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MARTIN MARIETTA

System Design and Integration Analysis for the Integrated Booking System (IBS)

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Energy Division

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ABSTRACT

In accordance with tasking for the Military Traffic Management Command (MTMC), the Oak Ridge National Laboratory (ORNL) investigated design and integration issues and identified specific options for MTMC's Integrated Booking System (IBS). Three system designs are described: the single-server, stand-alone IBS; the area-based IBS; and the fully-integrated IBS. Because of the functional and technical requirements of IBS and because of the MTMC strategy of sharing resources, ORNL recommends the fully-integrated design. This option uses the excess computing resources provided through the architectural components of the Integrated Cargo Database (ICDB) and provides visibility over the cargo record from initial request through final delivery.

1. INTRODUCTION

The purpose of this document is to report on tasking conducted by the Oak Ridge National Laboratory (ORNL) for the Military Traffic Management Command (MTMC) related to the Integrated Booking System (IBS). ORNL investigated design and integration issues and identified specific design factors, constraints, and technical considerations. This report describes options for the overall design of the system, including architectural and high-level data modeling considerations, and recommends a preferred configuration and system design.

The purpose and scope of IBS are briefly described below. Chapter 2 of this report includes an overview of IBS required capabilities. Chapters 3 and 4 specify design options and identify the preferred alternative.

1.1 PURPOSE OF IBS

MTMC has determined that IBS is a major system development and data integration initiative that will support MTMC's traffic management responsibilities. The overall objective of IBS is to provide a single, worldwide, automated booking system designed to support both peacetime and wartime movement of unit and nonunit cargo in an efficient and timely manner. Another goal of IBS is to provide the final link in Continental United States (CONUS) data integration for MTMC cargo traffic data. Thus, after IBS is implemented, cargo data produced in the booking process will interface with the Integrated Cargo Database (ICDB); ICDB will flow data to the appropriate Worldwide Port System (WPS) site and receive data from WPS sites within a seamless integrated design.

As a result of linking booking activities with port activities, several cargo management and documentation functions should be greatly enhanced. For example, current manual procedures of the Cargo Management Branches of the Area Commands (ACs) should become more automated. Terminals Division oversight functions should also become more easily accomplished.

IBS will automatically provide reports containing statistics to assist in management of the performance of carriers, shippers, and bookers. Accuracy and reliability are highly desirable characteristics of any system. One goal of the system design is to ensure that these features will be incorporated in IBS.

1.2 SCOPE

Although IBS will be used worldwide eventually, at this time the analysis will cover only CONUS requirements.

IBS will be an unclassified system. For booking of unit moves and exercises, there will be an interaction with a planning module, which will be coordinating booking during the time that the booking process is still classified.[1]

Currently the booking mission is supported by the Mechanized Export Traffic System II (METS II) for booking peacetime nonunit cargo and by the Automated System for Processing Unit Requests (ASPUR) for deploying units (used during exercises and contingencies). The Automated Cargo Offering System (TACOS) is an expert system designed to assist in the routing and booking of nonunit cargo along selected routes; TACOS is currently being used as an interface to METS II for determining the low-cost carrier. The Automated Carrier Interface (ACI) is another major interface to METS II and is used as a communication link to offer and book cargo with commercial carriers

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[1]At the time that this analysis was presented to MTMC, the system responsible for the planning and initial execution of unit moves and exercises was the execution module of a separate system. Design issues concerning specific responsibilities (i.e., IBS or the other system) for accomplishing unit moves functionality, timeframes for data exchanges, and precise procedures for these data exchanges were being discussed and resolved. Because the issues are implementation specific and have no impact on the architectural designs described in this document, they are addressed throughout this document only as required.

using Electronic Data Interchange (EDI) transactions. IBS will replace METS II, ASPUR, and TACOS and will incorporate and enhance the current ACI interface capabilities. It is proposed that this enhanced interface to EDI transactions will be used by ICDB also. IBS will provide a consistent interface for booking nonunit resupply cargo and for deploying unit cargo. Additional IBS functionality is described in the Updated and Revalidated Functional Description for the Integrated Booking System (IBS), hereinafter called the Updated and Revalidated IBS Functional Description (FD).

Because the architectural and database design of ICDB will influence the design of IBS, this IBS deliverable will draw from the Architectural Analysis for the Worldwide Port System (WPS) Integrated Cargo Database (ICDB) and the Database Specifications for the Worldwide Port System (WPS) Integrated Cargo Database (ICDB) reports for pertinent information. Complete citations of these documents are provided in Section 1.4.

IBS is one of a number of MTMC systems that must work together. All IBS interfaces (system and organizational) have been clearly defined and the anticipated volumes have been documented. This information, which is detailed in the Updated and Revalidated IBS FD, is used in this report to arrive at a recommended system design. In addition to major system interfaces (e.g., ICDB), there are issues concerning individual IBS users who log in remotely. Sections 2.3, 2.6, and 2.8 address some of these issues.

The database design for IBS will be closely related to several existing database designs. These include the TACOS design, which does not include all of the functionality (e.g., booking hazardous cargo) required for IBS; the IBS prototype design, which was constructed using a personal computer (PC)-based, non-relational database tool; and ICDB, which does not incorporate all of the IBS functionality but which will be a major user of IBS data. The data integration concept briefly described in this document examined these related databases.

It must be noted that this report focuses on (1) system design issues (i.e., architectural considerations and communications requirements) and (2) database integration issues. Other functional and technical requirements, which are described briefly in Section 2, are addressed in light of the recommended system design. Additional procedural and administrative issues that must be addressed are beyond the scope of this document.

1.3 ACRONYMS

AAFES	Army and Air Force Exchange Service
AC	Area Command
ACI	Automated Carrier Interface
AFCAC	Air Force Computer Acquisition Contract
ATCMD	Advanced Transportation Control and Movement Documents
ASPUR	Automated System for Processing Unit Requirements
CFM	CONUS Freight Management
ChUI	Character-based User Interface
CMB	Cargo Management Branch
CONUS	Continental United States
CPU	Central Processing Unit
DDN	Defense Data Network
DOE	Department of Energy
EDI	Electronic Data Interchange
FD	Functional Description
GUI	Graphical User Interface
HP	Hewlett-Packard
HQ	Headquarters
IBS	Integrated Booking System
ICDB	Integrated Cargo Database
ID	Identifier
I/O	Input/Output
LAN	Local Area Network
MAISRC	Major Automated Information System Review Council
METS II	Mechanized Export Traffic System II
MSC	Military Sealift Command
MTMC	Military Traffic Management Command
OCCA	Ocean Cargo Clearance Authority
OCR	Optical Character Recognition
ORNL	Oak Ridge National Laboratory
PC	Personal Computer
PL	Procedural Language
PMO	Product Management Office
RDBMS	Relational Database Management System
SQL	Structured Query Language
STRADS	Strategic Deployment System
TACOS	The Automated Cargo Offering System
TC-AIMS	Transportation Coordinator's Automated Information for

	Movements System
TCP/IP	Transmission Control Protocol/Internet Protocol
TERMS	Terminal Management System
TRANSCOM	Transportation Command
UPS	Uninterruptable Power Supply
VAN	Value Added Network
WAN	Wide-Area Network
WPS	Worldwide Port System
4GL	Fourth-Generation Language

1.4 REFERENCES

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2. SPECIFICATIONS AND REQUIREMENTS

The Updated and Revalidated IBS FD presents all the specifications and requirements to meet the desired functionality of the IBS. A brief overview of these requirements is given below. Section 3 presents a discussion of data model options; Section 3 also presents three possible architectural configurations for IBS that can meet these requirements within the confines of the performance specifications given in the Updated and Revalidated IBS FD.

2.1 CURRENT AVAILABILITY ISSUES

IBS must closely interact with the ICDB system already being developed and fielded. The ICDB system uses the Unix operating system and the Oracle7 Relational Database Management System (RDBMS). Because of this, ORNL highly recommends that IBS also use Unix and Oracle7. There is a communications infrastructure already in place that is available for use by MTMC. This infrastructure allows access to any potential IBS architecture for the users and for other MTMC and U.S. Transportation Command (TRANSCOM) systems. ORNL highly recommends the continued use of this existing communications infrastructure. Because this continued use makes sense functionally, technically, and financially, the use of alternatives to Unix, Oracle7, and the existing communications infrastructure will not be considered in this document.

All attempts will be made to allow potential IBS users' current PCs/workstations/terminals to connect with and interact correctly with the IBS user interface. All current end-user hardware can be connected to any IBS configuration described herein. Currently, "dumb" terminals are used to access METS II, and X-terminals are connected to the TACOS server. Connection as a terminal does not allow client-server workstation applications nor does it guarantee a graphical user interface (GUI). This document does not recommend specific software for connecting those users but does suggest areas for consideration (see Section 2.6, "User Interface Requirements").

2.2 INTELLIGENT DECISION SUPPORT

Currently, TACOS supplies artificial-intelligence-like booking assistance to the booking branches at the ACs. This functionality is described in The Automated Container Offering System (TACOS) Preliminary and Detailed Software Design Document. This booking assistance functionality must also be incorporated into IBS. It will be expanded as much as possible to support additional booking processes not described in this TACOS document (e.g., breakbulk shipments).

The Updated and Revalidated IBS FD describes a broad spectrum of functional requirements to support the bookers and other users. To provide this support, IBS will employ a network of interconnected programs. These decision support programs will have the following characteristics:

- The programs will be many and varied. Most of them will be in Unix shell script/SQL or PL/SQL fourth-generation (4GL) code.
- Most of the programs will require access to the IBS (or ICDB) database tables. Some programs, such as communications programs, will not require database access.
- Only one or at most a few of these programs will be running at any given time for any user on the system. Most of the time, IBS will be waiting for the user to enter some value or execute a command (e.g., while conducting booking operations). During those times, no programs are running (consuming computing and/or communications resources) for that user.

2.3 THROUGHPUT REQUIREMENTS

Throughput requirements are determined by the types (e.g., human input/query or automated database update) and numbers of processes projected to occur and the performance criteria (e.g., response time for a query) of the system.

The requirements for IBS response times and other performance indicators are given in Section 3.1.2 of the Updated and Revalidated IBS FD. It is expected that, for queries that involve the ICDB database on the Central Server, the IBS response times be at least as good as ICDB response times.[2] There are currently approximately 6000 peacetime non-unit requests booked each month at the Eastern AC and 3000 at the Western AC. For a normal 40 hour week, this averages out to 35 bookings per hour at Eastern (or one every minute and 40 seconds) and 18 per hour at Western (or one every 3 minutes and 20 seconds). Any system design must be able to handle this level of traffic as its minimum. During wartime, IBS must be able to handle the possibility of twice as much traffic with only a mild degradation in response time.

In addition, IBS must incorporate cargo information concerning movements of entire units to support an exercise or operation plan or special relief mission. (The precise volume and frequency of data inputs and outputs, the formats, and the procedures for exchanging unit movement data were incomplete at the time this Integration Analysis was written because a complete definition of the interface with the planning system was not available.) It is assumed that the volume described in the previous paragraph for wartime traffic will be sufficient for handling throughput requirements for the unit movement cargo data flows.

It is possible for as many as 120 users to be logged into IBS concurrently with 80% of them doing actual booking work. Over 60% of all IBS booking activity will be generated by the Eastern AC. Any potential IBS architecture must consider this to be the minimum number of simultaneous users. During wartime, IBS must be able to handle the possibility of twice as many simultaneous users with only a mild degradation in response time.

Booking technicians will access IBS through a known and controlled access interface [i.e., the local area network (LAN) at the ACs]. These bookers provide the heaviest workload for IBS because, even though they are limited in number, they will be logged on almost constantly and will be accessing the processing capabilities of IBS (e.g., see Sections 2.2 and 2.5). The greatest number of IBS users will be requestors/shippers. These users will access IBS through uncontrolled access via:

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[2]Target performance timeframes for ICDB are given in Table 3-1 of the Functional Description for the Worldwide Port System (WPS) Integrated Cargo Database (ICDB).

- Internet
- Defense Data Network (DDN)
- Value Added Networks (VANs)
- Modems (dial-up telephone lines)

Any potential IBS architecture must be able to accommodate all of these user connection methods and provide as complete functionality as possible for the user on any of the listed connections. Although the IBS architecture cannot control the user end of the connection, the IBS architecture must assure the user the best possible capability at the IBS end. This demands that any potential IBS architecture exhibit strong communications capability.

After the initial request is submitted, each booking record is altered several times. Records are updated with information supplied by bookers, requestors, shippers, or carriers. Eventually the booking record is completed, put on hold awaiting action, or deleted. Each stage, status change, or other update in the life of a booking requires throughput (and storage) resources that must be provided by IBS.

2.4 INTER-OPERABILITY

IBS will be communicating in some way with nearly a dozen other existing (and planned) systems. Figure 5.1 of the Updated and Revalidated IBS FD depicts the other systems that will communicate with IBS. The IBS communications infrastructure must be robust enough to accommodate all of these diverse interfaces and formats. ORNL estimates that as much of the IBS resources will be devoted to communications as to actual data processing. This means that IBS will need an architecture with strong communications processing.

2.5 STATISTICAL CAPABILITIES

As stated in the Updated and Revalidated IBS FD, IBS is required to maintain a broad range of statistics and statistical histories. Evaluation of any candidate IBS architecture must consider the special computing requirements for statistics (i.e., strong floating point performance). The data to compute these statistics will be found in both IBS and ICDB. Therefore, the IBS statistical capabilities must also include the ability to extract data from other related systems (e.g., ICDB) for the calculations. ORNL recommends the use of the RDBMS 4GL for any simple statistical calculations and presentations. ORNL recommends the use of commercial statistical packages for complex statistical calculations and presentations.

Since statistics are generally best understood when graphically presented, IBS requires graphical capabilities to support statistical presentations.

2.6 USER INTERFACE REQUIREMENTS

The IBS user community consists of the following: (1) Ocean Cargo Clearance Authority (OCCA) booking technicians at the ACs, (2) personnel in organizations that have been given permission to perform direct booking [e.g., the Army and Air Force Exchange Service (AAFES)], (3) remote (sometimes infrequent) users submitting requests online and/or querying the status of requests, (4) remote (sometimes infrequent) users submitting requests in batch mode and/or querying the status of requests, (5) personnel in the Cargo Management Branch (CMB) at the ACs, (6) personnel in the Terminals Division at the ACs, (7) management personnel at the ACs and MTMC Headquarters (HQ), and (8) personnel in MSC who need to reconcile the Shipping Order/Clearance Order with manifest documents in order to authorize payments. Carriers are users in a modified sense in that they receive and send data through the EDI interface communication link. Shippers submitting Advanced Transportation Control and Movement Documents (ATCMDs) may use the booking record as a starting point for completing the ATCMD record.

The IBS user community clearly stated the need for a GUI during user reviews of the IBS prototype. The booking technicians are familiar with a windowing environment because TACOS uses windows.

The Unix industry is standardizing on "Motif" as the GUI of choice. Motif is an X-window based interface. This means that any display device that is to display Motif must be (or have access to) an X-window server system. For PCs, this requires a software package that implements an X-window server within the Windows operating system (e.g., Hummingbird) or one that completely replaces DOS (e.g., QuarterDeck).

A GUI is communications intensive. A lot of information about the picture on the screen must be communicated to the display. A responsive GUI requires that the GUI user be attached to a network. The Internet and its major components operate on Transmission Control Protocol/Internet Protocol (TCP/IP). This is also the native network protocol of all Unix systems. For best Motif GUI response, the PC or workstation using Motif should be connected to a network and utilize TCP/IP as the network protocol.

Those remote users that can support the Motif GUI but are not on the network must have very fast modems to access IBS. Any modem speed less than 9600 baud is unusable. A baud rate of 14.4 kbaud is frustrating but usable. For those users who cannot (or will not) use a GUI, the proposed IBS must be able to provide appropriate IBS functionality to those users. Character User Interfaces (ChUIs - pronounced "chewies") must be available for those users that have non-graphical terminals. Those ChUIs must exhibit full IBS functionality though not the extensive GUI picture display capability. For those users, it is not necessary to have the extremely high speed modems needed by the GUI. A 2400 baud modem will work for a ChUI.

Users of dumb terminals or dumb terminal emulators will log into the IBS and will utilize the IBS application software for online builds. However, users of PCs can also run programs that can build records locally and then upload them to IBS. Unfortunately, these users do not have ready access to the static tables and codes available to interactive IBS users unless these tables and codes are down-loaded to all the batch users whenever there is a change in one of them. This feat is technically possible but resource expensive. (The tables/codes would have to be broadcast to all the known batch users which means that they would all have to be accessible. Most PC users do not leave their machines running constantly. IBS would have to be constantly monitoring all these users trying to detect when they come onto the network or dial in.) Therefore, instead of downloading tables to all batch users, code will be written for validating requests received via batch mode; in addition, mechanisms will be provided for automating the correction of incorrect data (e.g., Section 2.8).

This document does not address the purchase of end-user interface equipment because of the broad diversity currently in use by the users of systems that IBS will replace. It is quite possible for IBS to know and/or detect the end-user equipment and format the user interface accordingly (e.g., if the user has a PC under Windows with Hummingbird software, the X-window interface could be used; if the user has a dumb terminal, the VT100 emulator would be used). The Unix operating system can be programmed to recognize some of the terminal equipment characteristics of a particular login ID. When that user logs in, those characteristics are initiated and the user sees the highest level interface possible for his equipment. For normal AC LAN users (e.g., the booking branches), IBS can standardize on a particular package (e.g., Hummingbird) that will provide a very high level of GUI for the user. The Oracle7 GUI packages (Forms 4.0 and Oracle Graphics) can also present the same functionality at several interface levels. ORNL recommends that IBS use the latest software techniques as the means for knowing/detecting the end-user interface equipment rather than attempting to buy/force the use of certain terminal hardware.

2.7 SECURITY

Any system that incorporates a modem interface for dial-in users exposes itself to potential unauthorized access. For dial-up users, it is suggested that all modems be either dial-back modems or caller-ID modems. In the dial-back security scenario, a user dials into the IBS system from a known phone number and first logs into the modem. The IBS system verifies that the user is one of the known users and calls the user back at the phone number assigned to that user. A hacker would have to have been at the real user's remote workstation to have successfully dialed into the system. The caller-ID scenario works much the same way except that the user's caller-ID is compared with a list of possible calling phone numbers. Any hacker would have to be calling from one of those known phone numbers. It is suggested that military systems with dial-up users be set up with dial-back or caller-ID modems.

It is possible to tighten up the security on IBS by making it accessible to only a selected few, official, known, outside systems. All other systems can be locked out of IBS access. This is done by programming the modems with lists of Internet/Milnet IP addresses that can pass into the IBS. That is, IBS can communicate out to any system but only official, known systems can communicate into IBS. This network "Firewall" is currently the best means of network protection; the hackers would have to first break into a system known to IBS in order to break into IBS.

2.8 COMPUTERIZED FAX CAPABILITIES

It is desirable and technically possible to have IBS both send and receive FAXs. There are several vendors of FAX software for Unix systems. These FAX packages can be integrated into the applications software for seamless sending and receiving of FAXs. But a FAX is just a picture, it is not text and cannot be processed as text. However, there are Optical Character Recognition (OCR) software packages for the FAX software that attempt to convert the FAX pictures into their equivalent text and graphics. Since the information on a FAX can be anything (it's just a picture), these OCR packages are limited in their performance. The most likely scenario is to allow the computer to send a FAX but still require a human to receive a FAX. This requires the FAX users' data to be rekeyed but it is more reliable that attempting to scan it in via OCR.

2.9 INFORMATION FLOWS AND DATA MODEL

The logical design of IBS must consider the flow of information from initial request to the documentation sent to the port about the cargo. As noted in Section 2.1, the infrastructure (i.e., hardware, communications, and certain processing capabilities) for ICDB is already established. The functionality of IBS requires additional processing modules; however, some of the functionality described in the Updated and Revalidated

IBS FD should actually come from the data currently modeled in ICDB. Therefore, it is critical to have a seamless integration of IBS within the context of total cargo visibility for MTMC surface cargo moving through common user ocean ports. Figure 2.1 shows some of these information flows. Figure 2.2 shows how data are shared among the functional users at the ACs and the ports. This figure shows clearly the benefits of early integration of IBS data within ICDB. Three data integration concepts are described in Section 3.1.

2.10 OTHER FUNCTIONAL REQUIREMENTS

Reports from IBS are listed in the Updated and Revalidated IBS FD. The capability to print certain documents will be a requirement. In the current environment, paper copies of most records are retained in files in several different departments. Once the information is available online, these multiple file copies will be unnecessary.

Either AC must be able to support the other AC workload in the event of hardware failure, reoffer, and/or workload overload. Thus, the capability to "share" requests between the ACs is a definite requirement. Similarly, the capability to reconstruct a request must exist in case the site to which the request was submitted becomes inoperative.

The intelligent decision support module will assist the booking branches with the most common types of cargo booking requests (e.g., container moves of general cargo). IBS will provide limited assistance with special moves, (e.g., breakbulk cargo, containerized refrigerated cargo, hazardous and protected cargo, ammunition, and foreign military sales). IBS must have sufficient programmed "intelligence" to determine when the automated features can suggest the appropriate carrier and when intervention by a booking technician is required.

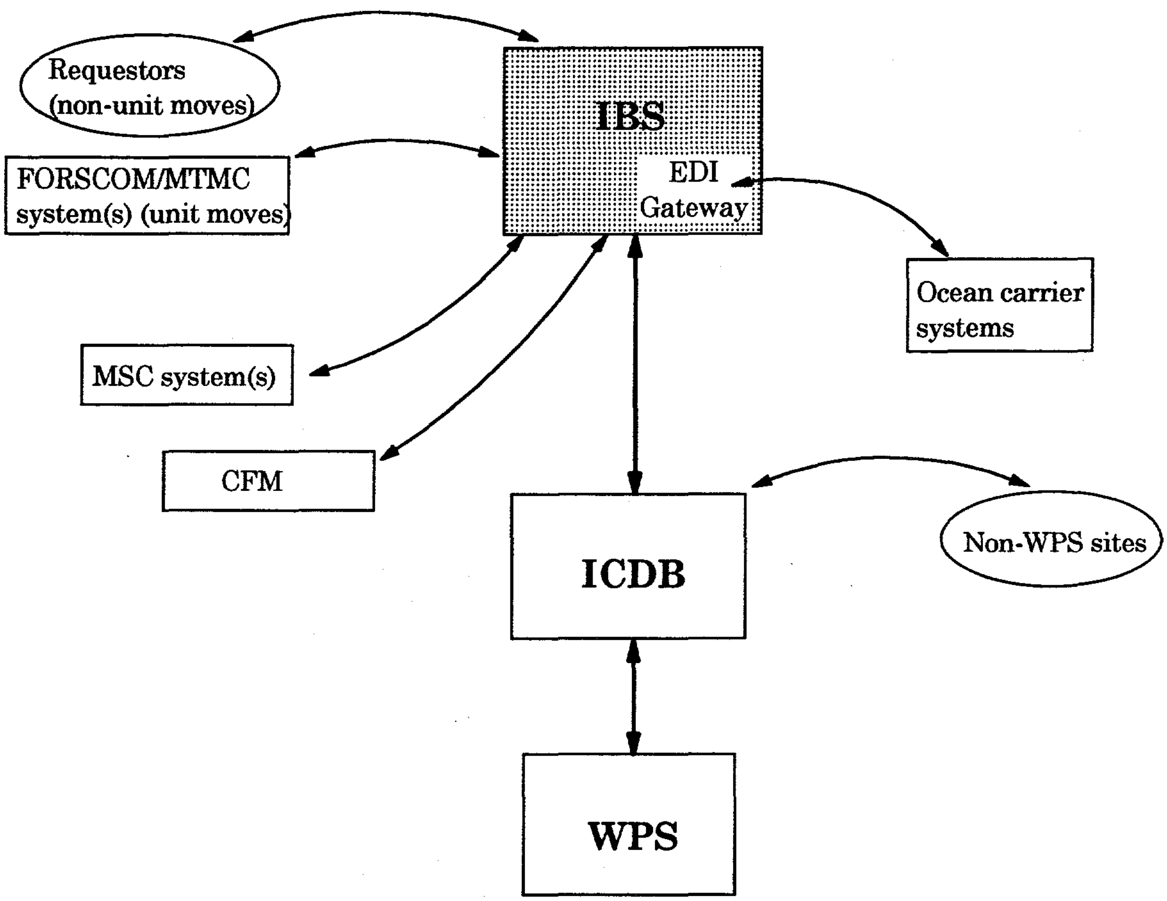

Fig. 2.1. Selected MTMC surface-cargo information flows. Total visibility is contained in ICDB, the centralized repository. See also Section 3.1 for additional information on the data model and data flows.

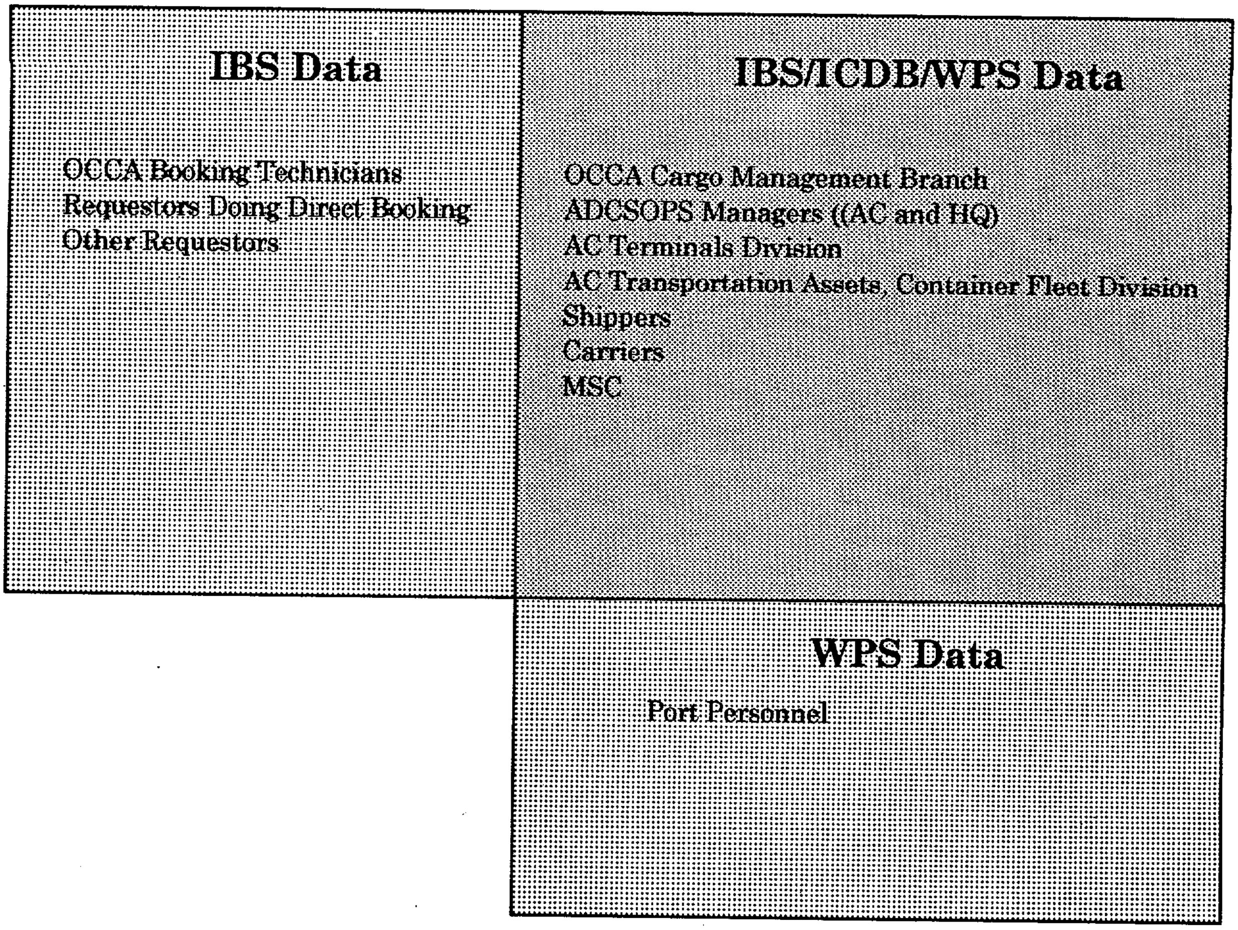

Fig. 2.2. Users of MTMC surface cargo data in IBS, ICDB, and WPS.

3. DESIGN AND INTEGRATION OPTIONS

MTMC's philosophy is to conform with the AUTOSTRAD 2000 strategy of sharing resources. Thus, the need to integrate IBS within the current MTMC computer system superstructure must be addressed when considering possible design and integration options. Two primary areas must be considered: (1) data and database integration concepts and (2) architectural and communication requirements.

Section 3.1 presents a brief discussion of data and data integration concepts and describes a recommended design. Following the data discussion, Sections 3.2-3.4 explore three of the most probable architectural designs. In the discussion of each possible design, there is a system description containing configuration diagrams and geographic layouts, a data model discussion for incorporating the recommended data strategy within that architectural design, a cost discussion, and a summary statement of advantages and disadvantages. In each of the configuration diagrams, equipment beyond the scope of this document is depicted as boxes with double lines and *italics* printing. Equipment within the scope of this document is depicted as boxes with single lines and **bold** printing.

3.1 OPTIONS FOR DATA INTEGRATION CONCEPTS

There are three major options to examine when attempting to relate IBS data to the ICDB database (see Section 2.9). For all three options, it is necessary to identify when a booking record is considered "complete." For nonunit moves, the booking record could be considered "complete" when an Export Traffic Release is sent to the requestor, when the cargo is received at the port, when an ATCMD is received by ICDB, or when the cargo is actually lifted as booked. For unit moves, the booking record could be considered "complete" when a Unit Cargo Release is sent to the installation or when a signal of some type is received from the system initiating the initial booking for the unit move record. Exactly when a booking record should be considered "complete" (for both nonunit and unit moves) will be determined at a later date.

3.1.1 Totally Separate Data in IBS and ICDB

The first option is to totally separate IBS data from ICDB until the booking record is "complete." At that point the record would be sent to ICDB for incorporation, after which it would be updated through ICDB and WPS processing modules. This concept is very similar to the current METS II operation with the advantage that the booking data would be incorporated into ICDB [which is not currently done with the Terminal Management System (TERMS)]. Another advantage is that there is no duplication of data between IBS and ICDB and no problems related to ensuring data concurrency. Disadvantages are that (1) because of the lack of redundancy, there is no easy way to reconstruct a record if it is lost (except from backup tapes, which may be outdated), and (2) visibility over all cargo data at all stages would not exist in a single repository (i.e., individuals would access IBS for booking information but would access ICDB for information on shipments that have "passed beyond" the booking process).

3.1.2 All Data in ICDB, None in IBS

A second data concept is to store all booking <u>data</u> only on the ICDB central database server. All booking <u>processes</u> would take place at IBS via applications residing on IBS processors; however, the data would be accessed from the ICDB for each application. This has a visibility advantage but has potential for communication problems. It also has the disadvantage of having booking data placed in ICDB tables prior to being considered "complete." This early incorporation in the ICDB active shipment unit tables has the potential (especially for unit moves processing) for considerably slowing down normal ICDB processes (e.g., data exchanges with WPS).

3.1.3 IBS-ICDB Data Integration

In the third concept, submission of a booking request initiates a set of request data in IBS, and these data are duplicated on the ICDB Central Server. This duplication ensures that the request data can be reconstructed from the data on the Central Server, if necessary.

For nonunit requests, the data are inserted into the main ICDB tables on the Central Server which send to and receive data from WPS and provide data visibility through the ICDB user query capabilities. As the booking process continues in IBS, the Central Server data are updated in near real time so that ICDB data are synchronized with IBS data. Because requests for unit moves are often initiated a long time before the move occurs and the details of the request often change significantly, the unit movement data are stored in separate tables on the ICDB server, for backup purposes. Data on the Central Server are updated as needed. At the appropriate time, the unit move data are incorporated into the main ICDB tables and become visible to WPS and the ICDB user community. For both unit and nonunit data, data are retained in IBS until the booking record is "complete," at which time the record is deleted from IBS and all subsequent updates to the shipment record (e.g., from WPS) occur on ICDB. The data remain in ICDB, which serves as an archive of the IBS data. This data integration concept is shown in the preliminary data model in Figure 3.1.

ORNL recommends the third option because it provides central visibility at the earliest reasonable stage of the process and, because of the data redundancy, allows recovery of IBS data lost at the processing site. It also supports data visibility if IBS is implemented on more than one hardware platform, as described below.

3.2 THE STAND-ALONE IBS

3.2.1 System Description

IBS could be implemented as a stand-alone server. This architecture places a single IBS server at or near the central ICDB server (Figures 3.2 and 3.3). The single IBS server is an expensive, high-reliability system based on a single, fault-tolerant server or possibly two servers in a clustered configuration. This configuration communicates to the outside world via one or more existing gateways and one or more terminal servers. It communicates with ICDB via LAN.

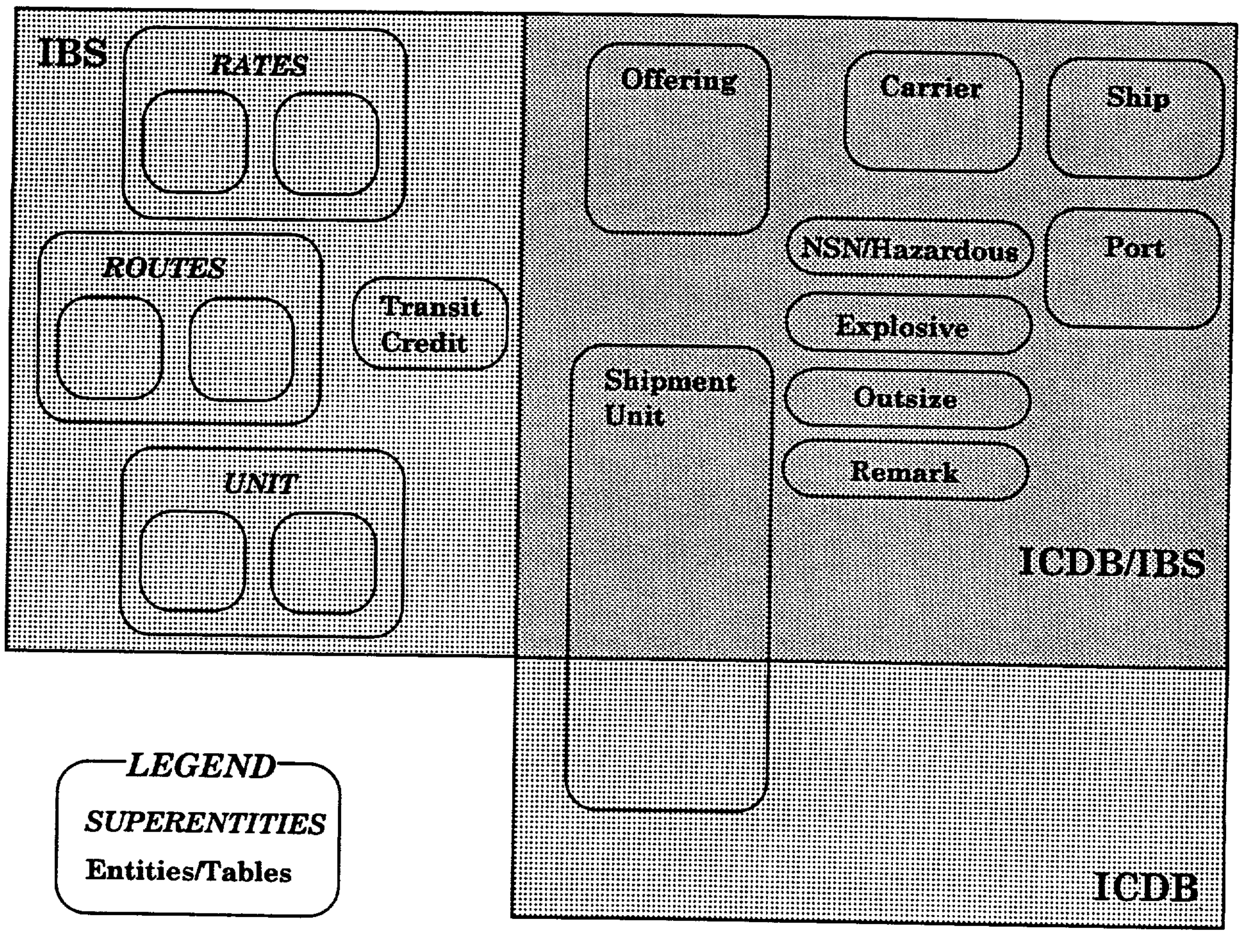

Figure 3.1. Concept of data integration between IBS and ICDB.

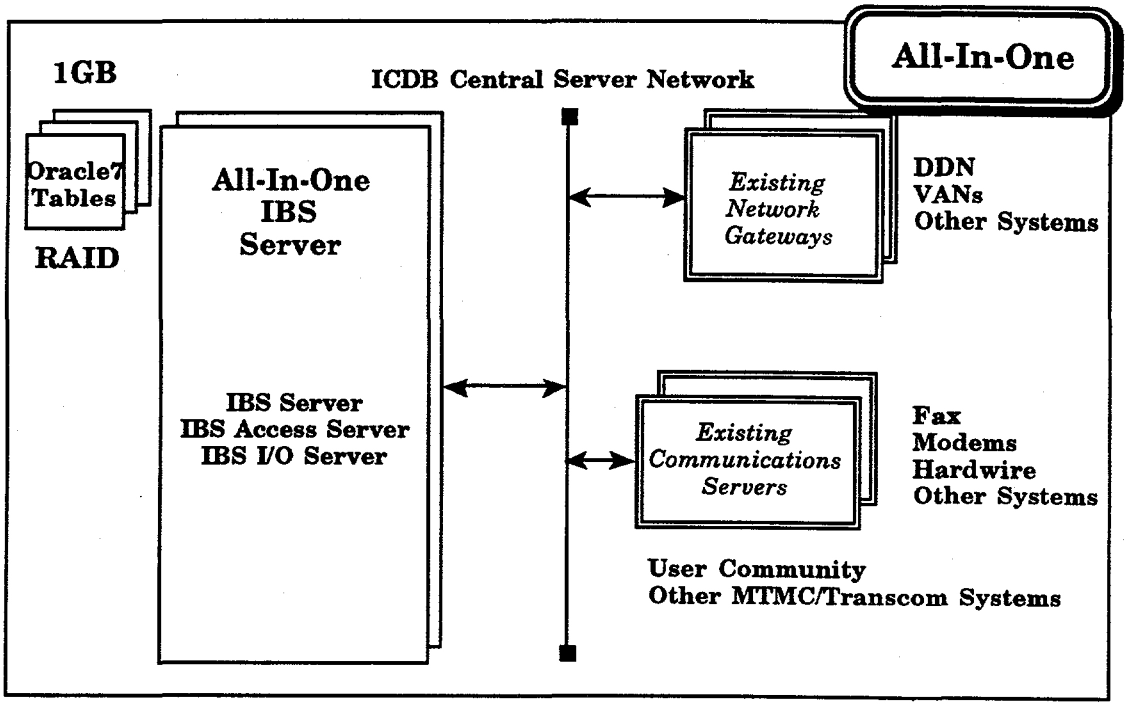

Figure 3.2. The single-server, stand-alone configuration.

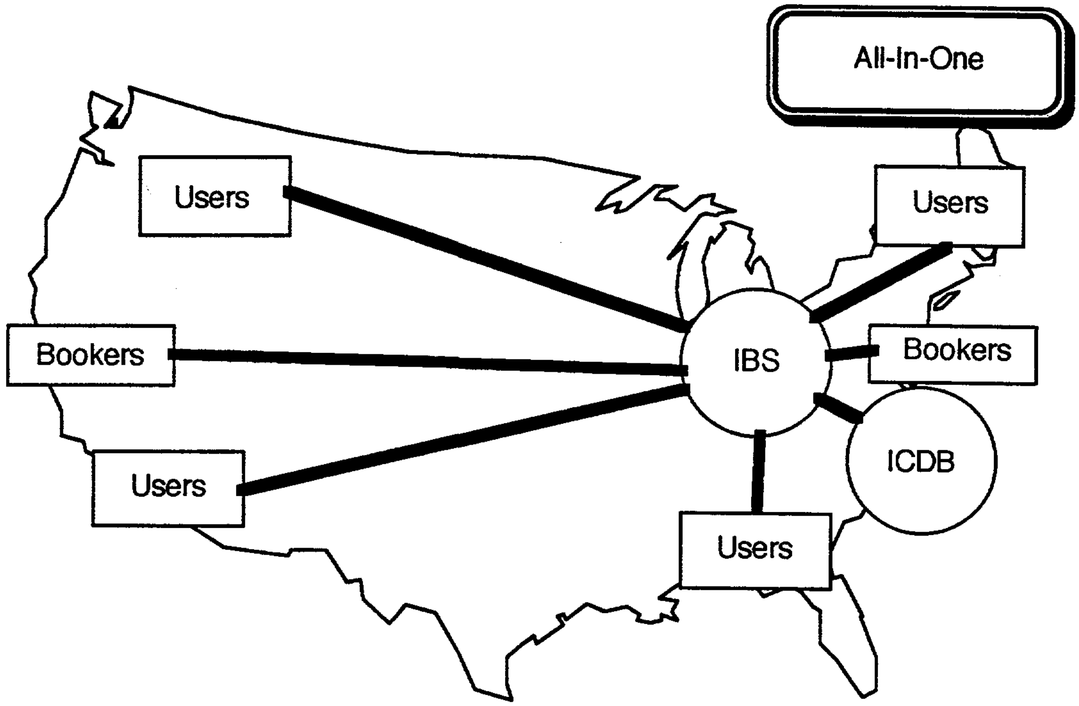

Figure 3.3. Geographic layout of the single-server, stand-alone configuration.

3.2.2 Data Model

The IBS database for both CONUS ACs would exist totally within the single IBS database server. All requests would be sent to the same machine, all processing would be done on this machine. No other data (e.g., ICDB data) would be on the IBS server. The overall description of data duplication of IBS data in ICDB is as described previously for the recommended data integration concept (see Section 3.1.3).

3.2.3 Costs

The Updated and Revalidated IBS FD states that there will probably be no more than 120 users simultaneously logged in during peacetime. A hardware configuration that will support this architecture is available via the Super-Minicomputer Contract. Table 3.1 summarizes the cost of a suitable hardware platform for this configuration. This table summarizes hardware costs only and does not include communication costs (e.g., additional lines and communication servers).

Table 3.1. Cost of the single-server configuration

Quantity	Description	Vendor & model	Price
1	128-user super minicomputer	HP 9000/877	$99,350
2	3 KVA UPS	Clary Onguard	7,572
Total			$106,922

Source: PRC, Super-Minicomputer Contract.

3.2.4 Summary

The following list summarizes both the architectural and the data model primary advantages and disadvantages for this design option.

Advantages

- All booking information for CONUS is in one place. This allows area commands to easily book shipments leaving from the opposite coast.

- Because there is only one of everything, this design is cheaper than the area-based IBS architectures.

- There is centralized control.

- Requestors have only one system location to book through.

Disadvantages

- Once the system is sized to handle the IBS requirements, the performance bottleneck would be shifted to communications systems. Redesigning the communications system to handle the increased load is beyond the scope of IBS.

- Because there is only one copy of the processing modules, it is an unreliable single point of failure. It would be possible to have a "hot backup" for IBS but the communications aspects for the central IBS would be costly and difficult to maintain.

- There is no system-wide failsafe mechanism as there is in ICDB.

3.3 THE AREA-BASED IBS

3.3.1 System Description

Another viable design is that of splitting the single IBS server across area commands (Figures 3.4-3.7). In one scenario, the area IBSs are connected directly to the ICDB Central Server via their own dedicated lines. In this architecture, the AC IBSs can be placed at any convenient location. A slight alteration to this design connects the IBSs to the ICDB Hubs. This architecture places an IBS server at or near each ICDB Hub.

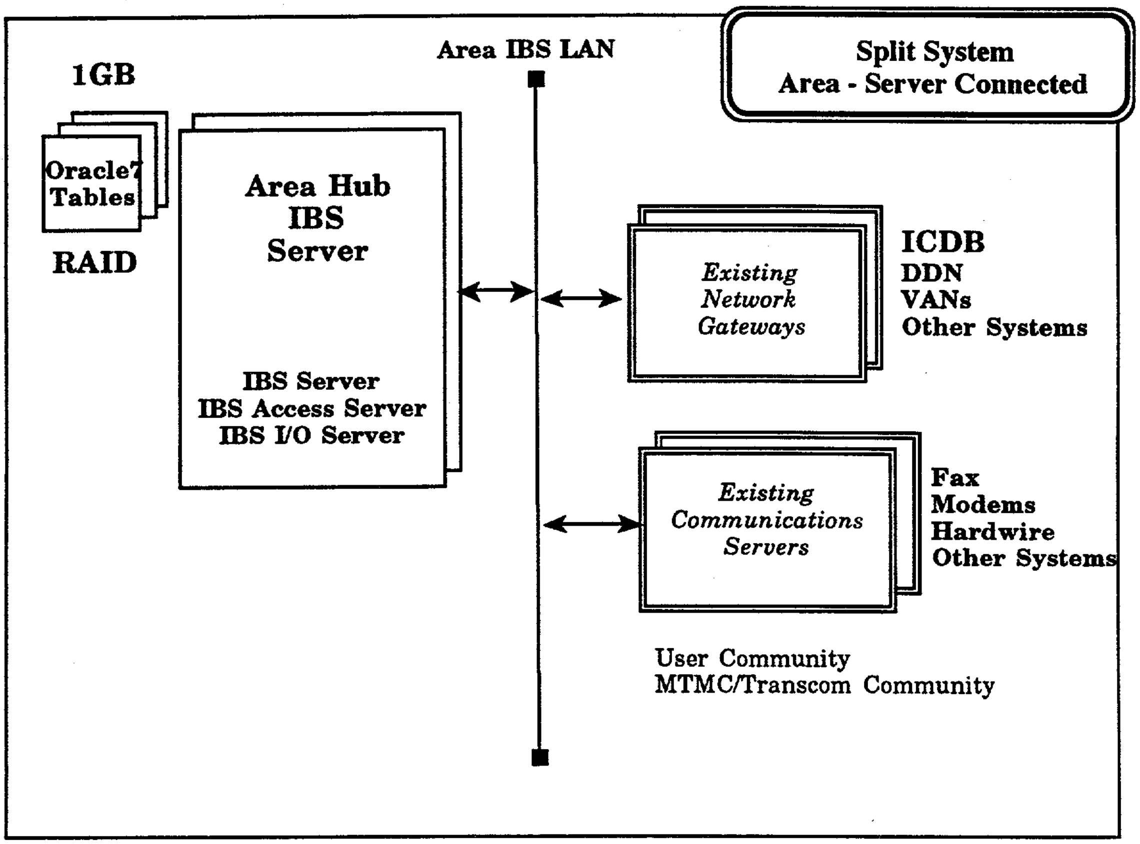

Figure 3.4. The area-based configuration with IBS directly connected to the ICDB server.

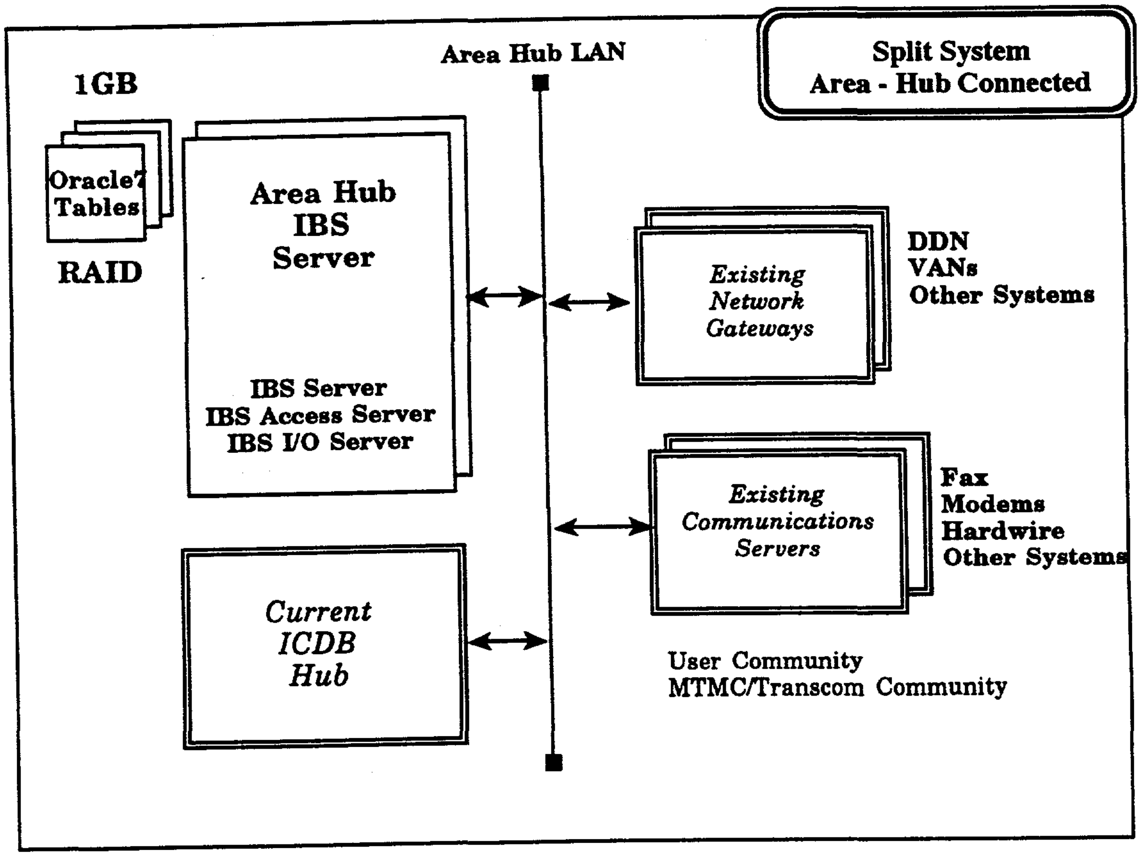

Figure 3.5. The area-based configuration with IBS directly connected to the ICDB AC Hub.

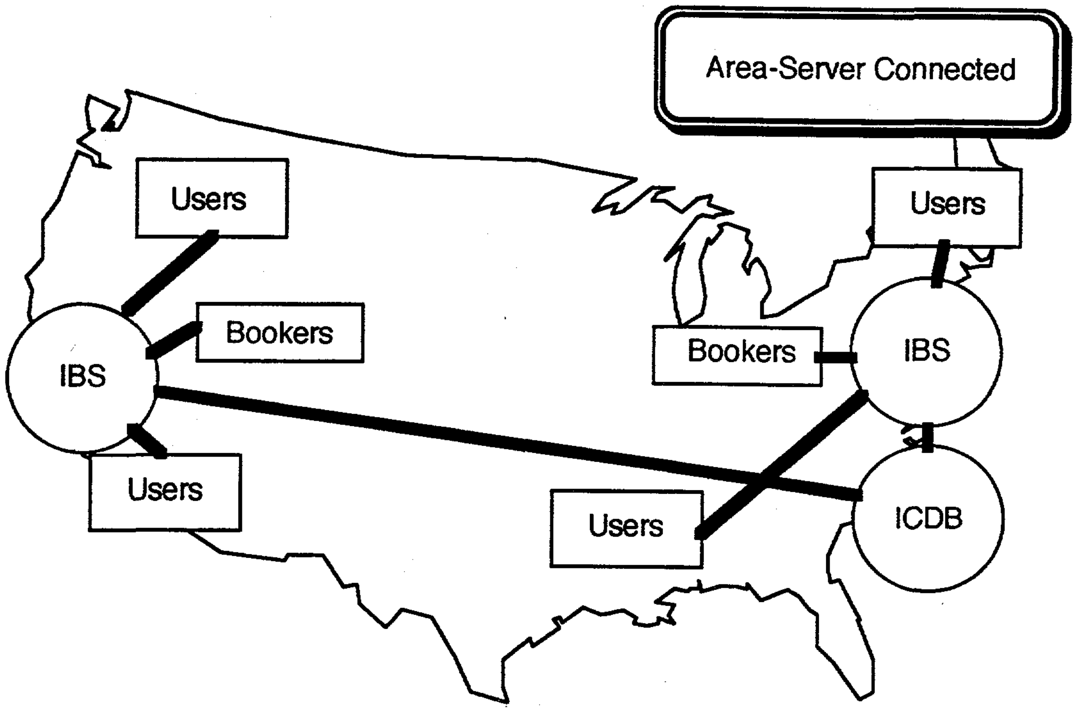

Figure 3.6. Geographic layout of the area-based configuration with IBS directly connected to the ICDB server.

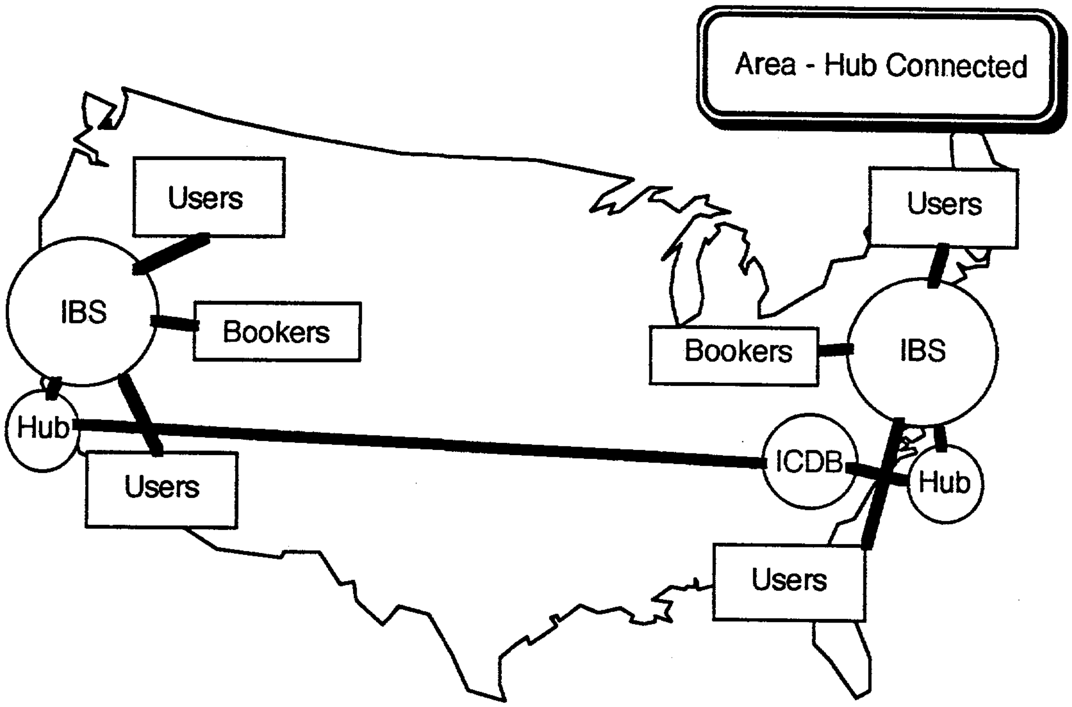

Figure 3.7. Geographic layout of the area-based configuration with IBS directly connected to the ICDB AC Hubs.

3.3.2 Data Model

The IBS database for each AC would reside on the Area IBS server. Two options exist for ensuring that a booking record could be reconstituted in case of a failure: first, all data for both ACs could be contained on both Area IBS servers, which implies a considerable communications overhead. If all data for both ACs are contained in both IBS Area servers, code would need to be written for keeping the databases synchronized, and additional communications lines would be required to directly connect the IBS Area servers. Second, the data for each AC could reside in its own IBS Area server and the booking data for both ACs could be duplicated on the ICDB server, from which it could be accessed if needed in order to provide cross-booking and/or reoffer capabilities. This second option follows the recommended data/database concept.

3.3.3 Costs

The split architecture requires two separate systems that are smaller than the single-server system. A hardware configuration for this architecture is also available on the Super-Minicomputer Program Contract. Table 3.2 summarizes the cost of a suitable hardware platform for this configuration. This table summarizes hardware costs only and does not include communication costs (e.g., additional lines and communication servers).

Table 3.2. Cost of the area-based configuration

Quantity	Description	Vendor & model	Price
2	75-user super minicomputer	HP-9000/877	$129,734
4	3 KVA UPS	Clary Onguard	15,144
Total			$144,878

Source: PRC, Super-Minicomputer Contract.

3.3.4 Summary

The following list summarizes both the architectural and the data model primary advantages and disadvantages for this design option.

Advantages

- Eliminates single point of failure. Some booking capability would always be available at other sites.
- Could network into the ICDB Hubs which would save considerable communications costs.

Disadvantages

- The requestor would need to know in which AC his request should be initiated prior to offering it for booking.
- This configuration requires a new hardware component (in addition to that currently in existence for the ICDB Area Hub configuration). Thus new connectivity would be required, implying new transfer programs as well as new communications devices.

3.4 THE FULLY-INTEGRATED IBS

3.4.1 System Description

In this design, IBS is integrated into the ICDB system completely (Figures 3.8-3.10). All IBS resources reside on existing ICDB equipment. Some independent IBS tables are kept in the ICDB database at both the Hubs and the Central Server while other IBS data elements are integrated into existing ICDB tables at the Central Server. The current ICDB Central Server and Hubs are 256-user HP 9000/877 each with four HP 9000/730 attached compute servers. There are approximately 50 to 150 ICDB users at each Hub generating throughput for up to 300 users at the Central Server. This means that there is a reserve capacity at the Hubs worth from 100 to 200 users. It is this reserve capacity that can be exploited by integrating IBS into the ICDB Hubs. Using the Hubs for IBS work will have little if any impact on the Central Server (which does NOT have reserve capacity) because, at the Central Server, IBS requires only storage resources, not computing resources. All IBS computing work is done at the Hubs.

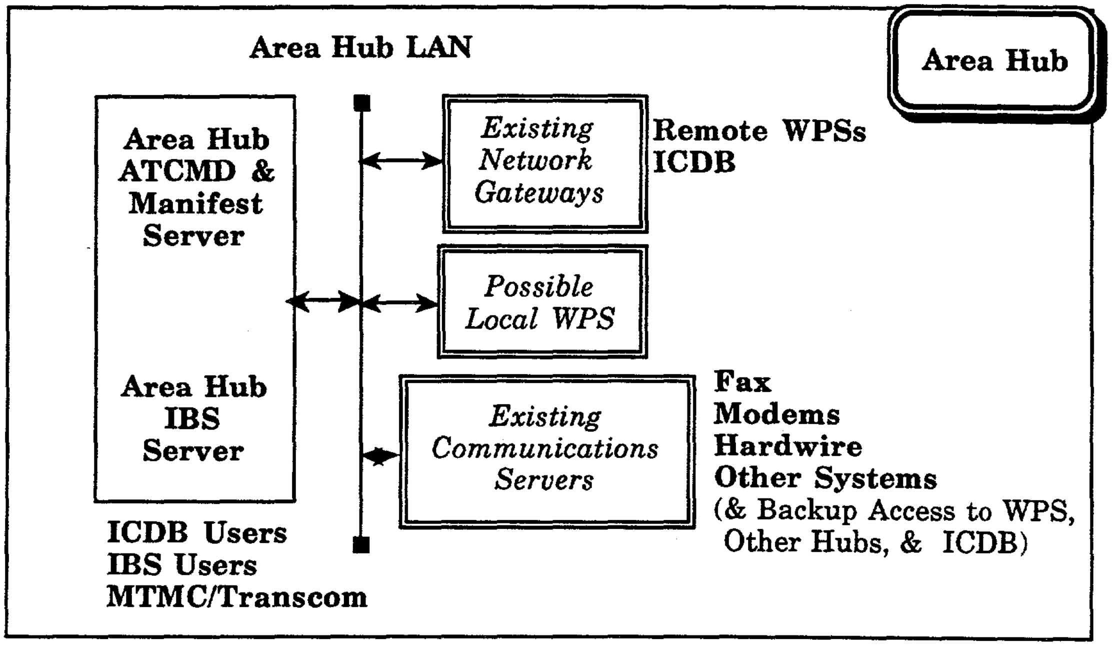

Figure 3.8. Configuration of the fully-integrated IBS system design at the AC Hub LAN.

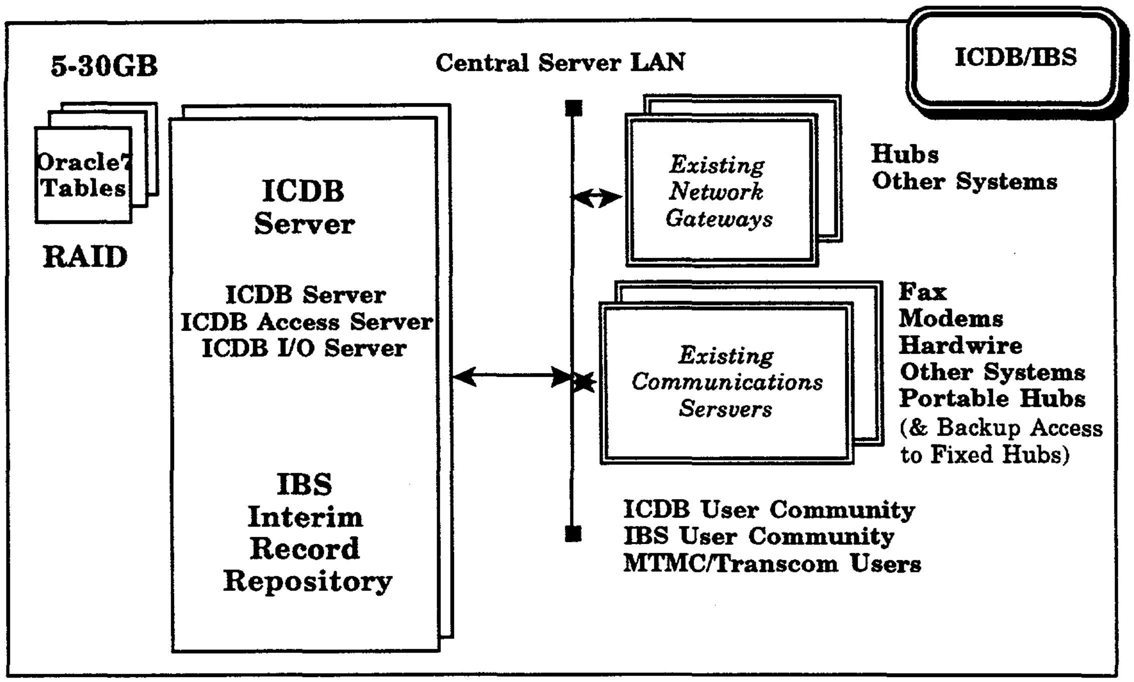

Figure 3.9. Configuration of the fully-integrated IBS system design at the Central Server LAN.

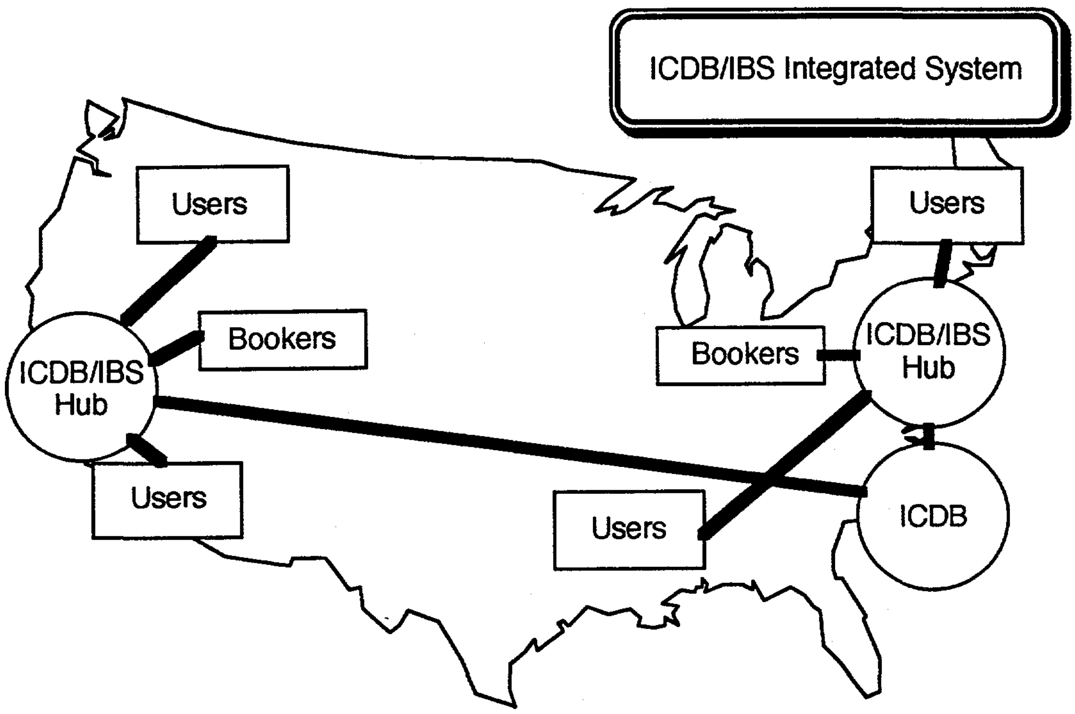

Figure 3.10. Geographic location of the fully-integrated IBS system design.

Another advantage of this design is its flexibility with respect to sizing. Because it would be built on existing architectural and communication capabilities and integrated within existing database capabilities, it would not require additional hardware purchases. Thus, it would be more manageable in case of downsizing. In addition, because it is built around the Hub-Central Server design, it has built-in potential for expandability for global booking operations with minimal additional hardware purchases.

3.4.2 Data Model

The recommended data model works best with this configuration. That is, the fully integrated architectural and communications infrastructure blends smoothly with the integrated data and database concept. Therefore, while a booking is in progress at the IBS/ICDB Hub, the booking data is incrementally built up in tables at the Hubs. With each incremental change in the IBS record at the IBS/ICDB Hub, a copy of the change is sent to a duplicate IBS record at the ICDB Central Server and, for nonunit cargo, to the ICDB shipment unit table. The Central Server maintains an up-to-date copy of every in-process booking record at every IBS/ICDB Hub. Once the booked cargo record is complete, the booking record is removed from the IBS/ICDB Hub database and is retained in the ICDB Central Server as an ICDB record.

3.4.3 Costs

There is no additional computing hardware costs for this IBS architecture. As discussed above, the entire functionality of IBS can be integrated into existing ICDB hardware and system software. But because some of IBS users are dial-up users, it may be necessary to add more modem servers to the Hubs. This addition is not expected to have an impact on performance; however, the potential for performance impacts has been examined and alternatives explored (see Section 3.4.5).

3.4.4 Summary

The following list summarizes both the architectural and the data model primary advantages and disadvantages for this design option.

Advantages

- Complete CONUS visibility of IBS data including current active booking records.
- No single point of failure. The ICDB Central Server can rebuild any partially completed IBS record at any IBS/ICDB supporting Hub.
- This has the least cost per incremental unit of any design. Because ICDB resources already in place are shared, any cost impact considerations are minimized.
- This has the least cost for operation and maintenance because of sharing resources.
- The system-wide fault tolerance and survivability of ICDB are inherited by IBS.
- The ability to communicate with other systems is inherited by IBS from current ICDB strategy.
- There is a built-in flexibility for downsizing or expansion.

Disadvantages

- Must share resources with ICDB. As noted above, this has been considered in the design.

3.4.5 Performance Contingencies

Although ORNL does not believe that performance of ICDB would be adversely affected by the addition of IBS processing to the current architectural and communication infrastructure, there is always the possibility that actual usage may be greater than the estimated usage metrics for IBS. If this unexpected situation does occur, system performance for ICDB might show some degradation, and it would be necessary to increase the capabilities of the ICDB/IBS components for each type of performance failure to bring the system back in line with the requirements and expectations. The following examines several of the possible performance failures and their corrective remedies:

Poor Hub/Server Response Time Caused By Too Many Simultaneous Users or Processes

This condition is most often due to limited memory. When there is not enough memory for the number of users or processes, many of the applications are temporarily swapped out onto disk while the user contemplates the next keystrokes or a process waits for a response. When the user is ready to continue the application or a process response is received, another user's application or process must be swapped out and this user's application or process swapped back in. This constant swapping degrades response time by magnitudes. The remedy is to increase memory on the affected HP machines. Each 64 MB increase in memory costs $4210 and improves response time for 4 additional users or processes.

This condition will be most noticeable during the 5 minute checks of WPS sites. It will not be a problem until WPS comes on-line but after that time, there will be many WPS processes running for about 1 to 2 minutes. At that time, it may be possible to notice some momentary degradation in response. When the WPS processes finish, most of the resources will then be available to the users. Adding more memory can minimize this impact. An HP 877 can have up to 384 MB of memory.

Poor Hub Response Time Caused By Too Many Compute Intensive Processes

With the possible addition of IBS to the ICDB Hubs, there is the risk that the decision-support processes that support bookers using IBS can tie up sufficient computing resources to show a degraded response to these and all other resources. This is caused by the lack of Central Processing Units (CPUs) to process the CPU intensive decision-support applications of IBS. The remedy is to add more HP 730s to the affected HP 877s. Each additional HP 730 compute server costs $17,480 and improves response time for two additional compute intensive processes.

Each HP 730 compute server is tied to the HP 877 by an Ethernet segment. There should be no more than four compute servers on any one compute server segment. New Ethernet controllers can be added to the HP 877 at a cost of $700 and will provide access to four more compute servers. An HP 877 can have up to ten Ethernet controllers.

Poor Hub/Server Response Time Caused By Network Packet Collisions

In the event that many users are accessing the system via the Internet while the system is trying to communicate with its other components via the Internet, the network itself can become so saturated that its own traffic starts backing up and showing response degradation. The remedy for this situation involves providing more routes between the HP 877 and the network interfaces. Adding additional Ethernet controllers to the HP 877s at $700 each will provide additional routes and lessen the chance for network bottlenecks. An HP 877 can have up to ten Ethernet ports.

Poor Server Response Time Caused By Disk Thrashing

When many processes are reading or writing information from the same disk controller -- or worse, the same disk drive -- the disk access times and controller throughputs begin to slow the data throughput of the processes doing the disk input/output (I/O). An over-accessed disk drive will constantly make the sound of head motion and sound like it is out of control. This situation where a disk cannot ever resolve all of its I/O requests is called "thrashing." The remedy is to add more disk controllers and divide the disks among the controllers. An HP 877 can have up to ten SCSI disk controllers each of which can control up to six drives of any size.

Poor Server Response Time Caused By 100% CPU Utilization

Under the worst possible circumstances of sizing, it is possible that the HP 877 could become so saturated that response time is a victim of 100% CPU utilization. This means that the CPU of the system is working on some process 100% of the time and any more processes must wait to have their turn. The only remedy for this condition is to replace the HP 877 CPU with an HP 897 CPU. HP offers this upgrade as a standard line item kit. This item is not on the Super Mini Computer Program contract at this time and would have to be purchased by another method.

This section has explored some of the most likely possibilities for response degradation and their remedies. Due to the design emphasis on future growth of the system, many of these possibilities were considered in the original design of ICDB/IBS and are deemed unlikely to occur. But in the event that they do occur, remedies for each possible performance problem are known and could be obtained.

4. RECOMMENDATIONS

ORNL recommends the fully-integrated IBS in which IBS runs on ICDB equipment. In this design option, each Hub IBS contains all of the user interfacing programs, the decision support programs, and the incomplete or "in-process" booking records. A duplicate of every "in-process" IBS record is maintained at the ICDB Central Server. A booking record remains on the Hub IBS until the booking is complete. At that point, the booking record is deleted from the Hub tables and exists only on the ICDB Central Server database.

The ICDB Central Server database contains a duplicate copy of each IBS booking record being built at any of the Hub IBS facilities. It also contains maintenance copies of all the rate and code tables for each area Hub IBS. This allows the ICDB Central Server to rebuild any booking record at any Hub IBS facility thus assuring continuous operation of all booking operations from any Hub IBS. IBS will exhibit the system-wide failsafe capabilities of ICDB.

As noted in Section 3.4.1, the ICDB system hardware is currently configured and implemented with enough capacity and available resources to handle the performance and storage requirements of IBS. By running IBS on ICDB, IBS will inherit all the advantages of ICDB. In addition, the close coupling of IBS and ICDB ensures the following enhancements:

- The data interface between IBS and ICDB is practically eliminated. Data pass transparently between the two systems.
- The total CONUS view of surface shipping is enhanced because data for planned shipments (e.g., requested, offered, booked) are now combined with data about actual cargo movements (e.g., received, lifted, discharged).

Specific functional, operational, and performance requirements for IBS are provided in the Updated and Revalidated IBS FD. Although this System Design and Integration Analysis focussed primarily on database and architectural design issues, it should be noted that the ten broad requirements discussed in Sections 2.1-2.10 can all be met with the recommended system design.

In conclusion, the data integration concept described in Section 3.1.3 and the architectural design described in Section 3.4 are recommended by ORNL as the total system and integration design for IBS. ORNL feels that the highest benefits at the lowest costs will be derived from this fully-integrated IBS architecture.

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