficiently large to be statistically significant. Based on the distribution of this data, statistical descriptors such as mean and standard deviation, or percentile statistics such as median, 90 percentile, etc., must be selected. Then the data must be analyzed. A discussion of statistical methods is beyond the scope of this document. ***The statistical criteria and sample size should be chosen in advance of any measurement of service quality.***

4.2 Other Measurements

The remaining attributes (correctness, availability, and reliability) are more difficult to quantify automatically than timeliness. The discussions accompanying the definition of these metrics included means of measurement, which are summarized here.

Correctness determination requires human intervention. There is no algorithm which can differentiate between correct and incorrect results as discussed herein. Once manually identified, incorrect runs may be repeated to obtain correct results. The time or cost or delay of such reruns may be tabulated as a measure of correctness.

Availability and reliability of RBS can involve failure of the remote batch device. It is, therefore, impractical to rely on that device to collect availability statistics. In some scenarios the RBS extends beyond the remote batch device; this eliminates the possibility of using the RBS for data collection. Manual means, such as logs, remain as data sources for measures of availability and reliability. The process can be partially automated by use of machine sensible forms to record failure, unavailability, and completion of repair.

5. RBS Measurement Environment

Choose a monitor; collect some data; wonder what to do with the data. This popular approach has the advantage of being obvious, and the disadvantage of being worthless. One of its fatal flaws is that it collects data on an undefined environment. The situation it examines is of fleeting duration, and will likely never occur again in precisely the same way. The differences may not be significant—or they may be significant—but quite probably no one will be able to determine whether the changes are significant or irrelevant. The alternatives available to the analyst are many; the successful ones include choosing objectives prior to picking a measurement approach, and defining the environment prior to taking measurements.

After choosing objectives carefully, the analyst can decide whether to control the loading and, if so, whether these controls should be total or partial. In partial control the normal situation is usually allowed to exist, but some additional load is added with known characteristics. In total control the remote batch system is idle except for a totally artificial load.

As more control is exercised over the load, a decline may occur in the degree to which the resulting situation represents the normal situation. However, increased control improves the ability of the analyst to interpret the data; in many cases it "improves" ability from an impossible challenge to a possible one due to decreased random variability. The analyst, therefore, must choose how much control should be exercised so that variability reduction can be traded off against representativeness. The trade-off decision is dependent, of course, on the objectives of the analysis.

5.1 Measurement Under Uncontrolled Conditions

The most obvious approach, the one that can usually be implemented most readily, and the one that is usually the logical first step in an analysis effort, is measurement of an uncontrolled loading situation. Most installations keep some historical data on their performance, so measurement of the current, uncontrolled situation can be compared with the past performance. Some of the potentially valuable insights that can come from such an analysis involve:

The degree to which performance varies;
The types of remote submissions commonly input to the central site;
Generally achievable levels of reliability, availability, timeliness, and correctness;
The dependability of the measurement devices.

Measurement under uncontrolled conditions is, of course, the most widely employed technique for obtaining information in support of performance management. A performance management system usually attempts to control both the load and the performance in response to that load. Both of these require measurement of the natural environment. However, the results of such

measurements must be interpreted carefully because of the confusing variety of effects that can occur and the limitations of the measurement tools commonly employed.

The standard job accounting system from computer vendors sometimes fails to report the presence of certain submissions due to the operating system failing prior to the completion of the submission's processing. Since the job's resource demands may only be reported at job completion, the analyst may know that a submission was not processed, but not know that it consumed a major part of the computer for several hours. Therefore, the analyst concludes that the service has become unaccountably sick and fails in the analysis. ***Special care should be exercised to detect the presence of submissions that consume unusually large quantities of resources in an uncontrolled loading environment.***

In addition to anomalous conditions, most remote batch services experience peaks in demand on a periodic basis. Projections from periods of low demand to periods of high demand are typically unreliable. Characterization of remote batch service performance often requires examination at both peaks and valleys of demand. Since many RBSs also have an annual peak, the analyst may conclude that measurement of the uncontrolled environment requires examination of operations over a full year. This excessively expensive approach is seldom needed. Instead, the analyst may need to refine the objectives or to employ some degree of control over the load.

5.2 Measurement Under Partial Control

Partial control of a remote batch service may be employed to ensure that a few submissions with unusually large resource demands do not dominate measurement results, to determine the effects of heavier loading such as year end processing, or to investigate specific effects that might decrease availability such as a new software package. These objectives can usually be achieved with only a minimal impact on the services to normal consumers, so the cost of the investigation is far less than in the case of total control. Because some random variability can be controlled, more confidence can usually be placed in conclusions about the effects of a change.

Implementation of partial control may make obvious to consumers that the service is not in a normal state. This is particularly true when the control is exercised at the remote site (by limiting submissions to those that do not have extensive input, for example). Consumers may alter their normal activities in response to their recognition that different service is being provided. Elapsed times through intermediate measurement points may become very different when this occurs. ***Measurement under partially controlled conditions may require measurement under uncontrolled conditions in order to provide comparison values for detection of uncontrolled changes.***

Artificially loading a remote batch service is usually an easy task. The analyst need only input from one or more remote batch devices a few special submissions. The submissions must be carefully chosen or constructed, but after that the mechanics for causing the loading are simple. Since submission is so easy, the analyst may find that submitting a small test job and measuring its turnaround time provides an easy way to determine the timeliness of the RBS.

5.3 Measurement Under Total Control

The effects of any uncontrolled loading in a remote batch system can confuse the analysis. The magnitude of operating system overhead, for example, can be blamed for delays in processing by one consumer while another blames loading on a shared communication line. Both—or neither—could be correct, but determination of the correct answer is difficult unless all perturbing effects are eliminated. This elimination can be achieved only by gaining total control over the load.

Measurement under total control causes the remote batch service to be unavailable to consumers during the period of the experiment. Therefore, the experiment will be expensive in execution and require considerable effort to define objectives, procedures, and analysis approach before its initiation. ***Measurement under total control is available to the provider of the RBS. It should be pursued only if partial control is inadequate and only after thorough design of the experiment*** [1,7].

The objective of the experiment has considerable bearing on its design. A test to determine the effect of some hardware or software change at the central site would be quite different than a test to determine why one remote batch site was receiving very slow turnaround compared to other remote batch sites. In the design of the experiment, the analyst must decide on the technique for loading the remote batch service. If the experiment is to investigate effects localized in the central site, the analyst may find that the situation can be treated like a conventional batch system and load a series of jobs through any convenient input device (e.g., tape or punched cards). This approach may ease control by putting the analyst in the computer room where he or she can input all artificial submissions and also ensure that any special operational procedures are followed.

Alternatively, the analysts may find their jobs easier if they load submissions from a remote batch device. This may actually be the only mechanism that will operate successfully in some systems where recognition of the

input device is important in determining the way the system performs. In addition, the objectives of the experiment may require that the effects of loading on the remote batch devices need to be determined.

6. Conclusions

6.1 Required Technological Advances

The technology for measuring remote batch services is deficient in several respects. In some cases the needed advances represent rather minor extensions of existing technology and can be accomplished rapidly. In other cases extensive research is required to correct the deficiency. This section describes needed improvements in measurement technology for the four metrics applicable to RBS.

6.1.1 Availability

When a communication line is continuously active between the remote site and the central site, availability can be determined by having the remote batch device automatically attempt to send and receive trivial messages. Although this capability is not currently a standard part of remote batch device software, its addition should not present any overwhelming problems.

However, when dial-up lines are used for transmission, measurement of availability is more difficult. The automatic dial-up capability of some terminals could be invoked repeatedly resulting in extra communication charges to compute a number for availability. When the communication line must be manually dialed, determining availability through repeated pseudo-use would simply be unrealistic. Instead, research is needed to determine whether the individual failure rates of remote batch devices and central sites can be employed to estimate total remote batch service availability for individual remote sites. Some of the issues that require resolution are:

Availability of communication ports,

Failure of some shared ports at a central site,

Failure of the communication capability of the remote batch device,

Automatic transmission of failure information to the central site,

Simultaneous failure of remote and central equipment.

One potential approach to determining availability is to provide hardware devices that simulate a central site when connected to a remote batch device. Although mechanical devices probably could not be checked with such a device, the bulk of electronic equipment could be examined every few seconds.

6.1.2 Reliability

Inclusion of minimal data collection capabilities in the central computer and the remote batch device should be adequate for determining reliability. Although these capabilities are not now included in most systems, their development should not be difficult.

6.1.3 Timeliness

Three primary technological inadequacies limit the utility of timeliness determinations in remote batch services. They are:

Sophisticated remote batch devices may create output at a different time than the central site's computer has recorded. Collection of data about submission and completion times should be automatic at the remote batch device.

The beginning and ending of data base updates is frequently difficult to determine. These times should be recorded automatically and identified in a manner so that turnaround and appropriate metrics can be employed.

Data about submission and completion times that are collected at the remote sites do not automatically find their way into the central site! Therefore, the important information about how well a complex automated system performs is created with the use of manual processing.

6.1.4 Correctness

Measurement of correctness by examination of rerun rates is inadequate. In most cases the metric is employed in a rather arbitrary manner and cannot be relied upon. In some instances the values obtained have been so open to question that installations have stopped trying to evaluate correctness.

A significant research program is critically needed in the area of operations correctness in commercial data processing installations. It should address the problems that result in incorrectness from operations, programming, data input, and catalog maintenance.

6.2 What Can and Should Be Done Now

Even though measurement technology could stand some improvement, there is presently a sufficient basis for remote batch service performance management. A very modest effort, such as the one suggested here, can significantly improve relations between providers and consumers of remote batch service. It can further provide each of them with metrics by which first, to measure, and second, to manage, their involvement with RBS. The

measurement approach presented in these guidelines addresses only part of remote batch service operation. It should be employed in context as part of a performance management system.

The first step is the identification of the provider and consumer. This is not necessarily trivial when dealing with groups of consumers who may belong to different organizational units and who may deal with the provider through different spokespersons.

The second step is selection of the scenario descriptive of how the consumer obtains RBS. The scenarios presented in this report should serve as a starting place. They may be sufficient, or may require development before being acceptable. Both provider and consumer should agree on the representativeness of the scenario.

The third step is the selection of RBS metrics. This selection must be done in concert with the fourth step, selection of measurement methodology. The problem is to determine what should be measured and what can be measured. This process can also identify needed advances in measurement methodology. A cost benefit study can be conducted to help decide whether technology advancement in measurement methodology should be pursued. The consumer group should be kept aware of and educated about the selections of metrics and methodology and the logic which led to that selection.

The final step is implementation. RBS performance evaluation may be employed to settle disputes, to contractually establish definitions of satisfactory RBS, to support negotiation or litigation when agreed-upon service criteria are violated, to alert provider management when service levels are out-of-bounds, or to help consumers select a new RBS.

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Glossary

BATCH PROCESSING: 1) The processing of data or the accomplishment of jobs accumulated in advance in such a manner that each accumulation thus formed is processed or accomplished in the same run. 2) The processing of data accumulated over a period of time. BATCH PROCESSING can be differentiated from INTERACTIVE processing.

CENTRAL SITE: The facility maintained by the PROVIDER of the REMOTE BATCH SERVICE to perform data processing. This facility usually includes one or more computers with data storage devices, software, personnel, support services, and communications facilities. A REMOTE BATCH SERVICE may be supported by several central sites, and these central sites may be nodes on a computer network.

CONSUMER: The CONSUMER of a REMOTE BATCH SERVICE employs the service to satisfy needs for data processing. The CONSUMER may be either developing programs or employing data processing to support other (e.g., non-data processing) functions.

IMMEDIATE OUTPUT MODE: In IMMEDIATE OUTPUT MODE the output destined for a particular REMOTE SITE is transmitted when the output is ready, the necessary communications lines are available, and the REMOTE BATCH DEVICE is ready to receive. Output in IMMEDIATE OUTPUT MODE may be ordered by priority, and it may be transmitted to the REMOTE SITE for queuing in a REMOTE BATCH DEVICE with the capability to store the output for later conversion to readable form.

INPUT PROCESS: The process that consists of the reception of data into the data processing system, into a subsystem, or into a device. Synonymous with input. The INPUT PROCESS to a REMOTE BATCH SYSTEM includes all steps taken to prepare the SUBMISSION for processing.

INPUT TO RBS: The transfer of control over a submission to the RBS for the purpose of processing. This may be a manual process if PROVIDER personnel operate the REMOTE BATCH DEVICE, or if the CONSUMER operates the REMOTE BATCH DEVICE. Several attempts may be necessary by the CONSUMER to INPUT TO RBS due to availability problems with the RBS.

INTERACTIVE: A mode of operation wherein the computer and consumer communicate with each other through on-line keyboard terminals. In this mode of operation, each unit of transmission from the terminal is processed immediately and a response returned to the consumer. A "dialog" is said to exist between the consumer and computer. Interactive computer utilization may be used for programming, problem solving, inquiry, file update, text editing, or other data processing tasks.

JOB: A group of tasks prescribed as a unit of work for a computer. A job begins with identification of the consumer, the source of authorization/funding, and other information necessary for operation; and ends when a termination instruction, or equivalent, is executed.

OUTPUT PROCESS: The process that consists of the delivery of data from a data processing system, from a subsystem, or from a device. In a REMOTE BATCH SERVICE each REMOTE SITE must possess a capability to receive output via communication lines, but output may also undergo media conversion at the CENTRAL SITE with the converted media (usually paper or microfiche) physically delivered to the REMOTE SITE. Output may, therefore, be provided physically, or via transmission in a REQUEST OUTPUT MODE or in an IMMEDIATE OUTPUT MODE.

PERFORMANCE MANAGEMENT SYSTEM: A set of approaches, procedures, and reporting mechanisms designed to control a data processing system so that acceptable consumer service can be reliably provided. Objective data on service to CONSUMERS, as well as usage of system resources, are compared with previously established criteria so that actions can be taken when performance deviates from anticipated values. A performance management system may address just the production aspects of a computer service, or it may include the development and maintenance aspects as well. For adequacy in a REMOTE BATCH SERVICE, a PERFORMANCE MANAGEMENT SYSTEM must address all areas in which the PROVIDER supplies SERVICE.

PROVIDER: The PROVIDER of a REMOTE BATCH SERVICE maintains the hardware, software, personnel, support services, and communications facilities necessary to the SERVICE. The PROVIDER may also supply a communications network, REMOTE BATCH DEVICEs, and personnel at the REMOTE SITEs.

REMOTE BATCH DEVICE: Equipment with the capability of receiving a submission to RBS in machine-sensible form for transfer to a communication facility and/or the capability for receiving output from the RBS transferred from a communication facility and converting it to human-readable form. Many REMOTE BATCH DEVICEs have the ability to store input and/or output; some REMOTE BATCH DEVICEs can be employed as interactive consumer terminals as well. Printers, card readers, paper tape reader/punches, etc., are frequently included as parts of REMOTE BATCH DEVICEs.

REMOTE BATCH SERVICE: A data processing SERVICE which can be used by CONSUMERS, remote from the computer, in order to have their submissions submitted for BATCH PROCESSING. A REMOTE BATCH SERVICE is sometimes called an RJE (remote job entry) system or a remote computer service. The computers supporting REMOTE BATCH SERVICEs frequently also provide INTERACTIVE services to remote consumers.

REMOTE SITE: The facility maintained by either the PROVIDER or the CONSUMER of the REMOTE BATCH SERVICE to enable the CONSUMER to input submissions to the SERVICE. The remote site may be located distant from the CENTRAL SITE, or it may be located in the same vicinity as the CENTRAL SITE. The remote site consists of, at least, one or more REMOTE BATCH DEVICEs and a means of communication with the CENTRAL SITE. It may also include personnel to operate the REMOTE BATCH DEVICEs.

REQUEST OUTPUT MODE: In REQUEST OUTPUT MODE the CONSUMER requests output for a particular JOB and the CENTRAL SITE responds by transmitting the requested output to the designated REMOTE BATCH DEVICE.

SERVICE: The ability to meet the functional needs of CONSUMERS of data processing. SERVICE includes the attributes of timeliness, reliability, availability, cost, and accuracy. When a data processing SERVICE is provided to CONSUMERS, they need not be concerned with the techniques for processing, the hardware, the computer languages, or the identity of support personnel. Frequently, the SERVICE provided includes maintenance of programs and control statements as well as updating of databases; in some cases it includes review of the accuracy of reports and the control of financial data.

TURNAROUND TIME: The elapsed time from the beginning of INPUT to a REMOTE BATCH SERVICE until the results of the processing are available to the CONSUMER.

Appendix

Providers and Consumers of Remote Batch Computer Service

A.1 The Consumers' Problem

The physical distance of the consumers from the central site creates a new dimension of non-technical problems. In a conventional batch service environment, consumers knew data processing personnel because they belonged to the same organization—and probably worked in the same building.

Remote batch service, on the other hand, may be impersonal. Consumers frequently have no way to determine the status of the system. If the system is excessively sluggish, or is totally inoperable, the consumers do not know which of the many parts of the system are at fault. They probably don't *need* such information, but being able to obtain it may alleviate anxieties or make it possible to expedite repair. Unless special arrangements have been made, they do not know whom to call to resolve their problems. And they cannot even walk down the hall to the data center to find out what's wrong.

The issues are too important for responsible consumers simply to trust to fate. The technology is too complex for them to attempt to become knowledgeable in computing while dealing with their functional problems. The consumers are, therefore, faced with a problem: how can they ensure acceptable service from the remote batch service without trying to take on all the difficulty of learning enough to personally run the data processing center? The approach presented in this document is to identify the types of metrics relevant to the consumer's viewpoint. Consumers can and should use these metrics in describing the service quality they want to receive. Providers can and should use these metrics to describe the service objectives provided to consumers. When a contractual relationship exists between provider and consumer, these metrics can and should be specified in that contract.

As stated in the introduction, the purpose of this document is to aid parties, dealing in good faith, to reach a common agreement about the service that will be provided to remote consumers, and to determine whether the promised service has been provided. Since remote batch services are frequently incorrectly characterized, this document includes definitions and statements of limitations. In addition, it provides examples and explanations in order to be explicit about implications of the document. If you are either a consumer or provider of remote batch services, the guidelines provided here can aid you in negotiations, selections, and evaluations of remote batch services.

A.2 Objectives of Provider vs Consumer

A central site is basically a production facility that attempts to run reliably, with high efficiency, and at low cost. *The manager of the central site must be concerned with the utilization of equipment, its maintenance, its reliability, and its operation. Consumers, on the other hand, are concerned with what happened to their particular submissions.* They are annoyed when their needs are not met in a timely, accurate manner due to decisions by the provider—even when the motivation is cost reduction.

The difference in concern and objective is not the result of a lack of interest in the the problems, but is due to the variety of objectives adopted within large organizations. The individuals involved in disputes about machine productivity as opposed to responsiveness are reflecting the conflicts between these objectives. *Even when no dramatic conflict exists, the individuals involved in a remote batch service may become frustrated in describing the service's performance because they do not know which parts of it to measure.*

Many measures have been applied to remote batch service. Several have already been mentioned in this publication. In order to reduce contention, ***the definitions of remote batch service quality should be agreed upon and published in advance at any attempt to measure that service.***

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