Meridian 1

Capacity Engineering

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Standard, release 1.00. This is the first issue of this document. It replaces 553-2201-151 Appendix 1.

Contents

Introduction

Content list

The following are the topics in this section:

Purpose

This document is a global document. Contact your system supplier or your Nortel Networks representative to verify that the hardware and software described is supported in your area.

This document is intended to provide the information necessary to properly engineer a Meridian 1 switch. A switch must be engineered upon initial installation, during upgrades, and when traffic loads change significantly, or increase beyond the bounds anticipated when the switch was last engineered. A properly engineered switch is one in which all components work within their capacity limits during the busy hour.

The engineering of functionality of major features such as Automatic Call Distribution (ACD) or Network Automatic Call Distribution (NACD), and of auxiliary processors and their applications, such as Meridian Mail and Meridian Link Module, is not the topic of this document. Guidelines for feature and auxiliary platform engineering are given in documents relating to the specific applications involved. Sufficient information is given in this document to determine and account for the impact of such features and applications upon the capacities of the Meridian 1 itself.

This document is not intended to provide a theoretical background for engineering principles, except to the extent required to make sense of the organization of the information. Furthermore, technical details and data are sometimes omitted, when the impact is sufficiently small. This helps to control the complexity of the presentation.

Scope

All Meridian 1 systems currently supported are covered by this document: and Options 11C, 51C, 61C, and 81C.

The impact of the Nortel Networks proprietary auxiliary processors on the Meridian 1 is included in this document. For engineering of the auxiliary processors themselves, please refer to the documentation specific to that product.

The capacity impact of specific third party products that interface with the Meridian 1 is not addressed. However, certain generic factors are described which may be used to assess the impact of such products, so that their effect may be included in the engineering process.

Audience

The primary audience for this document are the system engineers responsible for engineering the switch, and the Nortel Networks Technical Assistance Support personnel who support them. The engineer may be an employee of the end user customer, a third party consultant, or a distributor.

It is expected that the engineer attempting this process will have several years of experience with Meridian 1 systems.

Other persons who may be interested in this information, or find it useful, are Sales and Marketing, Service Managers, Account Managers, Field Support, Product Management, and Development.

How to use this document

There are two major purposes for using this document: to engineer an entirely new system, and to evaluate a system upgrade. The procedures for these activities are described in this document.

The Meridian Configurator System provides an alternative to the manual process given in this document. It is beyond the scope of this document to describe the Meridian Configurator process.

Engineering a new system

Figure 1 illustrates a typical process for installing a new system. The function expected to perform each step of the process is listed to the right of the block. The highlighted block is the subject of this document. It is expanded on in Figure 2.

Figure 1
Engineering a new system

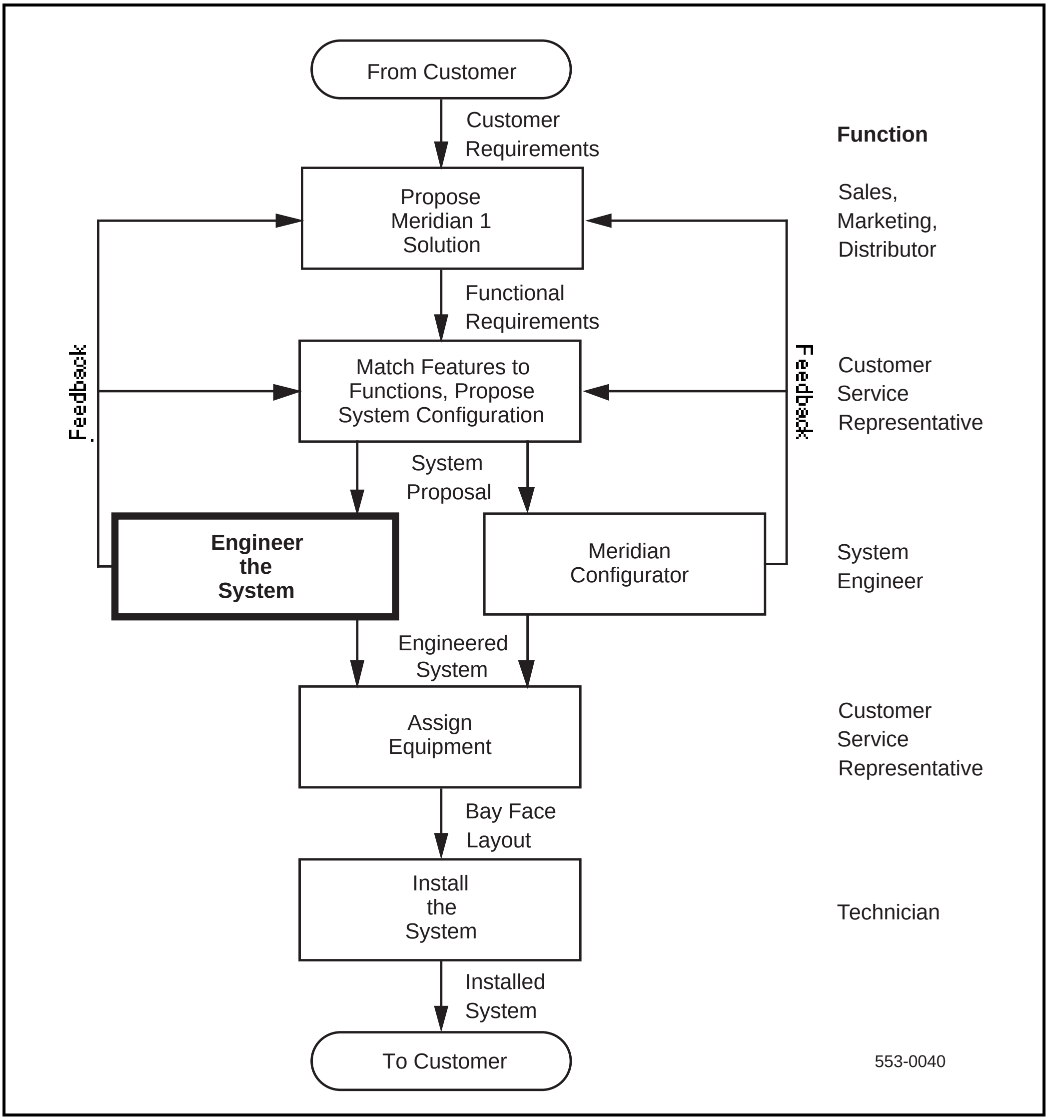
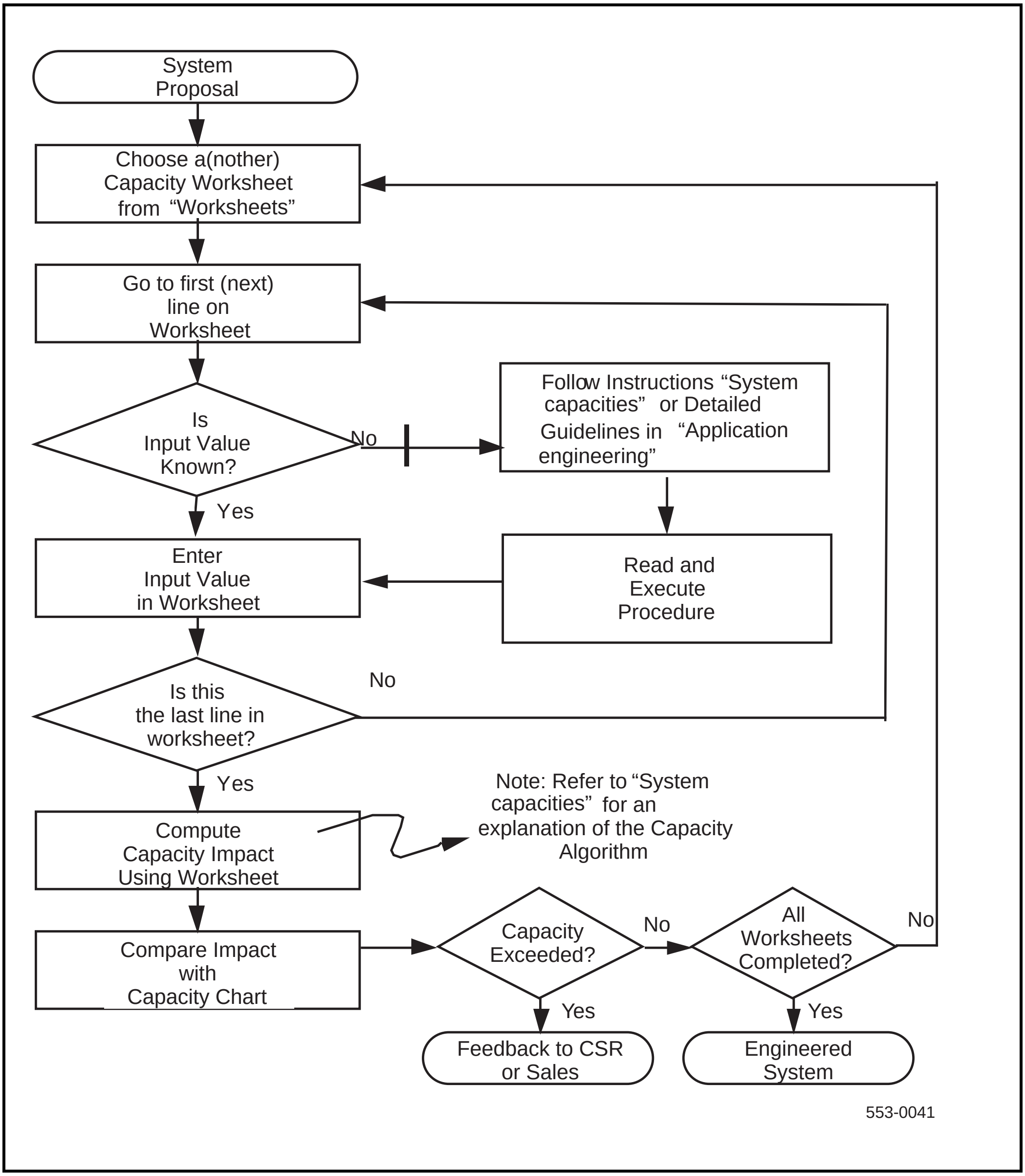


Figure 2
Engineer the system



Engineering a system upgrade

In cases of major upgrades, or if current resource usage levels are not known, it is recommended that the complete engineering process be followed, as described in the previous section.

If minor changes are being made, the incremental capacity impacts can be calculated and added to the current resource usage levels. The resulting values can then be compared to the capacity chart to determine whether the corresponding capacity has been exceeded.

Other resources

This section contains a short description of tools available to assist the site engineer, sales person, and/or customer in engineering the switch. Differences between the tools, their platforms and implementation and usage are described.

Meridian Configurator

The Meridian Configurator allows users to prepare quotations for a new Meridian 1 system. Meridian Configurator supports system sales by analyzing input specifications for a digital PBX to produce a full range of pricing, engineering reports, and graphics. These reports include a complete equipment list, part numbers, software listing, engineering capacities, and pricing for currently available Meridian 1 configurations.

Meridian Configurator runs on the user's own DOS/Windows-based personal computer. Specific system requirements depend on the version of Meridian Configurator. For details, contact the Nortel Networks account team or Nortel Networks DSM.

Meridian Configurator implements the algorithms specified in this document for real time, memory, and physical capacities. It is the official tool for determining whether a proposed configuration will meet the customer's capacity requirements.

Where applicable, in this document, references are made to the Meridian Configurator inputs which correspond to parameters being described.

1-Up

The Meridian 1 Upgrade Configuration Tool (1-Up) provides an efficient means to engineer Meridian 1 upgrades. It incorporates the engineering rules and pricing data required to upgrade an existing system to the latest hardware/software platform. It also includes the Autoquote algorithms used for new systems to permit port expansion and application add-ons as part of the upgrade proposal.

1-Up is a Windows™ PC application.

System architecture

Content list

The following are the topics in this section:

Reference list

The following are the references in this section:

- *Basic Telecom Management Guide*

This section gives a high level description of Meridian 1 architecture, emphasizing those components of the system which have capacity limitations or impacts. After reading this section, the reader should have a general understanding of the role which each major component of the system plays in handling calls and other switch functions.

A Meridian 1 is a digital system which provides switching of voice and data calls. The “circuit-switching” method is used, which means that a circuit is established for each call, and dedicated to that call for its duration. It is called a “digital” switch because, in general, the messages which are used to establish and tear down circuits are digital packets, rather than analog signals. It is a digital system because it uses a computer, or “central processor,” to control its functions.

The hardware of the Meridian 1 is divided into the following functional areas (see Figure 3):

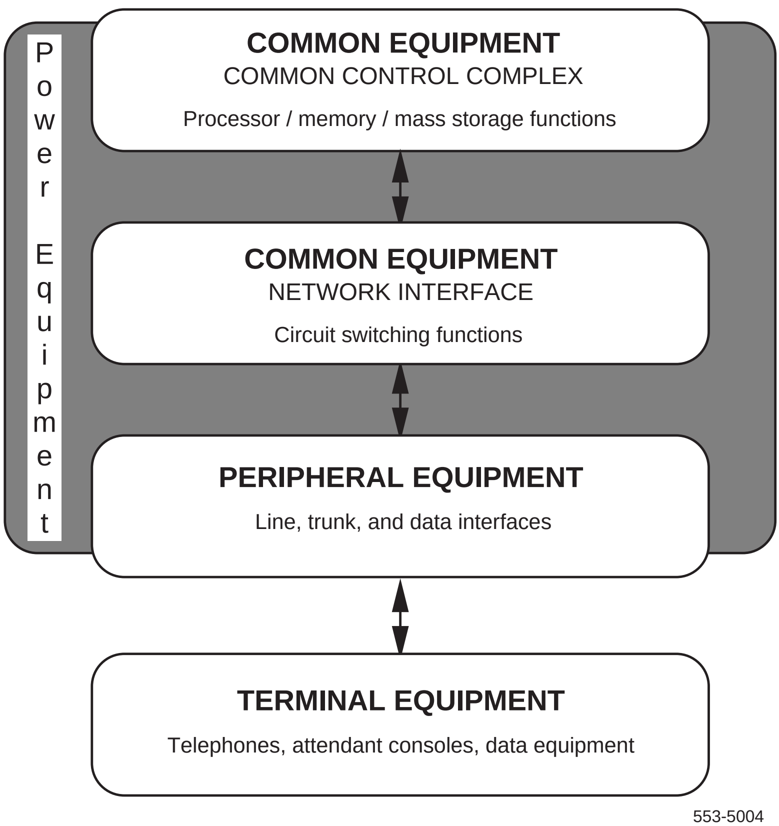
- Common equipment circuit cards provide the processor control, software execution, and memory functions of the system.
- Network interface circuit cards perform switching functions between the processor and peripheral equipment cards.

  Note: As shown in Figure 3, the network interface function is generally considered a subset of the common equipment functions.

- Peripheral equipment circuit cards provide the interface between the network and connected devices, including terminal equipment and trunks.
- Terminal equipment includes telephones and attendant consoles (and may include equipment such as data terminals, printers, and modems).

- Power equipment provides the electrical voltages required for system operation, and cooling and sensor equipment for system protection.
- Auxiliary equipment includes separate computing platforms that provide additional functionality which interfaces with and sometimes controls the activities of the switch's main processor.

Figure 3
Meridian 1 basic architecture



Common equipment

The central processor is the common control complex of the system. It executes the sequences which process voice and data connections, monitor call activity, and perform system administration and maintenance.

The processor communicates with the network interface over a common control bus that carries the flow of information.

The common control complex consists of:

- the processor card or cards that provide the computing power for system operation
- system memory that stores all operating software programs and data unique to each system
- the disk drive unit that provides mass storage for operating programs and data
- I/O interfaces that provide an information exchange between the user and the system

Core Processor (CP)

At system power-up, prestored instructions are executed by the CP to begin the process of loading programs from the system's mass storage device into memory. The program's first activity is to read in the site's configuration database from mass storage. Once the system loading and initialization process is complete, the program enters its normal operational state.

During normal operation, the CP performs control and switching sequences required for call processing, system administration and maintenance, and processes input/output messages which provide interfaces to auxiliary processors and the system administrator. Each of these activities is controlled by a preprogrammed sequence of instructions. The CP is capable of executing a limited number of these instructions in a given time period. This number depends on the processing power of the CP.

Some system options provide redundant CP and memory components. The active CP writes status changes to both memories and each CP can read from either memory. If the active CP fails, the backup CP is activated. If the active memory fails, the same CP continues to operate, but operates using the backup memory.

System memory

System memory contains all software programs and data required by the main processor. Four types of solid-state memory are used: Flash Electronically Programmable Read-Only Memory (Flash EPROM), Read-Only Memory (ROM), and Dynamic Random-Access Memory (DRAM).

ROM is permanently programmed memory (firmware) housed on a CP daughterboard. This memory stores basic instruction interpreters, firmware procedures for operating system functions such as arithmetic and memory access, and the bootstrap procedures necessary to initialize the system and bring it into a working state. ROM also stores the recovery, or trap, sequence which is automatically activated at power-up, system reload, or when certain faults are detected.

Flash EPROM is used to store code (i.e. bootstrap code, OS, call processing code and any other application code on the CP3, CP4 options).

DRAM is dynamic writable memory contained in chips which may be located on a separate memory board, or, for some systems, on the CP board itself. It is volatile, that is, its contents are lost when power is disconnected. Therefore, its contents must be restored from nonvolatile memory (mass storage) whenever power is lost, the system is reloaded, or certain faults occur.

On the CPV5350 (CP PII), DRAM is divided into five functional areas:

- Unprotected data store (UDATA) holds constantly changing, unprotected data (such as call registers, call connection, and traffic data) required during call processing.
- Protected data store (PDATA or office data) holds protected customer-specific information (such as trunk configuration and speed call data).
- Program store holds call processing programs, input/output procedures, programmed features and options (such as conference and call transfer), and diagnostic and maintenance programs.

- OS Heap is an area from which features can allocate memory during run time by means of VxWorks memory allocation function calls. Features introduced in Release 22 and later which are relatively self-contained and have taken advantage of the VxWorks C/C++ development environment are the heap users and include QSIG, mobility, message-based buffering, Taurus, MMIH, SMP. On the CP PII systems, the patch storage area is included in the OS heap area. On the CP1 systems, it occupies a separate fixed area.
- Miscellaneous fixed OS requirements.

On the NT5D10, NT5D03 CP (3,4) cards, and Option 11C, DRAM is divided into the following functional areas:

- Unprotected data store (UDATA) holds constantly changing, unprotected data (such as call registers, call connection, and traffic data) required during call processing.
- Protected data store (PDATA or office data) holds protected customer-specific information (such as trunk configuration and speed call data).
- Dynamic OS Heap space for OS and for certain Meridian 1features (MAT, Mobility, MMIH, QSIG, PRI) to allocate as needed during run time.
- SL-1 patching area
- Miscellaneous fixed OS requirements.

Program store holds call processing programs, input/output procedures, programmed features and options (such as conference and call transfer), and diagnostic and maintenance programs.

Memory and storage: Option 11C

PCMCIA drive cards are used for software delivery, patch delivery, and external data storage for optional feature data. (e.g., the Mobility feature is one feature that makes provisions for using this space).

ROM is provided on CP daughterboards. The initial daughterboard provides 24MB of flash for program store and 8MB for the "disk emulator" memory which is used for SL-1 Pdata, PSDL, patches, package and network data, and SL-1 logging. At present there is only this one daughterboard. If more ROM is needed, an additional daughterboard may be added.

Mass storage

SL-1 Customer Data Storage: Mass storage devices (floppy disks and fixed head rotating disks) are used to permanently store "SL-1 customer database" information required by the Meridian 1 main processor and peripherals. The floppy disk medium to save site-specific data periodically as it is updated. On some systems a hard disk is used as a back up for floppies, and as a time saving mechanism.

System Software Delivery: X11 system software is delivered to a customer on a CD-ROM disk.

Floppy Use on a Live System: At system power-up or during a system reload, protected SL-1 customer data, program store information, and peripheral device software are automatically transferred from the disk drive unit to the system memory or peripheral devices. During regular operation, the CP accesses information from the memory.

If information in protected data store is changed (such as a change in a telephone configuration), the information on the disk drive unit must be updated. Transferring data from the system memory to the disk drive unit is called a data dump. Data dumps can occur automatically or manually (through software program commands).

The NT5D61 Input/Output Disk Unit with CD-ROM (IODU/C) is used on Meridian 1 systems:

- Options 51C, 61C, 81C
- one 3.5-inch floppy disk drive with a formatted capacity of 1.44 MB
- one 3.5-inch hard disk
- one CD-ROM drive (the NT5D61BA vintage does not have a CD-ROM drive)

  Note: On the Option 81C, two IODU/C, one in each core module, are used in a redundant arrangement.

Input/output interfaces

Input/output (I/O) ports provide an interface between the system and external devices, such as terminals and teletypewriters, and application module link (AML) applications, including Meridian Mail and Meridian Link. The I/O devices may be located at local or remote sites.

With the NT6D80 Multi-purpose Serial Data Link (MSDL) Cards, a maximum of 64 I/O ports is supported (there are four ports per card; up to 16 cards can be configured). However, the maximum number of AML ports supported remains at 16.

Several types of I/O ports are available, each with its own unique protocol and bandwidth characteristics. The bandwidth of an I/O port may constrain the amount of information which can be exchanged over that link.

Network equipment

The network is a collection of paths over which voice and data information can be transmitted. The Meridian 1 network is digital, meaning that the voice and data information is encoded in digital form for transmission. These digital signals are multiplexed together on a physical entity called a “loop.” Each path or “channel” on a loop is identified by its “time slot,” which signifies the order in which the data is placed on the loop during the multiplexing operation.

Loops transmit voice, data, and signaling information over bidirectional paths between the network and peripheral ports (that is, two channels are allocated for each conversation, one in each direction). The network is designed so that any terminal can be connected, through proper assignment of time slots, to any other (functionally compatible) terminal on the system. The technology used is called space switching and time division multiplexing.

The use of transmission channels in the switch is known as “traffic.” Traffic is generated by terminals (sets and trunks). Each loop or superloop has a capacity for traffic which is a function of the number of time slots available, and the blocking level which the user is willing to accept. Blocking is the probability that a caller will not be able to complete a call because there is no time slot available at the particular time it is needed. The higher the traffic, the higher the blocking. A typical acceptable level of network blocking is P.01, which means 1% of all calls (1 in 100) will be blocked, on the average.

Network cards

Network cards are the physical devices which digitally transmit voice and data signals. Network switching also requires service loops (such as conference and Tone and Digit Switch [TDS] loops) which provide call progress tones and outpulsing.

Two types of cards provide network switching control:

- The NT8D04 Superloop Network Card provides four loops grouped together in an entity called a superloop.
- The QPC414 Network Card provides two loops.

Network organization

On most Meridian 1 system options, network loops are organized into groups. A system is generally configured as one of the following:

- a half-group system that provides up to 16 loops
- a full-group system that provides up to 32 loops
- a multiple-group system that provides up to 160 loops
- a multiple-group system with the Network Capacity Expansion (“NCE”) feature, provides up to 256 loops

NCE offers an improved architecture in which intergroup traffic is carried on a fiber-optic SONET ring with enough capacity to prevent blocking.

Peripheral equipment

Peripheral equipment refers to the hardware devices that connect ports (lines and trunks) to the network (loops). Since most ports have analog voice channels, and the network is digital, peripheral equipment cards must convert the signals received from ports from analog to digital.

A process called pulse code modulation (PCM), is used to convert analog signals to digital signals before switching is performed by the network. This conversion method samples the amplitude of the analog signal at a rate of twice the highest signal frequency, then converts the amplitude into a series of coded pulses. For telecommunications, the PCM-sampling frequency standard is 8 kHz.

Compressing-expanding (companding) PCM is a standard technique for using 8-bit words to efficiently represent the range of voice and data signals. Two standards for companding, A-Law and μ-Law, are recognized worldwide. Meridian 1 intelligent peripheral equipment conforms to both standards; the standard required is selected through software.

Intelligent peripheral equipment (IPE) cards are supported by NT8D04 Superloop Network Card loops.

IPE cards are housed in the NT8D37 IPE Module.

Intelligent peripheral equipment includes:

- controller cards that provide timing and control sequences and monitoring capabilities
- analog and digital line and trunk cards that provide interfaces to equipment outside the modules (such as telephones, data terminals, and trunks)

Table 1 lists the IPE cards and the number of terminations each supports.

Each equipment card contributes traffic to the network. The traffic required by a peripheral equipment card is the sum of the traffic generated by the ports (sets or trunks) serviced by the card. The traffic requirements of all peripheral equipment cards provisioned on a particular network loop must match the traffic capacity of that loop.

Table 1
Intelligent peripheral equipment

Intelligent peripheral equipment cards	Number of terminations
Controller cards:	
NT8D01 Controller card-4	N/A
NT8D01 Controller card-2	N/A
Line cards:	
NT8D02 Digital Line card	16 to 32
NT8D09 Analog Message Waiting Line card	16
Trunk cards:	
NT8D14 Universal Trunk card	8
NT8D15 E&M Trunk card	4

Note 1: Terminal number (TN) density per segment is 16 to 128 TNs, with 64 to 512 TNs per IPE Module. The maximum TN density assumes all slots are equipped with NT8D02 Digital Line Cards with 16 voice and 16 data TNs provisioned. A typical mix of line and trunk cards yields a nominal density of 64 TNs per segment, 256 TNs per IPE Module.

Remote Peripheral Equipment

In addition to supporting peripheral equipment cards collocated with the common equipment, Meridian 1 systems may be configured to support Remote Peripheral Equipment (RPE). Depending on the type of transmission media required between the host site (Meridian 1 system) and the remote site and the type of peripheral equipment cards selected, the following RPE products are supported:

- Remote Peripheral Equipment
- Carrier Remote IPE
- Fiber Remote IPE
- Fiber Remote Multi-IPE

Each of these remote products allow the peripheral cards to be located remotely from the host system. In the case of Remote Peripheral Equipment (RPE) and Carrier Remote IPE, these products allow the system network interface to be converted and transported across commonly used T1 or E1 digital facilities including digital microwave radio. The Fiber Remote IPE and Fiber Remote Multi-IPE products provide the same network conversion requirements, but transported use fiber facilities instead of T1 or E1. All of these products offer the remote users the same level of feature functionality provided to the local users. Essentially, these remote products allow the remote peripherals to function as if they were collocated with the local peripheral equipment.

For more information on Remote Peripheral Equipment (RPE), refer to *Remote Peripheral Equipment: Description, Installation, and Testing* (553-2601-200); Carrier Remote IPE , refer to *Carrier Remote IPE: Description, Installation, and Maintenance* (553-3001-021); Fiber Remote IPE, refer to *Fibre Remote IPE: Description, Installation, and Maintenance* (553-3001-020); Fiber Remote Multi-IPE, refer to *Fiber Remote Multi-IPE Interface: Description, Installation, and Maintenance* (553-3001-022).

Terminal equipment

Meridian 1 supports a wide range of telephones, including multiple-line and single-line telephones, as well as digital telephones with key and display functions and data transmission capabilities. A range of options for attendant call processing and message center applications is also available. In addition, a number of add-on devices are available to extend and enhance the features of telephones and consoles. Add-on devices include key/lamp modules, lamp field arrays, handsets, and handsfree units.

Digital telephones

In digital telephones, analog-to-digital conversion takes place in the set itself, rather than in the associated peripheral line card. This eliminates attenuation, distortion, and noise generated over telephone lines. Signaling and control functions are also handled digitally. Time compression multiplexing (TCM) is used to integrate the voice, data, and signaling information over a single pair of telephone wires.

For applications where data communications are required, Meridian 1 digital telephones offer an integrated data option that provides simultaneous voice and data communications over single pair wiring to a port on a digital line card.

Meridian 1 supports the following digital telephones:

- The M2006 single-line telephone.
- The M2008/M2008HF standard business telephone.
- The M2216 Automatic Call Distribution (ACD) telephone.
- The M2317 intelligent telephone.
- The M2616 performance-plus telephone.
- The M3110 telephone.
- The M3310 telephone.
- The M3820 telephone.
- The M3900 telephone.
- The M3901 telephone.
- The M3902 telephone.

- The M3903 telephone
- The M3904 telephone.
- The M8000 telephone.
- The M8009 telephone.
- The M8314 telephone.
- The M8417 telephone.

Refer to *Basic Telecom Management Guide* for digital telephone details.

Attendant consoles

Meridian 1 attendant consoles (M1250 and M2250) provide high volume call processing. Indicators and a 4 x 40 liquid crystal display provide information required for processing calls and personalizing call answering. Loop keys and Incoming Call Identification (ICI) keys allow the attendant to handle calls in sequence or to prioritize answering for specific trunk groups. An optional busy lamp field provides the attendant with user status.

Meridian attendant consoles support attendant message center options. The attendant console can be connected to an IBM® PC or IBM-compatible personal computers to provide electronic directory, dial-by-name, and text messaging functions. All call processing features can be accessed using the computer keyboard.

Power equipment

Meridian 1 provides a modular power distribution architecture.

Each column includes:

- a system monitor which provides:
  - — power, cooling, and general system monitoring capabilities
  - — error and status reporting down to the specific column and module
- circuit breaker protection
- a cooling system with forced air impellers which automatically adjusts velocity to meet the cooling requirements of the system
- backup capabilities

Each module includes:

- an individual power supply unit with shut-off (switch or breaker) protection
- a universal quick-connect power wiring harness which distributes input voltages and monitor signals to the power supply

All options are available in both AC-powered and DC-powered versions. The selection of an AC- or DC-powered system is determined primarily by reserve power requirements and existing power equipment at the installation site.

Although AC-powered and DC-powered systems have different internal power components, the internal architecture is virtually identical. AC- and DC-powered systems differ primarily in the external power components.

AC power

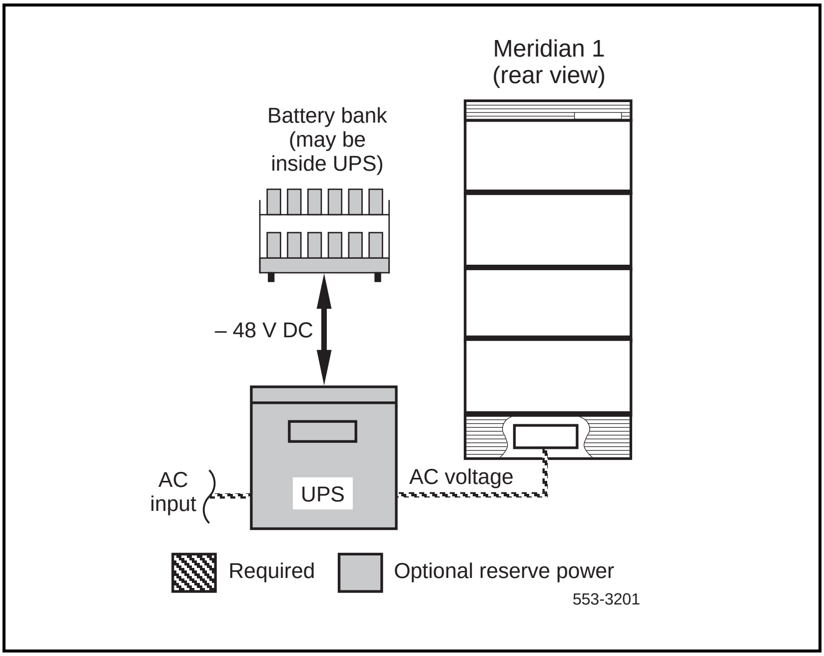
AC-powered systems require no external power components and can plug directly into commercial AC (utility) power. AC-powered systems are especially suitable for applications that do not require reserve power. They are also recommended for small to medium sized systems that require reserve power with backup times ranging from 15 minutes to 4 hours.

If reserve power is required with an AC-powered system, an uninterruptible power supply (UPS), along with its associated batteries (either internal or external to the unit), is installed in series with the AC power source (see Figure 4). AC-powered systems that do not require long-term backup can benefit from a UPS with short-term backup because the UPS typically provides power conditioning during normal operation, as well as reserve power during short outages or blowouts.

DC power

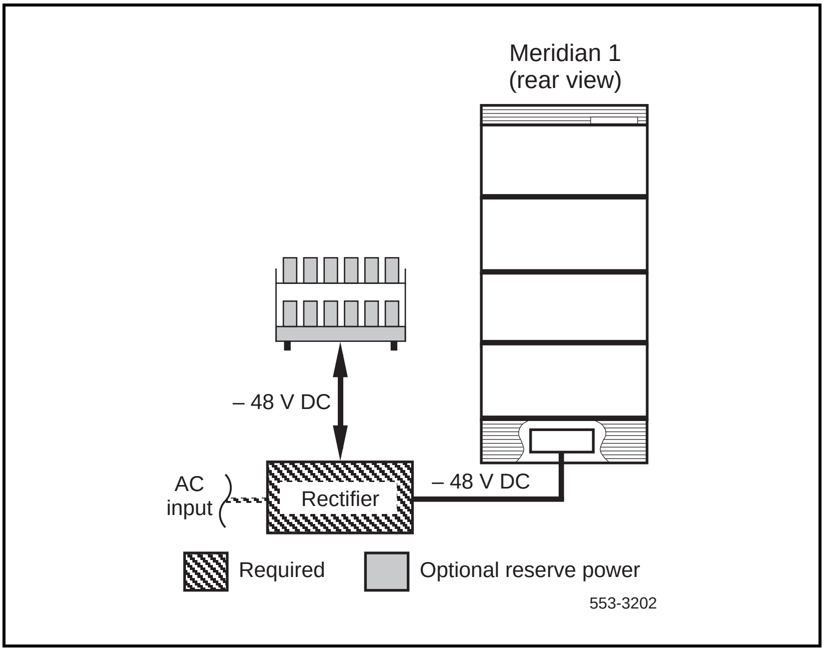
DC-powered systems are available as complete systems, with external power equipment provided by Nortel Networks; these systems can also be equipped for customer-provided external power.

Figure 4
External AC-power architecture with reserve power



DC-powered systems always require external rectifiers to convert commercial AC power into the standard –48V dc required within the system (see Figure 5). Batteries are generally used with DC-powered systems, as the traditional telecommunications powering method is for the rectifiers to continuously charge a bank of batteries, while the system power “floats” in parallel on the battery voltage. However, batteries are required only if reserve power is needed.

Figure 5
External DC-power architecture with reserve power



System capacities

Content list

The following are the topics in this section:

Reference list

The following are the references in this section:

- *Option 11C, General Information and Planning Handbook* (553-3021-200)
- *System Overview* (553-3001-100)
- *System Engineering* (553-3001-151)
- *Traffic Measurement: Formats and Output* (553-2001-450)
- *Option 11C Planning and Installation* (553-3021-210)
- *Meridian MAX Installation* (553-4001-111)

This section describes the six primary capacity categories of the Meridian 1 system: hardware, network traffic, signaling and data link, processor load, memory size, and mass storage size. For each category, the units in which the capacity is measured are identified. Primary physical and functional elements affecting the capacity are detailed, and actions which can be used to engineer the capacity are described. An algorithm is given by which capacity impacts can be computed.

The worksheets in "Worksheets" on page 191 implement the algorithms. In some cases applications such as call center require detailed engineering. These applications are discussed in "Application engineering" on page 105.

Hardware

The hardware resources considered in this section include physical capacity, power, and heat dissipation. Here, physical capacity is a broad term that is used to subsume three specific resources: loops, slots, and I/O devices. An overview of the physical configuration provides an explanation for the slot constraints.

Physical configuration overview

System types

Option 11C

The Option 11C is a small Meridian PBX, offering the advantage of simple installation, maintenance, and administration, while retaining the full features of a large system. Option 11C uses XPE hardware to maintain compatibility with other Meridian systems.

The main difference in architecture of Option 11C from larger Meridian systems is that it extends the CP bus to XPE slots, thus eliminating the network bus, and limiting the network capacity to 320 timeslots per box. This architecture eliminates one level of bit-to-byte and byte-to-bit conversion, and also eliminates a phase lock loop circuit to synchronize the DS-30 5 MHz timing to the Meridian 1 network bus 8 MHz timing.

The maximum sized Option 11C consists of three boxes, a base box, the box with daughterboard, and the expansion box. The maximized Option 11C has a main cabinet with two expansion cabinets.

The Option 11C uses a Motorola 68040 CP with VxWorks operating system. This affects the real time performance and the memory architecture. Its real time capacity is about 8 times that of the Option 11, but its physical capacity is still the same. (In actual practice it is greater for some configurations, now that real time is no longer a constraint.)

The memory architecture of the 11C is most like that of the Option 81C. Program and data are stored in physically separate memory components - flash EPROM and DRAM, respectively. DRAM is one 8 Mb SIMM in the single DRAM slot, which can be replaced with a 16Mb or 32Mb SIMM. EPROM is on a daughterboard which allows 24Mb program storage. This can be increased by adding a “babyboard” whose capacity can grow in 8Mb increments. Residing on the EPROM daughterboard is also the 8Mb of disk emulator ROM. The plan for increasing memory capacity on these systems has yet to be fully worked out.

For a detailed description of the hardware architecture of the Option 11C, see the overview *Option 11C, General Information and Planning Handbook* (553-3021-200).

Option 11C with Line Size Expansion

The 11C with Line Size Expansion increases the current three cabinets to a maximum of five cabinets, providing more room for growth for the small/medium user. The 11C can support an additional 20 IPE cards through additional fiber expansion cabinets through new dual port fiber expansion daughterboards, thereby increasing the line capacity of the 11C to 700 lines (from the previous 400 lines.)

In general, call processing feature operations remains unchanged from the existing 11C other than changes required to be compatible with the new daughterboards. The new dual port fiber daughterboard supports two conference devices, therefore increasing the maximum number of conference devices to six for a five cabinet 11C system (from four for a three cabinet 11C system). OA&M are modified to accept IPE card TNs in slots 31 to 50.

The dual port and single port daughterboards can co-exist on the same SSC card.

Option 81C with Fiber Network Fabric

With Fiber Network Fabric (FNF), an Option 81C is expanded to eight groups inter-connected by fiber optic rings. Due to the high capacity of OC-12 fiber fabric, non-blocking inter-group connection is achieved. Since network within a group can be engineered to non-blocking, with inter-group blocking removed, a truly non-blocking network can be engineered with the FNF network.

For a more detailed description of system types and modules, see *System Overview* (553-3001-100).

Physical capacity

Resource constraints

The physical constraints consist primarily of loop card slot limitations at the network shelf. From practical experience, running out of PE shelves is rare, particularly for Call Center applications.

Option 11C

The base box in Option 11C has 10 XPE slots with 9 available for general use. The expansion daughterboard provides 10 XPE slots, and the expansion box has 10 additional XPE slots. The number of available card slots is the limit of the physical capacity of an Option 11C.

For the purpose of card slot calculation, an agent supervisor set is treated like an agent set, however, its call intensity is reduced for real time calculations.

1 Agent Sets and Analog Trunks

When the system serves as a Call Center, it will most likely be equipped with more trunks than agent sets (lines). A practical trunk to agent ratio is within the range of 1.1 to1.5. The reason for having a higher number of trunks is that there are calls in the queue which engage trunk circuits but not ACD agents until they are served. In addition, in an NACD application, the overflowed calls continue to occupy trunks without the service of agents at the source node.

An XDLC card can accommodate 16 agent sets, and an XUT analog card can serve 8 trunks. These numbers of ports per card and ratio are used as the basis of calculations in this document. Any other cards used which different from these numbers will change the equations. Let L= the number of lines, agent sets and supervisor sets, T = the number of trunks. N_1 = the number of XPE slots for agent sets and analog trunks. Use the following equation to calculate the number of slots required:

Number of slots for agent sets with analog trunks = $N_1 = [L/16]^+ + [T/8]^+$.

$[]^+$ means use the next higher integer, or “round-up”. For example, $[4]^+=4$ and $[3.1]^+= 4$.

If $N_1 > 29$, the configuration requirement exceeds the capacity of an Option 11C.

2 Agent Sets and PRI trunks

This configuration requires that all PRI cards (NTAK09-1.5Mb) be equipped in the base cabinet from slot 1 through 9. Although Clock Controller (NTAK20) and D-channel (NTAK93) cards are needed for PRI applications, they are daughter boards used in conjunction with the PRI card and therefore, do not take up an XPE slot. We will ignore them for the purpose of calculating card slot requirements.

TDS/DTR functions are provided by the CP card, they do not require any XPE slot. There are a maximum of 29 slots available for a combination of PRI cards and XDLC cards for agents.The split of slots for trunks and agents should meet the objective of providing a balanced trunk/agent traffic. The following equation provides the calculation procedure for digital trunks:

Number of slots for agent sets with digital trunks = $N_2 = [L/16]^+ + [(T+2)/24]^+$.

If $N_2 > 29$, the configuration requirement exceeds the capacity of an Option 11C. When a back-up D-channel is not needed, the term (T+2) in the equation can be replaced by (T+1).

For an international version PRI, a card has 30 ports instead of 24. Since 30B+D is always required (no nB+D), the last term in the equation should read [T/30].

3 Slots for RAN, MUS, MMail and Applications

Ports in a trunk card can be configured to provide RAN or MUSic service. Except for very special applications, one XUT card is usually sufficient for this type of services. We will always assume that one XUT is adequate in the following procedure.

To provide ESDI ports for AML applications, such as CCR or HER, a SPORT card is needed. Use the following equation to calculate the number of slots required:

Number of slots for service ports = N_3 = 1 (for RAN/MUS) + 1 (for Meridian Mail) + 1 (for AML/CCR/HER)

Since there are 3 SDI ports on the COMBO card (two are used for TTYs), we assume that there is no need to add a DCH/SDI card (NTAK02) for additional SDI ports for (MAX or CDR).

4 Physical Limit

The following procedure can be used to calculate Nt, the total number of card slots required in the system:

$N_t = N_1 + N_3$, if agent sets and all analog trunks.

$N_t = N_2 + N_3$, if agent sets and all digital trunks.

When a system allows a mixed analog and digital trunks, the total number of slots can be calculated as follows:

$N_t = N_1 + N_2 + N_3$, if agent sets and mixed analog and digital trunks.

If the total number of card slots (N_t) is less than or equal to 9, one base cabinet is sufficient to meet the configuration requirement.

If $29 \geq N_t > 9$, the configuration can be met by Option 11C with a daughterboard and the expansion box.

If $N_t > 29$, the configuration requirement can not be met by an Option 11.

If $N_t > 49$, the configuration requirement can not be met by an Option 11 with line expansion.

Option 51C, 61C, 81C

Loop constraints

The maximum number of loops in a network group is 32, including service loops. For practical applications, the number of traffic loops is usually limited to 28, reserving two loops each for TDS and CONference.

1 Non-ACD (non-Automatic Call Distribution) sets and analog trunks

Non-ACD sets and trunks will be treated differently from ACD applications for estimating loop requirements. These circuits are equipped in the PE shelf, and do not use slots in the Network shelf, and, therefore, will not be included in the Network Module Card Slots Calculation.

If there is any doubt about potentially running out of PE slots for a given application (for example, Hotel/Motel environment), going over PE slots to check possible card slot limitations may be desired. Since this is a rare occurrence, a calculation procedure will not be developed for it.

For Call Center applications, due to high common channel signalling (CCS) on circuits (agents or trunks), there is no need to be concerned about physical slot constraints on the PE shelf since real time will be the limiting resource.

The following procedure should be usable for general and Call Center applications.

For EPE ENET loops:

Number of loops for non-ACD set and trunk traffic = N_{0e}=

$[(\text{No. of sets x } 6 + \text{No. of non-ACD trunks x } 26)/660]^{+}$

For IPE XNET loops:

Number of loops for non-ACD set and trunk traffic = N_{0x}=

[(No. of sets x 6 + No. of non-ACD trunks x 26)/875]$^{+}$
and $N_0 = N_{0e} + N_{0x}$

The above calculations account for blocking ENET and XNET loops.

$[\,]^{+}$ means use the next higher integer, or “round up.” For example, $[4]^{+} = 4$ and $[3.1]^{+} = 4$.

To simplify the notation in this document, the “+” at the upper right corner of the bracket will be omitted. Therefore, [x] will mean to round up x to the next higher integer.

The default value of 6 CCS per set and 26 CCS per trunk can be replaced by actual numbers for a particular site if they are given. Note that the default trunk traffic assumed for non-ACD application is lower than that of an ACD trunk (28 CCS). The 875 CCS per loop in IPE is derived from superloop capacity of 3500 CCS divided by 4 to obtain the average CCS per loop.

When Primary Rate Interface (PRI) trunks are involved in non-ACD applications, they should be treated just like ACD PRI trunks and included in the calculations for both loop and card slot requirements.

2 Agent sets and ACD analog trunks

When the system serves as a Call Center, it will most likely be equipped with more trunks than agent sets (lines). The reason for having a higher number of trunks is that there are calls in the queue which engage trunk circuits but not ACD agents until being served. In addition, in an NACD application, the overflowed calls continue to occupy trunks without the service of agents at the source node. However, this trunk-to-agent ratio may change if a service requires a long post-call processing time from an agent. In that case, CCS per agent should be reduced reflecting the actual agent service time which are associated with actual calls to the Meridian 1 CP.

Traffic at agent sets is conservatively assumed to be 33 CCS and 18.3 (= 33 x 100/180) calls per agent in the busy hour as a default in examples. For applications with long post-call processing time, the numbers 18 CCS and 10 calls per agent perhaps are appropriate default values.

Based on the standard Meridian 1 engineering rules, a loop can handle 660 CCS and a superloop can handle 3500 CCS. When an agent is loaded to 33 CCS, a loop can equip 20 agents (= 660/33) and a superloop 106 (= 3500/33); both numbers are less than their respective number of time slots (30 for loop, 120 for superloop). Thus, normal network engineering rules for Meridian 1 do not apply in a Call Center environment, because the “infinite traffic source” assumption in the Erlang model is violated.

The traffic model will be ignored here. Instead the rule of equipping 30 agents per loop and 120 agents per superloop for a nonblocking connection will be used. A superloop was created to take advantage of the traffic theory that a bigger server group is more efficient than a smaller one. This is no longer true in a nonblocking application, so any superloop can be replaced by four loops without capacity impact. If IPE is desired, divide the required number of loops by four to get the equivalent number of superloops (except for a DTI/PRI loop which has to be an EPE loop).

For loop requirement calculations, an agent supervisor set is treated like an agent set; however, its call intensity is reduced for real time calculations.

The following is the calculation procedure for loop requirements. Let the number of agent sets be L_1, the number of supervisor sets be L_2, the number of ACD analog trunks be T_a, and the number of Recorded Announcement (RAN) trunks be T_r:

Number of nonblocking loops for agent sets, supervisor sets and ACD analog trunks = $N_1 = [(L_1 + L_2 + T_a + T_r)/30]$

3 DTI/PRI trunks

At an average of 28 CCS per trunk, a loop of 660 CCS can equip 23 (=660/28) trunks. It is more practical to equip 24 trunks per PRI/DTI loop as a rule rather than doing traffic calculations. Let T_d be the number of DTI trunks and T_p be the number of PRI trunks.

The equations for trunk loop calculation are as follows:

Number of loops for DTI trunks, $N_{2d} = [T_d/24]$.

Number of loops for PRI trunks, $N_{2p} = [(T_p + 2)/24]$.

Number of loops for digital trunks, $N_2 = N_{2d} + N_{2p}$.

When a back-up D-channel is not needed, the term $(T_p + 2)$ in the equation for PRI trunks can be replaced by $(T_p + 1)$.

When the number of analog trunks is small (say, 15 or less), it may be included in the N_0 calculation to save loop and slot requirements.

Techniques for reducing the number of card slots required will be illustrated in engineering examples with small systems where physical slots are scarce.

For the international version of PRI, 24 ports should be replaced by 30 in the above calculations. The rest of the engineering procedure is the same.

4 Loops for Music (MUS) and Meridian Mail (MM) applications

Music in the Meridian 1 is provided by broadcasting a music source to a conference loop. Therefore, a maximum of 30 users can listen to music at one time, which is sufficient for most applications. If not, an additional conference loop must be provided for each additional 30 simultaneous music users.

Meridian Mail ports are interfaced with a loop to provide voice channels for messaging. Each set of 24 ports in the MM is interfaced with one loop. The conference loop connects to one half of the TDS/CON card. The second conference loop, if needed, will take another card and card slot, because it cannot be separated from the TDS loop.

The network to interface MM must be an ENET. The MM Module takes up a whole shelf, normally underneath the CE/PE or CP module. Therefore, it does not impact the available card slots in the Network Module (other than requiring an ENET loop for providing voice channels).

Calculation procedure:

N_{31} = [Music ports/30]

N_{32} = [MM ports for MM or MIVR or HEVP/24]

Number of loops for applications, $N_3 = N_{31} + N_{32}$

5 Physical limits in loops

The following procedure can be used to calculate N_L, the total number of network loops required in the system:

$N_L = N_1 + N_2 + N_3$.

Conference loops and TDS loops are called service loops. A service loop in EPE takes up the space of a dual network loop. The new Conference/TDS loop, combining two functions into one card, also takes up the same space.

A Music feature requires a Conference loop, a RAN card or a DTR card, each of which takes up a PE slot. In a small system, the service circuit will impact the number of card slots available for lines and trunks. The capacity impact of these service loops or circuits will be described.

Slot constraints

With eight card slots in the NT5D21 Core/Network Module for Option 61C, the availability of card slots in the network shelf tends to be the bottleneck for Call Center applications on small systems.

Another function which competes for network card slots is I/O ports for applications. I/O ports are needed for MM (Command Status Link [CSL]), Customer Controlled Routing/Host Enhanced Routing (CCR/HER) (Application Module Link [AML]), MAX (High Speed Link [HSL]) and TTY (SDI).

The 61C has slots available for I/O in the core net shelf. If a Clock Controller in the CP shelf is not needed in an Option 61C, its card slot can also be used for an SDI card.

To avoid complication in the worksheet, these fine points are pointed out here for the user to consider; however, they will not be included as alternatives in the card slot worksheet.

Large systems like Options 81C, may require multiple MSDL cards; however, since there is no practical limitation to the number of network slots, only loop limitations are considered in these cases.

The physical relations of cards discussed above are summarized in Table 2.

Table 2
Physical characteristics of cards and modules in Meridian 1

Name of card/module	No. of loops	Card slots	No. of ports/ cards	Comments
QPC414 ENET	2	1		Required for MM ports, DTI, PRI loops
NT8D04 XNET	4	1		Adjacent slot must be an I/O card
NT8D17 TDS/CON	2	1		1 network module, not separable
QPC720 PRI/DTI		2		Required for PRI/DTI T1s
ESDI		1	2	For Mail (CSL), AML, CCR, HER
DCHI		1	1 & 1	1 DCHI port, 1 SDI port; for PRI & NACD
SDI		1	2	For MMax (HSL), CDR
MSDL/MISP		1	4	provides SDI, ESDI and DCHI functions
NT5D21 Core/Network module		8		Option 61C; CC & extra SDI slot in CE
NT8D35 Network module		8		Option 81C; extra space for Options 61C

MSDL supports ESDI and DCHI, SDI functionality is added to the card's function.

1 General description of card slot requirements

An Option 61C consists of one Core/Network module and up to five IPE and UEM modules. The NT5D21 Core/Network module has eight card slots for Network and I/O cards. In addition, there is a fixed slot for a Clock Controller and an SDI which is not included in the eight slots. It is assumed that one TDS/CON card is equipped per Core/Network module. Without considering applications, the 14 card slots can support 28 IPE traffic loops.

Note that since there are 8 card slots in an NT8D35 module, a maximum of 4 NT8D04 Superloop Network cards, or 16 loops, can be equipped per module without being adjacent to each other; the other 4 slots can be used for I/O cards.

The Option 61C has a maximum of 32 loops, if TDS/CON loops are also counted. Note that when a system requires between 16 and 26 loops, it can be served by an Option 61C. The decision can be made by card slot and real time requirements of the configuration.

It appears that as long as some IPEs are used, an Option 61 will run out of loops before it will run out of card slots. For example, in a system of 14 slots, 7 NT8D04 XNET cards (slots) will use up all 28 loops while there are still 7 slots available for other functions. However, if the PRI/DTI feature is deployed, the card slots will run out very quickly.

The Option 81C comprises a maximum of 10 NT8D35 Network Modules when the system is fully equipped with 5 groups. Each network module has 8 slots for network cards. Therefore, a maximum of 80 slots or 160 loops is allowed in the system. As a general practice, we assign 2 TDS/CON cards to each group, so the number of loops usable for general traffic becomes 28. The system capacity becomes 70 slots or 140 loops. This should be the upper limit for general applications.

If an NT8D35 module is used mainly for providing power and space for QPC720 PRI/DTI cards without loops, it is not counted as one of the 10 modules. Therefore, each supporting module can accommodate 6 QPC720 doubled sized cards, which are cabled to an NT8D35 module with 3 QPC414 ENET cards to provide 6 loops for T1’s.

Other than potential space limitations in the switch room, the number of NT8D35 modules used for providing power and space is unlimited. Therefore, the capacity constraint in an Option 81C is the number of loops, not card slots.

With Fiber Optic Fabric, a system is expanded to eight groups. All engineering rules for 5-group system are applicable to 8-group system with the upper limit of loop number increased to 256 instead of 160.

2 Card slot calculation rules

From the above considerations, the following general rules are used to develop the card slot calculation worksheet:

- A PRI or DTI card (QPC720) takes up two card slots. On one side, it interfaces with a T1 carrier; on the other, it interfaces with one of the two loops on a QPC414 network card.
- A DCHI port is required for PRI. This port can be provided by a DCHI card (with one other port for SDI) or MSDL card (with three additional ports for other functions).
- A Clock Controller (CC) card is required for PRI or DTI. It will take one slot on an Option 61C CE shelf.
- An XNET card takes one card slot, but its adjacent slot cannot be used by either ENET or TDS/CON cards, due to address limitations. The slot next to an XNET card can equip only nonnetwork cards (such as ESDI, MSDL).
- All ENET loops can be lumped together to avoid the inaccuracy in rounding off the number of card slots to the higher integer number.

A PRI or DTI card is very slot expensive due to its double width and supporting circuitry requirements.

In general, IPE cards and superloops should be used as much as possible to maximize the utilization of card slots.

I/O device requirements

Most advanced features on the Meridian 1 are controlled by auxiliary processors which communicate with the Meridian 1 CP on routing and other instructions. Since I/O cards compete with network cards for slot space in a network shelf, they are crucial in deciding whether a given small system is able to provide all necessary ports and features. Table 3 summarizes information required to calculate the number of I/O cards needed as an input to the card slot calculation worksheet described in the following section.

Table 3
I/O interface for applications

Application	Type of link/interface	Type of port	Sync or async
AML (associated set)	AML	ESDI	Sync
CCR	AML	ESDI	Sync
CDR	RS232 C	SDI	Async
Host Enhanced Routing	AML	ESDI	Sync
Host Enhanced Voice Processing	CSL & AML	ESDI	Sync
ISL	Modem	ESDI	Sync
Interactive Voice Response	CSL	ESDI	Sync
Meridian Mail	CSL	ESDI	Sync
Meridian MAX	HSL	SDI	Async
Meridian 911	AML	ESDI	sync
Property Management System Interface (PMSI)	PMSI Link	SDI	Async
NACD (PRI)	64 kB D-Channel	DCHI	Sync
TTY (OA&M)	RS232 C	SDI	Async

Note: An ESDI card has two ports; an SDI card has two ports; a DCHI card has one DCHI port and one SDI port; an MSDL card has four combination ports

Certain other applications such as data may require interface to I/O ports. Since they are not addressed in the context of a Call Center, they will not be covered here.

By knowing the applications for a given site, the required number of I/O ports can be calculated. Depending on the type of I/O cards provided, the number of card slots, which will be used as an input to the following worksheet, can be determined.

The Meridian 1 has a maximum of 64 I/O ports ,using MSDL. This constraint may need to be considered for large systems with many application features. For smaller systems, the card slot constraint is a concern, but not the maximum number of I/O addresses.

Algorithm

The rules described in this section, which are summaries of earlier sections, will be implemented in the card slot worksheet for direct application by the user.

1 Determine TDS/CON card requirements: one card per Network Module or 14 loops.

2 Determine MUSic loop card: one TDS/CON card per music loop.

3 Calculate ENET cards: the total ENET loops divided by 2.

4 Clock Controller slot: put in a zero in this space.

5 Calculate XNET card slots: sum up all XNET loops and divide by 4 to get the card slots required.

6 I/O card slot: the number of slots next to XNET cards that are usable only for I/O cards, regardless of whether needed or not.

7 QPC720 DTI/PRI slots: each card takes 2 slots if they are not provided through the expanded NT8D35 network module.

8 The sum of the total card slots above should not exceed 16 for Option 61C. Under normal applications with expansion network modules, the Option 81C should have no physical constraints.

The algorithm described in this section will be implemented in the card slot calculation worksheet.

Power consumption

The power consumption of intelligent peripheral equipment (IPE) circuit cards is given in Tables 4 and 5.

The traffic assumptions used are 25 percent active (9 CCS) for digital and analog lines, and 75 percent active (30 CCS) for trunks. These values take the average efficiency of the module power supplies into account.

The power consumption of digital line cards does not vary greatly with traffic, as it may with analog line cards.

Table 4
Power consumption—IPE cards

Circuit card	Typical power (watts)
NT8D01AC Controller card-4	32
NT8D01AD Controller card-2	32
NT8D02 Digital Line card	24
NT8D09 Analog Message Waiting Line card	20
NT8D14 Universal Trunk card	36
NT8D15 E&M Trunk card	34
NT8D16 Digitone Receiver card	7

Table 5
Power consumption—PE cards

Circuit card	Typical power (watts)
NTIR20	YTD
NTND36	YTD
QPC578 Integrated Services Digital Line card	24.6
QPC789 16-Port 500/2500 (Message Waiting) Line card	26.4

Table 6 shows power consumption data for each fully configured module. This data can be used for rectifier and reserve power (battery) provisioning.

Table 6
Meridian 1 module power consumption

Module	Power consumption (watts)
NT6D44 Meridian Mail Module	240
NT8D35 Network Module	240
NT8D37 IPE Module	460
NT8D47 RPE Module	
• local site	175
• remote site	100
Pedestal (with blower unit)	50

Power calculation algorithm

The method for calculating Meridian 1 system power is based on the number of modules and columns in the system, regardless of how many cards are initially equipped. This method ensures that the external power supply provides adequate capacity, under all conditions and all possible growth scenarios, for the modules installed.

Heat dissipation

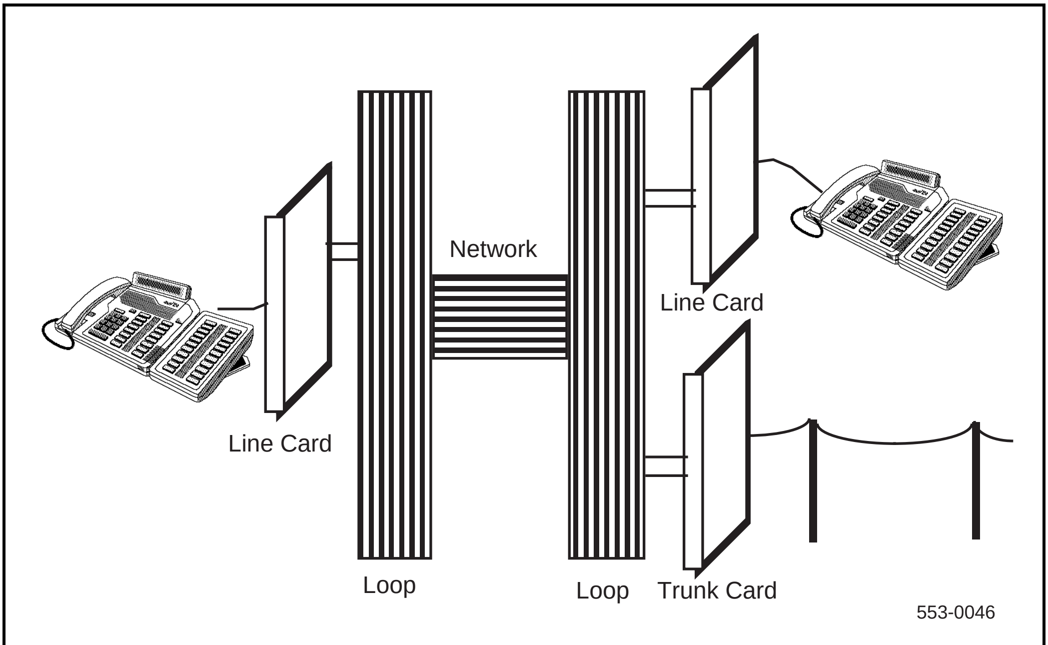
Option 11C does not have a cooling system. Extensive use of circuits on an analog card could cause system temperature to rise. Using digital cards for agent sets is recommended.

The other Meridian 1 systems considered here are equipped with cooling systems and do not have heat dissipation problems under normal applications.

Network traffic

Traffic is a measure of the time a circuit is occupied. On the Meridian 1, the circuit normally consists of a path from the set to its line card to a loop through the network to another loop, and on to another line or trunk card attached to the terminating set or trunk as illustrated in Figure 6.

Figure 6
Network traffic



Basic traffic terms used in this document are:

- An ATTEMPT is any effort on the part of a traffic source to seize a circuit/channel/time-slot.
- A CALL is any actual engagement or seizure of a circuit or channel by two parties.
- The CALLING RATE is the number of calls per line per busy hour: Calls/Line.
- The BUSY HOUR is the continuous 60 minute period of day having the highest traffic usage; it usually begins on the hour or half-hour.
- The HOLDING TIME is the length of time during which a call engages a traffic path or channel.

- The TRAFFIC is the total occupied time of circuits or channels, generally expressed in CCS or Erlangs: CCS—a circuit occupied 100 seconds; Erlang—a circuit occupied one hour.
- BLOCKING—Attempts not accepted by the system due to unavailability of the resource.
- OFFERED traffic = CARRIED traffic + BLOCKED traffic.
- Traffic load in CCS = No. of calls x AHT/100.
- Network CCS = Total CCS handled by the switching network

  or

  = CCS offered to the network by stations, trunks, attendants, Digitone receivers, conference circuits, and special features.

A loop is the physical channel that connects a network to the Intelligent Peripheral Equipment (IPE). Each loop is designed with a fixed number of time slots (120 for IPE, or Superloops). A time slot is a logical one-way channel over which voice or data information is passed during a conversation. Therefore, two timeslots are used for each normal two-way conversation. The load of information, both voice and data, which are transmitted over these time slots is called “traffic.” Network traffic capacity is determined by the total number of time slots available.

Given the number of lines and trunks required in the configuration and their usage levels, the desired system network size (i.e., the number of loops/superloops needed by the system) can be determined.

Loops

The number of loops needed in the system can be calculated from lines, trunks and traffic requirements such as average holding time (AHT) and CCS. The algorithms for these computations are described in this section, and incorporated into the traffic worksheet in "Network loop traffic capacity worksheet" on page 193.

Option 11C has a non-blocking network. Each card slot is interfaced with a DS30X loop which provides 30 channels. CCS per line, trunk or agent is to be used to balance traffic among applications. There is no need to calculate CCS per loop.

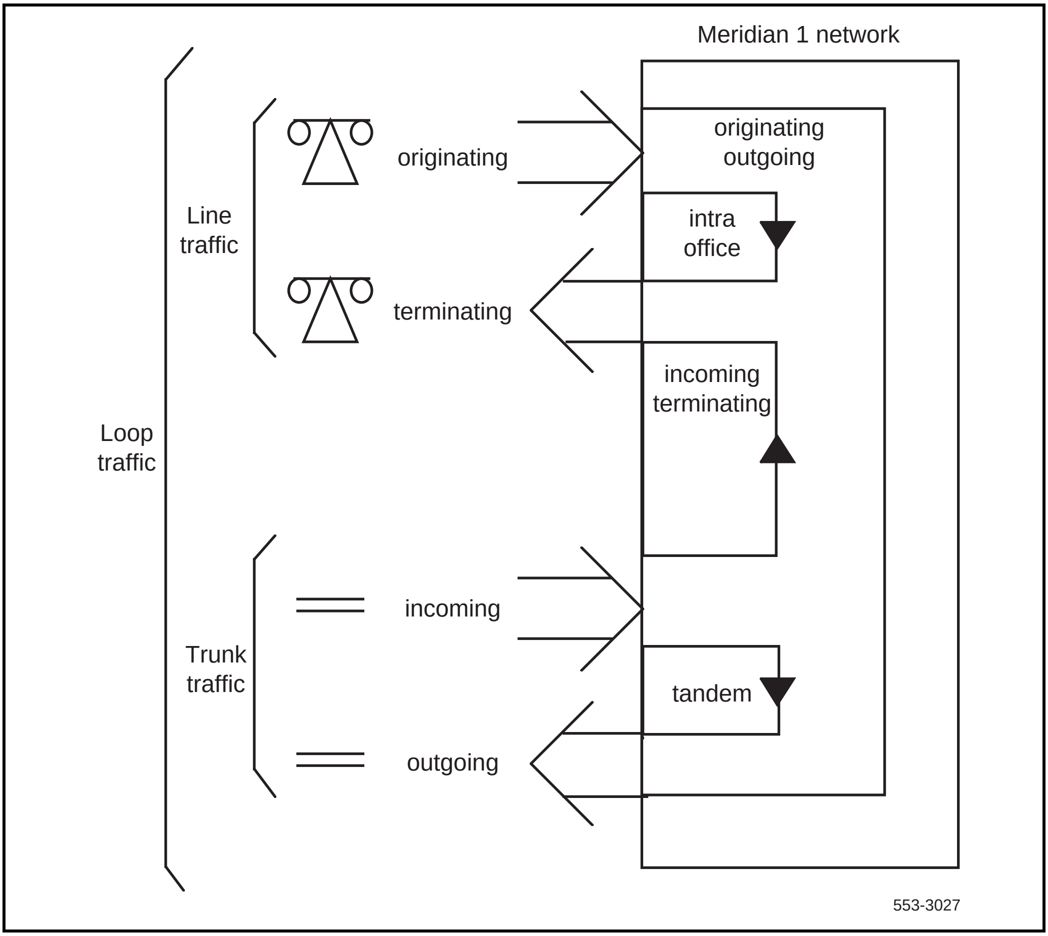
Intelligent peripheral equipment (IPE)

By combining four network loops, the superloop network card (NT8D04) makes 120 timeslots available to IPE peripheral cards. Compared to regular network loops, the increased bandwidth and larger pool of timeslots increase network traffic capacity for each 120-timeslot bundle by 25 percent (at a P.01 grade of service). The recommended traffic capacity for an IPE superloop is 3500 CCS, which meets all GOS requirements for network blocking. For nonblocking applications, a superloop can be equipped up to 120 lines or trunks, and each circuit can carry up to 36 CCS.

Lines and trunks

Line and trunk card assignment will not be discussed in this document. Detailed information is available in *System Engineering* (553-3001-151). This document will present the relationship between lines and trunks for the purpose of calculating loop requirements. The traffic parcels on a loop can be broken up as shown in Figure 7.

Figure 7
Traffic parcels on a loop



The following variables, equations and notation (in parentheses) are used to determine the provisioning requirements of a Meridian 1 system.

- Intra-office CCS (SS)—CCS generated by station-to-station calls
- Tandem CCS (TT)—CCS generated by trunk-to-trunk calls
- Originating-outgoing CCS (ST)—CCS generated by station to trunk calls
- Terminating-incoming CCS (TS)—CCS generated by trunk to station calls
- Line CCS (L) = 2 * SS + ST + TS
- Trunk CCS (T) = 2 * TT + ST + TS
- Total CCS (TCCS) = L + T
- Intra-office ratio (R1)—the portion of the total number of calls which are station to station calls
- Tandem ratio (Rt)—the portion of the total number of calls which are trunk to trunk calls
- Incoming ratio (I)—the portion of the total number of calls which are trunk to station calls
- Outgoing ratio (O)—the portion of the total number of calls which are station to trunk calls
- Average holding time (AHT_{**})—average holding time for different call types (AHTss, AHTtt, AHTst, AHTts)
- Weighted average holding time (WAHT) = (R1 * AHTss) + (Rt * AHTtt) + (I * AHTts) + (O * AHtst)
- Total calls (Calls) = TCCS * 100/(2 * WAHT)
- Intra-office calls (Css) = R1 * Calls
- Tandem calls (Ctt) = Rt * Calls
- Originating-outgoing calls (Cst) = O * Calls
- Terminating-incoming calls (Cts) = I * Calls

Poisson P.01 Table

To use the loop requirement calculation worksheet, the number of lines and trunks are given as inputs. In order to arrive at the number of trunks needed to meet the necessary GOS, the Poisson P.01 table is typically used. This table can also be used for other circuits requiring P.01 GOS, for example, RAN trunks. Refer to *System Engineering* (553-3001-151) for P.001 GOS and other tables.

The Poisson P.01 table is included here for easy reference.

Table 7
Trunk traffic—Poisson 1 percent blocking (Part 1 of 2)

Trunks	CCS	Trunks	CCS	Trunks	CCS	Trunks	CCS	Trunks	CCS
1	0.4	31	703	61	1595	91	2530	121	3488
2	5.4	32	732	62	1626	92	2563	122	3520
3	15.7	33	760	63	1657	93	2594	123	3552
4	29.6	34	789	64	1687	94	2625	124	3594
5	46.1	35	818	65	1718	95	2657	125	3616
6	64	36	847	66	1749	96	2689	126	3648
7	84	37	876	67	1780	97	2721	127	3681
8	105	38	905	68	1811	98	2752	128	3713
9	126	39	935	69	1842	99	2784	129	3746
10	149	40	964	70	1873	100	2816	130	3778
11	172	41	993	71	1904	101	2847	131	3810
12	195	42	1023	72	1935	102	2879	132	3843
13	220	43	1052	73	1966	103	2910	133	3875
14	244	44	1082	74	1997	104	2942	134	3907
15	269	45	1112	75	2028	105	2974	135	3939
16	294	46	1142	76	2059	106	3006	136	3972
17	320	47	1171	77	2091	107	3038	137	4004
18	346	48	1201	78	2122	108	3070	138	4037
19	373	49	1231	79	2153	109	3102	139	4070
20	399	50	1261	80	2184	110	3135	140	4102

Note: For trunk traffic greater than 4427 CCS, allow 29.5 CCS per trunk.

Table 7
Trunk traffic—Poisson 1 percent blocking (Part 2 of 2)

Trunks	CCS	Trunks	CCS	Trunks	CCS	Trunks	CCS	Trunks	CCS
21	426	51	1291	81	2215	111	3166	141	4134
22	453	52	1322	82	2247	112	3198	142	4167
23	480	53	1352	83	2278	113	3230	143	4199
24	507	54	1382	84	2310	114	3262	144	4231
25	535	55	1412	85	2341	115	3294	145	4264
26	562	56	1443	86	2373	116	3326	146	4297
27	590	57	1473	87	2404	117	3359	147	4329
28	618	58	1504	88	2436	118	3391	148	4362
29	647	59	1534	89	2467	119	3424	149	4395
30	675	60	1565	90	2499	120	3456	150	4427
Note: For trunk traffic greater than 4427 CCS, allow 29.5 CCS per trunk.									

Groups

A network group is comprised of two network modules of 16 loops each for a total of 32. The maximum size of a Meridian 1 with (FNF), the network is expanded to allow 8 groups or 256 loops.

There are two types of loops: terminal loops to provide channels for general traffic, and service loops to provide tones and service functions. The number of groups in a system is determined by the number of terminal loops and service loops required, which was discussed under loop and card slot calculations.

To summarize the general rules, a group normally consists of 28 traffic loops and 2 TDS/CON dual loops for a total of 32. A multi-group system comprises multiple groups up to a maximum of eight groups.

Once a system is larger than 32 total loops, a second group is required. To communicate between the two network groups, intergroup junctors are used.

Fiber Network Fabric The number of groups in a system is expanded to eight, and the intergroup junctor is replaced by an OC-12 Fiber Optic ring with a backup. The capacity of the Fiber Optic ring is large enough to carry all traffic from eight groups without blocking between groups.

The only remaining blocking in the network (loop blocking) can be eliminated if a shelf is equipped with no more than 120 ports in a single superloop configuration. So a truly non-blocking network can be achieved with a FNF configuration.

Service loops and circuits

Service circuits are required in call processing to provide specific functions to satisfy the requirements of a given application. They are system resources. Service circuits also consume system resources, such as physical space, real time, memory and so on. This section will describe the traffic characteristics of service circuits, their calculation algorithms and their impact on other system resources.

TDS

The Tone and Digit Switch (TDS) loop in Meridian 1 provides dial tone, busy tone, overflow tone, ringing tone, audible ringback tone, DP or dual tone multifrequency (DTMF) outpulsing and miscellaneous tones. All these tones are provided through the maximum 30 time slots in the TDS loop.

In other words, the maximum number of simultaneous users of tone circuits is 30, whether it be 30 of one tone or a combination of many different types of tones. One TDS loop is normally recommended for each Network Module or half network group of 14 traffic loops. Additional TDS loops may be added if needed, but this is rare.

Conference

The CONference loop is a part of the dual loop NT8D17 TDS/CON card. It provides circuits for 3-way or 6-way conferences. It can also broadcast music from a source to a maximum of 30 users simultaneously. In addition, a CON loop also provides temporary hold for a variety of features, chief among them, the End to End Signaling. One CON loop is normally recommended for each half network group or 14 traffic loops.

Option 11C TDS and Conference

Option 11C has two 16-channel conference loops, eight DTR/DTD channels and 30 tone generation channels (TDS) in the COMBO pack. In addition, when the daughterboard is equipped, another 16-channel conference loop is provided.

Music

MUSic is provided through conferencing a caller to a MUS source. Therefore, a CON loop is required for the Music on Hold feature. Each set of 30 simultaneous music users will require a CON loop, thus a TDS/CON card, since these two service loops are not separable. For a small system, music users can share a conference loop with other applications. However, this is not a common practice in Call Center applications.

The MUS traffic can be calculated by the following formula:

MUS CCS = # of ACD calls using MUS x MUS HT/100

A segment of music typically runs from 40 seconds to 60 seconds. If the average for a specific application is not known, a default of 60 seconds can be used. After CCS is obtained, the MUS port requirement can be estimated from a Poisson P.01 table or a delay table (such as DTR table) matching the holding time of a MUS segment.

RAN

Recorded Announcement (RAN) trunks are located on 8-port trunk cards on PE shelves just like regular trunk circuits. They provide voice messages to waiting calls. RAN trunks are also needed to provide music to conference loops for music on hold.

Each RAN trunk is connected to one ACD call at a time, for the duration of the RAN message. Different RAN sources require different RAN trunk routes. If the first RAN is different from the second RAN, they need different RAN trunk routes. However, if the same message is to be used, the first RAN and second RAN can use the same route.

RAN traffic can be calculated by the following formula:

RAN CCS = # of ACD calls using RAN x RAN HT/100

A RAN message typically runs from 20 seconds to 40 seconds. If the average for a specific application is not known, a default of 30 seconds can be used. After RAN CCS is obtained, RAN trunk requirements can be estimated from a Poisson P.01 table or a delay table (such as DTR table) matching the holding time of a RAN message.

DTR

A Digitone receiver (DTR) serves features involving 2500 sets or Digitone trunks. DTRs are system wide resources, and should be distributed evenly over all network loops.

There are a number of features that require DTRs. General assumptions for DTR traffic calculations are as follows:

- Digitone receiver traffic is inflated by 30 percent to cover unsuccessful dialing attempts.
- Call holding times used in intra-office and outgoing call calculations is 135 seconds if actual values are unknown.
- Digitone receiver holding times are 6.2 and 14.1 seconds for intra and outgoing calls respectively.
- The number of incoming calls and outgoing calls are assumed to be equal if actual values are not specified.

The major DTR traffic sources and their calculation procedures are as follows:

1 Calculate intra-office Digitone traffic

Intra-office =
100 x Digitone station traffic (CCS) ÷ AHT x (R ÷ 2)

Recall that R is the intra-office ratio.

2 Calculate outgoing DTR traffic

Outgoing =
100 x Digitone station traffic (CCS) ÷ AHT x (1–R ÷ 2)

3 Calculate direct inward dial (DID) DTR traffic

DID calls = DID Digitone trunk traffic (CCS) x 100 ÷ AHT

4 Calculate total DTR traffic

Total = [(1.3 x 6.2 x intra) + (1.3 x 14.1 x outgoing calls) +
(2.5 x DID calls)] ÷ 100

5 See Table 8 to determine the number of DTRs required. Note that a weighted average for holding times should be used.

Table 8
Digitone receiver load capacity—6 to 15 second holding time (Part 1 of 2)

Average holding time in seconds	6	7	8	9	10	11	12	13	14	15
Number of DTRs										
1	0	0	0	0	0	0	0	0	0	0
2	3	2	2	2	2	2	2	2	2	2
3	11	10	10	9	9	9	9	8	8	8
4	24	23	22	21	20	19	19	19	18	18
5	41	39	37	36	35	34	33	33	32	32
6	61	57	55	53	52	50	49	49	48	47
7	83	78	75	73	71	69	68	67	66	65
8	106	101	97	94	91	89	88	86	85	84
9	131	125	120	116	113	111	109	107	106	104
10	157	150	144	140	136	133	131	129	127	126
11	185	176	170	165	161	157	154	152	150	148
12	212	203	196	190	185	182	178	176	173	171
13	241	231	223	216	211	207	203	200	198	196
14	270	259	250	243	237	233	229	225	223	220
15	300	288	278	271	264	259	255	251	248	245
16	339	317	307	298	292	286	282	278	274	271
17	361	346	335	327	320	313	310	306	302	298
18	391	377	365	356	348	342	336	331	327	324
19	422	409	396	386	378	371	364	359	355	351
20	454	438	425	414	405	398	393	388	383	379
21	487	469	455	444	435	427	420	415	410	406

Table 8
Digitone receiver load capacity—6 to 15 second holding time (Part 2 of 2)

Average holding time in seconds	6	7	8	9	10	11	12	13	14	15
22	517	501	487	475	466	456	449	443	438	434
23	550	531	516	504	494	487	479	472	467	462
24	583	563	547	535	524	515	509	502	497	491
25	615	595	579	566	555	545	537	532	526	521
26	647	628	612	598	586	576	567	560	554	548
27	680	659	642	628	618	607	597	589	583	577
28	714	691	674	659	647	638	628	620	613	607
29	746	724	706	690	678	667	659	651	644	637
30	779	758	738	723	709	698	690	682	674	668
31	813	792	771	755	742	729	719	710	703	696
32	847	822	805	788	774	761	750	741	733	726
33	882	855	835	818	804	793	781	772	763	756
34	913	889	868	850	836	825	812	803	795	787
35	947	923	900	883	867	855	844	835	826	818
36	981	957	934	916	900	886	876	866	857	850
37	1016	989	967	949	933	919	909	898	889	881
38	1051	1022	1001	982	966	951	938	928	918	912
39	1083	1055	1035	1015	999	984	970	959	949	941
40	1117	1089	1066	1046	1029	1017	1002	990	981	972

Note: Load capacity is measured in CCS.

Traffic capacity engineering algorithms

Traffic capacities of subsystems in the Meridian 1 are estimated based on statistical models which approximate the way a call is handled in that subsystem. The traffic models used in various subsystem engineering procedures are described in the following sections.

When inputs to the algorithm are lines, trunks, average holding time (AHT), and traffic load (CCS), these algorithms can be used to determine the number of loops and system size.

Alternatively, when the loop traffic capacity is known for a given configuration, the algorithms can be used to determine the traffic level allowed at the line and trunk level while meeting GOS requirements.

Traffic Models

The basic assumptions, service criteria, and applicability of the following common models will be presented. The underlying assumptions of each model are listed:

1 Erlang B Model

- Infinite sources (traffic sources to circuits ratio > 5:1)
- Blocked calls cleared (no queueing)
- Applicability: loop, ringing circuit blocking

2 Erlang C Model

- Infinite sources
- Blocked calls delayed
- Infinite queue
- Applicability: Dial tone delay, I/O buffers, DIGITONE, RAN trunks

3 Engset Model

- Finite sources (traffic sources to circuits ratio < 5:1)
- Blocked calls cleared
- Applicability: loops with high traffic and low number of sources, blocking loops for ACD and data applications.

4 Poisson Model

- Infinite sources
- Blocked calls held for a fixed length
- Applicability: incoming/outgoing trunks, DIGITONE, Call Registers, RAN trunks

5 Binomial Model

- Finite sources
- Blocked calls held
- Applicability: small circuit groups, intergroup junctor blocking

Grade of service

In a broad sense, the grade of service (GOS) encompasses everything a telephone user perceives as the quality of services rendered, including (1) frequency of connection on first attempt, (2) speed of connection, (3) accuracy of connection, (4) average speed of answer by an operator, and (5) quality of transmission.

In the context of the Meridian 1 capacity engineering, the primary GOS measures are blocking probability and average delay.

Based on the EIA Subcommittee TR-41.1 Traffic Considerations for PBX Systems, the following GOS requirements must be met:

- Dial tone delay is not greater than 3 seconds for more than 1.5 percent of call originations.
- The probability of network blocking is 0.02 or less on line-to-line connections, 0.01 or less on line-to-trunk or trunk-to-line connections.
- Blocking for ringing circuits is 0.001 or less.
- Post dialing delay is less than 1.5 seconds on all calls.

Any connection in the Meridian 1 involves two loops, one originating and one terminating. In an intergroup connection of a multi-group system, it also involves an intergroup junctor which can also incur blocking. Each stage of connection is engineered to meet 0.0033 GOS. Therefore, overall network blocking in the Meridian 1 is less than 0.01, regardless of whether the call is a line or trunk call, or an intra- or intergroup call.

Signaling and data links

Physical links

Serial Data Interface (SDI)

The SDI is an asynchronous port, providing input access to Meridian 1 from an OA&M terminal, and printing out maintenance messages, traffic reports, and Call Detail Recording (CDR) records to a TTY or tape module. An SDI card has two ports. A DCHI card has one DCHI port and one SDI port. An MSDL card has four ports for a combination of interfaces. SDI is available only on an MSDL card.

Enhanced Serial Data Interface (ESDI)

ESDI provides the interface for a synchronous link. An ESDI card has two ports. The maximum data rate for an ESDI port is 19,200 bps. An ESDI port is primarily used for Application Module Link (AML) types of applications.

D-channel Interface (DCHI)

The DCHI card is used for ISDN PRI D-channel signaling; it provides the interface for a 64,000 bps synchronous link. A DCHI card has one DCHI port and one SDI port. Due to memory limitations on the card, both ports cannot be used for D-channel connections.

Multi-purpose Serial Data Link and Multi-purpose ISDN Signaling Processor (MSDL/MISP)

An MSDL card has four ports providing a combination of SDI, ESDI, and DCHI functions. Using MSDL cards, the number of I/O ports in the system can reach 64. If older I/O cards are used, the maximum number per system is 16. The data rate of each port of an MSDL card is dependent on the function it provides. The maximum rate is 64,000 bps for D-channel applications, but lower for other applications.

Functional links

For each of the following functions, the type of link and resulting capacity are given.

High Speed Link (HSL)

The HSL is a an asynchronous link, used for the Meridian 1 CP to communicate with the MAX module via an SDI port. Prior to MAX 8, the HSL bandwidth was 9600. With MAX 8 and later, 19,200 baud is available.

Application Module Link (AML)

AML is a synchronous link between the Meridian 1 and an Application Module (AM) through the ESDI port. The data rate of the link can be one of the following rates: 300, 1.2kB, 2.4kB, 4.8kB, 9.6kB, or 19.2 kbps. The standard setup between the Meridian 1 and an AM is the 19.2 kbps link.

Meridian Link (ML)

The Meridian Link is the signaling link between the AM and a host where the database for an application resides. The AM serves as an intermediary between the Meridian 1 and the host which instructs the Meridian 1 to take actions for a specific application.

Other than maintenance messages for the AM itself, there is a one-to-one correspondence between the message a host sends to the AM and the message the AM interprets and sends to the Meridian 1, and vice versa. Communications between the AM and a host is conducted via standard X.25 protocols. Therefore, the ML interface is not limited to any particular computer vendor’s products.

For practical applications, the same data rate at the AML and ML is recommended.

Command Status Link (CSL)

The CSL is the version of AML specifically used for the communications between the Meridian 1 and the Meridian Mail system (MM). It has some MM specific messages. The interface is through an ESDI port. For Meridian Mail 1 through Meridian Mail 9, the CSL link rate was 4800 baud. Beginning with Meridian Mail 10, the link rate is 9600 baud.

ISDN-AP link

The ISDN-AP link is an early version of the AML which allows direct access by DEC™ machines. Since the ML was developed, all host connections have to go through an AM. The AP link is no longer offered as an independent product, but it can be a feature in the AML called “AP Pass-through.”

OA&M

The Meridian 1 uses an SDI port to connect to a teletype (TTY) to receive maintenance commands or to print traffic reports, maintenance messages or CDR records. CDR records can also be output directly to a magnetic tape system.

ISDN Signaling Link (ISL)

An ISL provides common channel signaling for an ISDN application without PRI trunks. An analog trunk with modems at the originating switch and the terminating switch can be used as an ISL to transmit ISDN messages between these two remote Meridian 1s.

The interface for an ISL is an ESDI port. The maximum data rate for the link is 19.2 kbps.

D-channel

A PRI interface consists of 23 B-channels and one D-channel. The D-channel at 64 kbps rate is used for signaling. A D-channel interfaces with the Meridian 1 through a DCHI card or a DCHI port on an MSDL.

A D-channel on a BRI set is a 16 kbps link which is multiplexed to make a 64 kbps channel.

Property Management System Interface (PMSI)

The PMSI allows the Meridian 1 to interface directly to a customer-provided PMS through an SDI port. It is primarily used in Hotel/Motel environments to allow updates of the room status database either from the check-in counter or a guest room. The enhanced PMSI allows re-transmission of output messages from the Meridian 1 to a PMS. The maximum baud rate for this asynchronous port is 9600.

Table 9 summarizes the above functional links and interfaces and provides information required to calculate the number of I/O cards needed as an input to the card slot calculation worksheet described later.

Table 9
I/O interface for applications

Application	Type of link/interface	Type of port	Sync or async
AML (associated set)	AML	ESDI	Sync
CCR	AML	ESDI	Sync
CDR	RS232 C	SDI	Async
HER	AML	ESDI	Sync
HEVP	CSL and AML	ESDI	Sync
ISL	Modem	ESDI	Sync
MIVR	CSL	ESDI	Sync
Meridian Mail	CSL	ESDI	Sync
Meridian MAX	HSL	SDI	Async
Meridian 9-1-1	AML	ESDI	sync
PMSI	PMSI Link	SDI	Async
NACD (PRI)	D-channel	DCHI	Sync
TTY (OA&M)	RS232 C	SDI	Async

Note: An ESDI card has two ports; an SDI card has two ports; a DCHI card has one DCHI port and one SDI port; an MSDL card has four combination ports

Processor load

The Meridian 1 system consists of many processors, of which the Meridian 1 CP is the primary one. Others exist in auxiliary platforms such as Meridian Mail, and the Applications Module. In this section methods are described to determine the load on the Meridian 1 CP.

Meridian 1 CP

The call capacity report in TFS004 can be used to determine Rated Call Capacity and current utilization levels. Otherwise, the idle cycle count method can be used to calculate processor load. If a new switch is being configured, equivalent basic calls must be calculated, to estimate the processor loading of a proposed configuration.

Idle cycle count method

A procedure called the “idle cycle count method” is used to determine the call capacity and average load on an existing Meridian 1 CP. Two parameters are used in this procedure: idle cycle count, and CP attempts (also called “call attempts”). These are the first and second fields, respectively, of the TFS004 traffic report (after the header). Refer to *Traffic Measurement: Formats and Output* (553-2001-450) for a description of this report.

Pairs of these fields, taken over a 24-hour period or longer, are plotted on a graph with idle cycle counts on the y-axis, and CP attempts on the x-axis. The locus of points should be a well-defined straight line. If a few of the points fall below the line, they probably represent hours in which background activities, such as midnight routines, or maintenance were being done. These points should be ignored. If the remaining points do not define a clear straight line, error conditions and extraneous activities on the switch should be cleaned up, and a new set of measurements taken before proceeding. (For more detail on interpreting TFS004 output, see Chapter... “Rated Call Capacity Model”).

Rated Call Capacity determination

Rated Call Capacity is the number of featured calls which a switch can handle without exceeding its advertised grade of service. The Rated Call Capacity of each installation is different, depending on software release, configuration, feature mix, and usage patterns. Rated Call Capacity can be determined from the graph constructed using the idle cycle count method. (We summarize that here. It is described in full detail in Chapter... “Rated Call Capacity Model”.)

For simplicity, the following description assumes that the graph was constructed from data taken from hourly traffic reports. If half-hourly reports were used, the procedure is still valid, but “hour” should be replaced by “half-hour” wherever it appears. Note that this means the rated capacity will be in terms of calls per half-hour. It should then be doubled, to make it comparable. Also, the number of milliseconds in a half-hour is 1,800,000 rather than 3,600,000.

The x-intercept is the point on the x-axis where it intersects the plotted line. The Rated Capacity of the switch is equal to 70 percent of this value. For example, if the line crosses the x-axis at 20,000 CP attempts, then the rated capacity of the switch is:

$$0.7 \times 20,000 = 14,000 \text{ Calls-per-hour}$$

Call Service Time is the average number of milliseconds used up by a call. It can be computed by dividing the number of milliseconds in an hour (3,600,000) by the value at the x-intercept point. In the example above, the call service time is 3,600,000/20,000 = 180 milliseconds. In other words, for this particular switch, running with a particular release, and using its unique set of features and packages, an average call requires 180 milliseconds of processor time.

Average load determination

The average load on the processor during a given hour is determined by dividing CP attempts (from the TFS004 report) by the Rated Call Capacity, and multiplying by 100 to produce a percentage. If the load during a certain hour on the switch in the above example was 10,500 CP attempts, then the switch was $(10,500/14,000) \times 100 =$ percent loaded during that hour.

Equivalent basic calls

Real time capacity of a switch can also be specified in terms of Equivalent Basic Calls (EBC). An EBC is a measure of the real time required to process a Basic Call, which is defined as follows:

Basic Call: A simple, unfeatured call between two 2500 sets on the same switch using a 4-digit dialing plan. Both sets are on EPE loops. The terminating set is allowed to ring three times, then is answered, waits approximately 2 seconds, and hangs up. The originating set then hangs up as well.

When the capacity of a switch is stated in EBC, it is independent of such variables as configuration, feature mix, and usage patterns. It still varies from release to release, and between processors. However, since it is independent of other factors, it is a good way to compare the relative call processing capability of different machines running the same software release. Table 10 gives the real time capacity of the various system options for all releases since release 19.

Table 10
Real time capacity (EBC) by release and system option (EPE equipment)

System option	X11 Release 25
Option 11C	**40,125**
Option 51C/61C/81C w/NT5D10 CP card “CP3”	**62,450**
Option 51C/61C/81C w/NT5D03 CP card “CP4”	**86,625**
Option 81C CP PII	**259,875**

* For option 11C use 50,275 and 46,875 and 42,575 and 40,125(adjusted from the true IPE values of 58,000 and 54,100 and 49,125 and 46,325).

Feature impact

Every feature which is applied to a call increases the CP real time consumed by that call. These impacts can be measured and added incrementally to the cost of a basic call to determine the cost of a featured call. This is the basis of the algorithm used by Meridian Configurator to determine the Rated Capacity of a proposed switch configuration. Meridian Configurator is supported in US, UK, Canada and CALA only.

The incremental impact of a feature, expressed in EBC, is called the real time factor for that feature. Real time factors are computed by measuring the incremental real time for the feature in milliseconds, and dividing by the call service time of a basic call.

Each call is modeled as a basic call plus feature increments. For example, an incoming call from a DID trunk terminating on a digital set with incoming CDR is modeled as a basic call plus a real time increment for incoming DID plus an increment for digital sets plus an increment for incoming CDR.

A second factor is required to determine the overall impact of a feature on a switch. This is the “penetration factor.” The penetration factor is simply the proportion of calls in the system which invoke the feature.

The real time impact, in EBC, of a feature on the system can now be computed as follows

(call attempts) x (penetration factor) x (real time factor)

The sum of the impacts of all features, plus the number of Call Attempts is the Real Time Load on the system, in EBC. This number can be compared with the real time capacity in Table 10 to determine whether the proposed system will handle the load. If the projected real time load is larger than the system capacity, a processor upgrade is needed.

I/O impact

There are two types of I/O interface allowed at the Meridian 1: the synchronous data link and asynchronous data link. ESDI and DCHI cards provide interface to synchronous links, and an SDI card provides interface to asynchronous links. The MISP/MSDL card can provide both.

At the I/O interface, the Meridian 1 CP processes an interrupt from SDI port on a per character basis while processing an ESDI/DCHI interrupt on a per message (multiple characters) basis. As a result, the average real time overhead is significantly higher in processing messages from a SDI port than from an ESDI port. MSDL, however, provides a ring buffer.

Auxiliary processors

Interactions with auxiliary processors also have real time impacts on the Meridian 1 CP depending on the number and length of messages exchanged. Several applications are described in “Application engineering” on page 105.

Real time algorithm

As described above, calculating the real time usage of a configuration requires information on the number of busy hour call attempts and the penetration factors of each feature.

Busy hour calls

If the switch is already running, the number of busy hour calls or call load can be determined from the traffic printout TFS004. The second field of this report (except for the header) contains a peg count of CP Attempts. A period of several days (a full week, if possible) should be examined to determine the maximum number of CP attempts experienced. This number varies with season, as well. The relevant number is the average of the highest 10 values from the busiest 4-week period of the year. An estimate will do, based on current observations, if this data is not available.

If the switch is not accessible, and call load is not known or estimated from external knowledge, it may be computed. For this purpose, assumptions about the usage characteristics of sets and trunks must be made. In particular, the average holding time and CCS per hour of each type of line and trunk must be estimated. In addition, estimates for the fraction of total calls that are intra-office (Rl), that are tandem (Rt), that are incoming (I), and that are not successfully terminated (Ineff) ("ineffective") are required. It is also useful to have average holding time statistics for intra-office, outgoing/originating, incoming/terminating, tandem trunk, and data calls, denoted AHTss, AHTst, AHTts, AHTtt, and AHTdata, respectively. Default values are given in Table 11.

Table 11
Default traffic parameter values

Parameter	Default value
Rl	.25
Rt	.05
I	.40
Ineff	.05
AHTss	60 sec
AHTst	150 sec
AHTts	180 sec
ATHtt	60 sec
AHTdata	360 sec

Telephones

As the primary traffic source to the system, telephones have a unique real time impact on the system. For the major types listed below, the number of telephones of each type must be given, and the CCS and AHT must be estimated. In some cases it may be necessary to separate a single type into low usage and high usage categories. For example, a typical office environment with analog telephones may have a small call center with agents on analog telephones. A typical low usage default value is 6 CCS. A typical high usage default value is 28 CCS.

- Analog: 500, 2500, message waiting 500, message waiting 2500 telephones, and CLASS sets
- Electronic: SL-1 telephones
- Digital: M2000 series Meridian Modular Telephones, voice and/or data ports
- ISDN BRI: voice and data ports
- Mobility sets
- Consoles

Trunks

Trunks can be either traffic sources which generate calls to the system or a resource which satisfies traffic demands depending on the type of trunk and application involved. Default trunk CCS in an office environment is 18 CCS. Call center applications may require the default to be as high as 28 to 33 CCS.

Voice

Analog:

- CO
- DID
- WATS
- FX
- CCSA
- TIE E&M
- TIE Loop Start

Digital:

- DTI: number given in terms of links, each of which provides 24 trunks under the North American standard
- PRI: number given in terms of links, each of which provides 23B+D under the North American standard
- European varieties of PRI: VNS, DASS, DPNSS, QSIG, ETSI PRI DID

Data

- Sync/Async CP
- Async Modem Pool
- Sync/Async Modem Pool
- Sync/Async Data
- Async Data Lines

RAN

The default value for AHTran is 30 seconds.

Music

The default value for AHTmusic is 60 seconds.

Calculations

- Calculate Total CCS (TCCS) as TCCS = L + T
- Calculate weighted average holding time (WAHT):

  WAHT = Rl x AHTss + Rt x AHTtt + O x AHTst + I x AHTts
- Calculate total number of calls (Calls):

  Calls = TCCS x 100 / (2 x WAHT)
- Calculate number of calls for every call type:

  Css = Rl x Calls

  Ctt = Rt x Calls

  Cst = O x Calls

  Cts = I x Calls

- Calculate CCSs for every type of system traffic:

  SS = 2 x Css x AHTss / 100

  TT = 2 x Ctt x AHTtt / 100

  ST = Cst x AHTst / 100

  TS = Cts x AHTts / 100

- Calculate usable line and trunk CCSs:

  Lu = SS + ST + TS

  Tu = TT + ST + TS

- Calculate line and trunk usage ratios:

  Lr = Lu / L

  Tr = Tu / T

- Calculate Line and Trunk weighted average holding time:

  WAHTl = (Rl x AHTss + I x AHTts + O x AHTst) / (1 - Rt)

  WAHTt = (Rt x AHTtt + I x AHTts + O x AHTst) / (1 - Rl)

- Define SETS to be the total number of sets equipped.

Features

Procedures for calculating the penetration factor for various features are given below. Since the operation of a telephone switch is extremely complex, only features which have high utilization and/or significant real time impact are considered.

In any of the cases, if the feature is not used, the penetration factor is zero.

500/2500 calls: [Total 500/2500 set CCS x Lr x 100 / WAHTl] / Calls

SL-1 calls: [Total SL-1 set CCS x Lr x 100 / WAHTl] / Calls

Digital set calls: [Total digital set CCS x Lr x 100 / WAHTl] / Calls

BRI voice calls: [Total BRI set CCS x Lr x 100 / WAHTl] / Calls

Data calls: Total data CCS x 100 / AHTdata

CLASS calls: [total CLASS set CCS * Lr * 100 / WAHT1]/Calls

CPND calls:
Let CPND set ratio (Rcpnd) = # display sets / # total sets.
Denote the average CPND name length CPNDl

The penetration factor is given by
(Cst + Cts + 2 x Css) x Lr x Rcpnd x CPNDl / Calls

CDP calls: O x tie trunk CCS x Tu / (Tu+Tq) x Tr x 100 / WAHTt

MM (CSL) calls:
[(Lr x MM CCS x 100 / AHTmm) x (2 x SS + TS) / (SS + TS) / 2] / Calls
where AHTmm is the average holding time of Meridian Mail calls and MM CCS is the total Meridian Mail CCS

MM (EES) calls:
[(Lr x MM CCS x 100 / AHTmm) x (2 x SS + TS) / (SS + TS) / 2] / Calls
where AHTmm is the average holding time of Meridian Mail calls and MM CCS is the total Meridian Mail CCS

NMS (Main) calls: (Lr x NMS_Main CCS x 100 / AHTmm) / Calls

NMS (Remote) calls: (Lr x NMS_Remote CCS x 100 / AHTmm) / Calls

Auto Attendant calls: (Lr x AA CCS x 100 / AHTaa) / Calls
where AA CCS is the total Auto Attendant CCS and AHTaa is the average holding time for Auto Attendant calls

ACD (Inbound) calls: see “Application engineering” on page 105.

ACD-D/MAX calls: see “Application engineering” on page 105.

NACD overflowed calls: see “Application engineering” on page 105.

Meridian Link calls: see “Application engineering” on page 105.

MLink status messages: see “Application engineering” on page 105.

CCR/HER calls: see “Application engineering” on page 105.

IVR (no transfer): see “Application engineering” on page 105.

IVR (transfer): see "Application engineering" on page 105.

Predictive dialing calls: see "Application engineering" on page 105.

Internal CDR calls: Rl, if internal CDR is equipped

Outgoing CDR calls: O, if outgoing CDR is equipped

Incoming CDR calls: I, if incoming CDR is equipped

Tandem CDR calls: Rt, if tandem CDR is equipped

Authorization code calls:
0.15 x CO trunk CCS x Tu / (Tu + Tq) x Tr x 100 / WAHTt

Off-hook queueing calls: 0.05 x (O + Rt)

Trunk calls, incoming DTN: (I + Rt) x (%DTN)

Trunk calls, incoming DIP: (1 – %DTN) x (I + Rt)

Trunk calls, outgoing CO:
[O x CO trunk CCS x Tu / (Tu + Tq) x Tr x 100 / WAHTt] / Calls

RAN messages: see "Application engineering" on page 105.

MUSic: see "Application engineering" on page 105.

BARS/NARS calls: O, if BARS or NARS is equipped

NFCR calls: 0.1 x O

DTI calls: [DTI CCS x Tu / (Tu + Tq) x Tr x 100 / WAHTt / Calls

PRI calls: [PRI CCS x Tu / (Tu + Tq) x Tr x 100 / WAHTt / Calls

RVQ calls: see "Application engineering" on page 105.

Superloop calls:
[Lr x Total Superloop Line CCS x 100 / WAHTl + Tu / (Tu + Tq) x Tr x Total Superloop Trunk CCS x 100 / WAHTt] / Calls

Real Time usage

For each feature, Real Time Term = Penetration Factor x Real Time Factor

The Real Time Multiplier (RTM) is calculated by

$$RTM = 1 + Error\_term + \sum_{features} Real\_time\_term_f$$

The Error_term accounts for features such as call forward or transfer, conference, multiple appearance, and so on, which are not included in the list above, and is assigned the value 0.2. In some environments such as Call Center, such features are not used, so the Error_term should be given a value of 0.

For each system and software release, there is a measured Basic Call Service Time which is the real time required to process a Basic Call. The Rated Capacity in Featured Calls is given by

Rated Call Capacity (FC) = 2520000 / (RTM x Basic Call Service Time).

Memory size

In the following discussion, Option 51C/61C/81C w/ NT5D10 or NT5D03 CP (“CP3” or “CP4”) card employs a Motorola 68060 CP. Option 11C employs a Motorola 68040 CP. CP PII employs a Pentium II CPU. Of the CP3,CP4,3,4 have a separate Flash EPROM memory for program store and a DRAM for Data store, while CP1 and CP PII have code and data all stored in DRAM.

Memory options

The following memory cards are available:

- Option 11C: EPROM and disk emulator ROM reside on the same daughter board. Presently EPROM has 24Mb and ROM has 8Mb. More capacity can be added in 8Mb increments in the form of "babyboards" attached to the daughterboard. The physical possibilities for DRAM are as on the large systems (see next entry in this list). Presently 11C's are sold with 8MB or 16MB of DRAM.
- Option 51C/61C/81C, NT5D10 or NT5D03 CP card: Four SIMMs of EPROM for storing code. These SIMMs must all be the same size – either 8 MB or 16 MB. Currently 8 MB SIMMs are being used for EPROM. There are four SIMMs of DRAM for storing data. Each of these SIMMs can be in any of the following sizes: 2 MB, 4 MB, 8 MB, 16 MB, or 32 MB. Currently only 16MB SIMMs are used for DRAM on these systems.

Table 12
Memory sizes (MB)

Machine		Typical	Maximum
Option 11C	EPROM	24 MB	40 MB
	DRAM	8 MB	32 MB
Option 51C/61C/81C	EPROM	32 MB	64 MB
NT5D10 or NT5D03 CP card	DRAM	64 MB	128 MB

The following machine types have the following SIMM configurations:

- 11C DRAM: either 1 x 8MB or 2 x 8MB
- NT5D10, NT5D03 CP card machines (51C/61C/81C) flash EPROM: 4 x 8MB
- NT5D10, NT5D03 CP card machines (51C/61C/81C) DRAM

Different DRAM sizes are supported according to the number of mobility users the site wants to configure. The additional OS heap required to support mobility's dynamic memory use is then allocated during sysload according to the amount of DRAM in the system. CP machines are all configured with 48MB of memory and they all support 1500 mobility users.

Table 13
Recommended Maximum Call Register Counts and Release 24B-25 Memory Implications

Machine Type	**11C**	**51C CP3,4**	**61C CP3,4**	**81C CP3,4**	**81C CP PII <= 5 groups**	**81C CP PII > 5 groups**
Recommended Call Register Count	**1750**	**2000**	**4000**	**10000**	**20000**	**25000**
Memory Required (SL-1 words)	385,000	440,000	880,000	2,220,000	4,400,000	5,500,000
Memory Required (MB)	0.367	0.420	0.839	2.118	4.236	5.295

In Table 13, “CP3” means “with NT5D10” and “CP4” means “with NT5D03”.

* CP3 or CP4, 61C must have at least 32MB of DRAM and 81C must have at least 48MB. There may be exceptions, however, when a site with one of these obsolete options has a small enough database (i.e., as according to the table) to insure a safe upgrade.

Call registers are 219 SL-1 words long. One SL-1 word is 4 bytes.

> ***Note:*** Sites experiencing memory shortages during an upgrade should check that the call register counts are within the bounds set by this table.

Memory partitioning

Table 14
Release 25 DRAM memory map structure for systems equipped with CP PII cards (numbers in example are for 128MB DRAM**)**

DRAM bucket description	HEX address of lower boundary	# 64KB pages occupied / #MB occupied
top of DRAM (**sysPhysMemTopAdrs**)	8000000	0 / 0
persistent memory : OS upper address miscellany (bottom address is **sysPhysSl1TopAdrs** size defined as USER_RESERVED_MEM**)**	7E00000	32 / 2.0000
sl1 customer data area : (bottom address is **sysPhysProtHeapTopAdrs** defined as SYS_PHY_HEAP_TOP**)**	4C00000	800 / 50.0000
protected heap area : space for patches (bottom address is **sysPhysUnprotHeapTopAdrs** defined as SYS_PHY_UNPROT_HEAP_TOP**)**	4800000	64 / 4.0000
unprotected heap area : heap used by features for dynamic memory needs (bottom address is **_end)**	1A70000	729 / 45.5625
program store area : main_os bss, 2 copies of main_os data, main_os text (bottom address is RAM_LOW_ADRS)	0280000	383 / 23.9375
OS lower addresses : OS stack and lower address miscellany	0000000	40 / 2.5000

Memory engineering

Program store

Option 11C/51C/61C/81C

The number of packages included is fixed; that is, all packages are included. Therefore, the program store requirement is fixed, see Table 15.

Table 15
Program store size (MB) for Option 51C/61C/81C CP/CP32/CP3/CP4

Category	**X11 R25***
Code:	
Resident SL-1 code	14.7500
Overlay SL-1 code	
Option 81C/61C/51C OS	5.1875
	1.2500
Code size total	**21.1875**

*reduction in R25 SL-1 code size due to the removal of the mobility code.

Table 16
Program store size (MB) for Option 11C

Category	**X11 R25***
Code:	
Resident SL-1 code	14.1875
Overlay SL-1 code	
Option 81C/61C/51C OS	4.8750
Aux OS code	
	1.1875
	0.5000
Code size total	**20.7500**

Option 11C/51C/61C/81C OS Dynamic Memory and Patching Area

The Motorola processor (with VxWorks OS) based machines require special memory allocations in addition to that for code and customer data. These allocations are: an area for patching, various fixed memory allocations for OS (not all contiguous - this includes fixed variables for SL-1 and OS code, reserved areas at the very top and bottom of memory (see “Memory partitioning” on page 86.)), and a special area reserved for dynamic OS heap allocations. The OS heap includes memory allocated by SL-1 features via the VxWorks OS. In previous releases, the OS heap was used exclusively by the OS.

Table 17
Patching, Overhead and OS Heap (MB) for Option 11C DRAM

Category	X11 release 25 (no mobility)
Patching Area	1.0000
Misc. Fixed Overhead	1.6875
OS Dynamic Heap	14.2500
Total	16.9375

Table 18
Patching and OS Heap (MB) for CP2, CP3, CP4 Option 51C/61C/81C w/ NT9D19, NT5D10, NT5D03 CP cards

Category	X11 R25 Lite* <=32MB DRAM	X11 R25 Lite* 48MB DRAM	X11 R25 <=48MB DRAM	X11 R25 64MB DRAM
Patching Area	1.6250	2.1250	2.1250	2.6250
Miscellaneous Overhead	3.3750	3.3750	3.3750	3.3750
OS Dynamic Heap				
no mobility users	12.0625	19.3125	22.0000	29.2500
1500 mobility users				
3000 mobility users				

As shown in Table 18, on the NT5D10 and NT5D03 processors, the size of the patching area is a function of DRAM size. OS dynamic heap size is a function of DRAM size.

*R25 Lite is a special version of Release 25 built for customers who explicitly request minimal M3900 capabilities (M3900 sets being a feature introduced in Release 25) but with memory requirements small enough that 24B memory configurations can accommodate them. R25 Lite therefore excludes most other Release 25 functionality.

Data store

The data store consists of both protected and unprotected database information. This section describes the information stored in each area and how to determine the values for input to the memory size worksheet (see "Memory size worksheet" on page 210).

Protected data store

- Telephones:

  Assumptions:

  — average number of features defined per 500/2500 telephone is 8

  — average number of 500/2500 telephones sharing the same template is 10

  — average number of key lamp strips per SL-1 telephone is 1

  — average number of SL-1/Digital telephones sharing the same template is 2

  — average number of non-key features per digital set is 4.

  Calculations:

  — For every type of set the protected data store size is calculated using basic formula: Number of items x MS per item.

  The following items are included here:

  — 500/2500 telephones

  — ACD telephones

  — M2006/2008 telephones

  — 2216/2616 telephones

  — M2317 telephones

  — M3900 telephones

  — Consoles

  — Add-on Modules

  — Templates

  — Attendants

- DS/VMS access TNs:

  (Number of Meridian Mail ports + Number of data ports only) x

  MS per DS/VMS access TN

- Office Data Administration (ODAS):

  (Number of Meridian Mail ports + Number of data ports only +

  Total number of sets + Number of analog trunks) x MS for ODAS

- Customers:

  Constant term + Number of customers x MS per customer

- Directory Number (DN) translator:

  Assumptions:

  — the two lowest levels in the DN tree have average rate of 8 digits

  — the rest of the DN tree has a structure which provides the lowest possible digit rate for upper levels

  Calculations:

  — 5.8 x Number of DNs + 2 x (2 x Number of ACD DNs +

  — Number of ACD positions + Number of DISA DNs) + MS per console x Number of consoles + Number of dial intercom groups

- Dial Intercom Group (DIG) translator:

  Maximum number of DIGs + 2 x (number of DIGs + Total number of the sets within DIGs)

- Direct Inward System Access (DISA):

  Number of DISA DNs x MS per DISA DN

- Authorization Code:

  Assumption:

  — the length of the authorization code is in the range of 4 through 7

  Calculations:

  — Number of customers x MS per customer + 1.47 x Number of authorization codes

- Speed Call:

  Maximum number of Speed Call lists + Number of Speed Call lists x

  (3 + 0.26 x Average number of entries per list x DN size)

- Analog trunks:

  Number of analog trunks x MS per analog trunk

- Trunk Route:

  Constant term + Number of trunk routes x MS per trunk route

- Network:

  Number of groups x MS per group + Number of local loops x

  MS per local loop + Number of remote loops x MS per remote loop

- TDS, MF sender, Conference, DTR, Tone Detector:

  Number of DTRs x MS per DTR + Number of TDSs x MS per TDS

  Number of MF senders x MS per MF sender +

  Number of conference cards x Ms per conference card +

  Number of TDETs x MS per TDET

- ISDN PRI/PRI2:

  Number of D-channels x MS per D-channel + Number of PRI trunks

  + Number of ISL trunks

- ISDN DTI/DTI2/JDMI:

  Number of DTI loops x MS per DTI loop + Number of DTI2 loops x

  MS per DTI2 loop

- History file:

  Size for history file buffer

- Basic Alternate Route Selection/Network Alternate Route Selection (BARS/NARS):

  Assumptions:

— the length of any code = 3

— the typical structure of the tree for every code (in term of digit rate) is the following:

10-10-10.... - for SPN code

8 -10-10.... - for NXX/LOC code

6-2-10-8-10... - for NPA code

Calculations:

5684 + 31.21 x number of NPA Codes + 1.06 x Number of NXX Codes

+ 1.06 x (Number of LOC Codes + Number of SPN Codes) +

2 x Number of FCAS Tables

- ISDN Basic Rate Interface (BRI):

  Number of MISP boards x MS per MISP board +

  Number of DSLs x MS per DSL + Number of TSPs x MS per TSP

  + Number of BRI DNs x MS per BRI DN

- Coordinated Dialing Plan (CDP):

  Constant term + 3 x Number of steering codes + 8 x Number of route lists + 3 x Total number of entries in route lists

- Call Party Name Display (CPND):

  Number of trunk routes + Number of consoles + Number of ACD DNs + Number of SL-1 DNs + Number of digital set DNs

  + Number of Names x (5 + Average length of name)

  + Number of 1-digit DIG groups x 11

  + Number of 2-digit DIG groups x101

- Feature Group D (FGD) Automatic Number Identification (ANI) Database:

  Assumptions:

- — all Numbering Plan Area (NPA) codes designated for BARS/NARS are assumed to be used for ANI also
- — one NPA block is assumed for every fifty NPA codes
- — five NXX blocks are assumed for each NPA block
- — twenty SUB blocks are assumed for each NXX block

Calculations:

- — 3 x Number of NPA Codes + 658 x Number of NPA codes

- Automatic Call Distribution (ACD)/Network ACD (NACD):

  Number of ACD DNs x MS per ACD DN +

  Number of NACD DNs x MS per NACD DN +

  Number of ACD positions x MS per ACD position +

  Number of ACD agents + 11 x Number of customers

- Fixed address globals:

  MS for fixed address globals

Unprotected Data Store

- Telephone:

  For every telephone type (except BRI telephones) the memory size is calculated as

  - — Number of telephones x MS per item, where MS per item depends on the set type. For example:
  - — Number of 2500 telephones x MS per 2500 set,
  - — Number of telephones with display x MS per display, and so on

- BRI telephones:

  Constant term + MS per MISP x Number of MISPs

  + MS per DSL x Number of DSLs + MS per BRI line card x Number of BRI line cards,

  where

  MISP stands for the Multi-purpose ISDN Signaling Processor

  DSL stands for the Digital Subscriber Loop

- Analog trunks:

  The following types of the analog trunks are considered:

  Paging trunks, RAN trunks, Add-on Data Module (ADM), RLA trunks, other analog trunks.

  Calculations:

  — Number of paging trunks x MS per paging trunk

  — Number of other analog trunks x MS per other analog trunk, and so on

  — (Number of other analog trunks = Total number of analog trunks – Number of paging trunks – Number of RAN trunks – Number of ADMs – Number of RLAs)

- Trunks (Call Detail Recording [CDR]):

  Total number of trunks x MS per trunk

- BRI trunks:

  Number of BRI trunks x MS per BRI trunk

- Trunk routes:

  Number of trunk routes x MS per trunk route + Total number of trunks / 16.

  Note: The result of division should be rounded up.

- DTI/DTI2/JDMI:

  — Number of DTI loops x MS per DTI loop

— Number of DTI2 loops x MS per DTI2 loop

- ISDN PRI/PRI2/ISL

  PRI:

  — Number of D-channels x MS per PRI D-channel + Number of outputs

  — Request buffers x MS per output request buffer +

  — 2 x (Number of PRI trunks + Number of ISL trunks)

  PRI2:

  — Number of D-channels x MS per PRI2 D-channel + Number of output

  — Request buffers x MS per output request buffer +

  — 2 x (Number of PRI trunks + Number of ISL trunks)

- Teletypes:

  Total number of teletypes x MS per teletype

  Number of CDR links x MS per CDR link

  Number of HS links x MS per HS link

  Number of APL links x MS per APL link

  Number of PMS links x MS per PMS link

  Number of Other links x MS per other link

- For the following items (features) memory size is calculated using the basic formula

  Number of items x MS per item

  where item is one of the following:

  local loops, remote loops, secondary tapes, customer, Tone and Digit Switch, MF sender, Conference card, Digitone receiver, Tone Detector, attendant, Peripheral Signaling card, LPIB, HPIB, background terminal, MSDL card

  Note: The size of High Priority Input Buffer = Number of Groups x 32.

- PBXOB and BCSOB:

  Number of Peripheral Signaling Cards x 640

  Number of Peripheral Signaling Cards x 640

- DS/VMS access TNs:

  MS per DS/VMS TN x (Number of Meridian Mail Ports +

  Number of data only ports)

- Application Module Link (AML):

  Constant term + Number of AMLs x MS per AML

- Automatic Call Distribution (ACD):

  If ACD-C package is not equipped, then memory size for ACD feature is

  Number of ACD DNs x 298 + Number of ACD positions x 34.

  If ACD-C package is equipped, then additional memory size for ACD-C feature is

  Number of ACD-C routes x 46 + Number of ACD-C positions x 42+ Number of ACD-C DN's + Number of control directory numbers x 80 + Number of ACD-C trunks + Number of ACD-C CRTs x 30 + Number of customers with ACD-C package x 240.

- NARS/BARS/Coordinated Dialing Plan (CDP):

  Assumption:

  — if NTRF package is equipped, then Off Hook Queuing (OHQ) is also equipped

  Calculations:

  — MS per customer x Number of customers + 2 x (Number of route lists x MS per route list + Number of routes with OHQ x MS per route + Number of NCOS defined x MS per NCOS)

- Call registers:

  Assumptions:

  — The Call Register Traffic Factor = 1.865;

— The formula for the calculation of recommended Number of Call Registers depends on traffic load for the system;

— 28 CCS per ACD trunk.

Calculations:

— Call Registers Memory Size = Recommended number of call registers x MS per call register

— Snacd = Number of Calls Overflowed to all target ACD DNs x 2.25 – Number of calls overflowed to local target ACD DNs x 1.8 (0, if the system is not a source node)

— Tnacd = 0.2 x Number of expected calls overflowed from source (0, if the system is not a target node)

— ISDN CCS = PRI CCS + BRI CCS

— ISDN penetration factor:

— p = ISDN CCS / Total Voice Loop Traffic

— ISDN factor = $(1 - p)^2 + 4 \times (1 - p) \times p + 3 \times p^2$

— If Total Voice Loop Traffic > 3000 CCS, then

— Recommended number of call registers = (0.04 x Total Voice Loop Traffic + 0.18 x Number of ACD incoming trunks + Snacd + Tnacd +25) x ISDN factor

— If Total Voice Loop Traffic ≤ 3000 CCS, then

— Recommended number of call registers = (Number of system equipped ports – Number of ACD incoming trunks – Number of ACD agent sets) x 0.94 + Number of ACD incoming trunks + Snacd + Tnacd x ISDN factor

- Fixed address globals and OVL data space:

  MS for fixed address globals + MS for OVL data space.

Mass storage size

The Meridian 1 processor program and data are loaded from hard disk and/or floppies. The auxiliary processor operating system, programs, and data for such applications as Meridian MAX, Meridian Mail, Customer Controlled Routing, and Meridian 911 are loaded from tape. The capacities of these media along with brief descriptions of the layouts used for all processor types and applications are discussed in this section.

Meridian 1 processors

Mass Store on Option 51C/61C/81C systems (NT5D10, and NT5D03 CP cards)

Software installation and SYSLOAD

The SL-1 program is loaded to hard disk via an external medium and then SYSLOAD is performed from the hard disk. The software uploading medium is a CD-ROM. The SL-1 customer database is loaded to the hard disk on a separate floppy, which can be rewritten via a “backup” operation or reread to hard disk via a “restore” operation (LD 43).

The hard disk total capacity is a function of whatever is currently available from the manufacturers. At present, the disks being shipped with the Meridian 1 are 2GB. Whatever the total capacity, however, the actual storage capacity available to the Meridian 1 is determined by the disk partitioning into the protected and unprotected area. This has been set at 30MB for unprotected and 60MB for protected.

IODU/C

By means of the IODU/C feature, software delivery by CD-ROM to Meridian 1 systems. IODU/C incorporates a Keycode based S/W installation and feature expansion methodology. Highlights of IODU/C include:

- Software delivery via CD plus single install floppy. This replaces the (large) stack of floppies required to install software in the past.
- Replacement of single 4MB floppy drive with a 2MB drive.

The following table provides the expected maximum floppy disk space required (before compression) by SL-1 databases for the supported Option 51C/61C/81C machine types. These are conservative but realistic estimates; that is, not all sites with the given machine type will have databases as large as shown.

Table 19
Floppy Disk Space Requirements Projection for SL-1 Customer Data (MB)

	Rls 23C	Rls 24B	Rls 25	Rls 26
51C with NT5D10 or NT5D03 CP card			0.53	0.56
61C with NT5D10 or NT5D03 CP card			0.88	0.93
81C with NT5D10 or NT5D03 CP card. <= 5 group system			2.46	2.60
81C with NT5D10 or NT5D03 CP card. 6-8 group system			3.93	4.17

CD ROM usage is as displayed in the following table:

Table 20
CD ROM Usage

quantities shown are in KB	rls 23	rls 23C	rls 24B	rls 25
Machine types that will be represented on the CD ROM.				
CP3: 51C/61C/81C				94899
CP4: 51C/61C/81C				94899
CPP: 81C				64311
PSDL files				25200
SUMS				374208
in MB				365
CD ROM CAPACITY	650 MB			

In Release 25 replication of PSDL data is eliminated. This and the removal of mobility data and code accounts for the reduction in space requirement since r24B.

Hard disk layout

The hard disk has a total capacity of at least 120 MB. In addition to program and data storage, there is also a maintenance report database which provides logging capabilities. The hard disk is divided into two partitions—protected and unprotected. The protected partition uses 60MB and the unprotected partition uses 30 MB.

Table 21
Option 51C/61C/81C hard disk partitioning—Protected

Protected Partition (MB)	R25
SL_1 resident + overlay code	20.85
PSDL	5.33
OS code + data + tools	1.82
Report database	0.22
Language files	5.46
Total	33.68
Partition size	60

Table 22
Option 51C/61C/81C hard disk partitioning—Unprotected

Unprotected Partition (MB)	R25
SL_1 database (Option 81C Pdata + backup)	4.93
SL_1 database if 6-8 groups are assumed	7.88
Report log file	7.08
HW infrastructure DB + backup	0.22
Patches	3.00
M3900 directory database	10.30
Total (<= 5 groups)	25.53
Total (6-8 groups)	28.48
Partition size	30
Hard Disk Capacity (MB)	2000

Auxiliary processors

Currently, auxiliary processors include Meridian MAX, Meridian Mail, Customer Controlled Routing, and Meridian 911. These all incorporate a 155 MB tape drive and a hard disk (either 172 MB, 240 MB or 520 MB). The processor's UNIX® Operating System is loaded to hard disk from one tape, and the application program and data from another. In addition to the operating system and application program and data, the hard disk also accommodates caching areas and third-party applications.

Table 23 lists the various auxiliary processors and shows the sizes of the mass storage media for each. To see the available space on these media, see "Worksheets" on page 191.

Table 23
Mass storage media for the auxiliary processors

Product	System tape	Applications tape	Hard disk	Comments/ projections
Meridian Link Module	155 MB	155 MB	172 MB	These products all use the same system software.
Customer Controlled Routing	155 MB	155 MB	172 MB	
911 Services	155 MB	155 MB	172 MB	
ACD Reporting System MAX4 / MiniMAX	155 MB	155 MB	172 MB	Uses a subset of the available system software.
ACD Reporting System MAX5	155 MB	155 MB	520 MB	
Interactive Voice Response	155 MB	155 MB	240 MB	

Refer to the following documents for information regarding the auxiliary processors:

- *Meridian MAX Installation* (553-4001-111)

Meridian Link/Customer Controlled Routing:

- *Option 11C Planning and Installation* (553-3021-210)

Application engineering

Content list

The following are the topics in this section:

Reference list

The following are the references in this section:

- *Feature Group D: Description and Operation* (553-2901-102)

In this section, applications that have significant capacity impact and require engineering are addressed. Suggestions are given for engineering the application for proper operation from a capacity perspective.

Descriptions of features and their functionality are not given here. Please refer to feature documentation in the Nortel Networks Technical Publications.

Remote Virtual Queuing

Engineering parameters

Several timers are required to control the feature functions on an originating switch. T2, the duration timer for the originator to accept the RVQ offer is not service changeable, and is set to 16 seconds. T6, the duration timer for ring-again at the originating switch is set at 30 minutes. The retry timer, Tx, is user configurable within the range of 2-30 seconds, and is set to a default value of 10 seconds. The retry counter determines the number of times the initial set should be searched before the scanning includes the extended set. It is service changeable and supports values in the range of 4 to 10, with a default value of 5.

Real-time and signaling bandwidth usage depend on the number of retries required before the call is connected. The number of RVQ attempts, in turn, is a function of Tx, the retry counter, and the network topology/route list index. Considering the worst case scenario, assume that only one path is available. The RVQ feature cannot connect a call until the initial busy trunk becomes available.

To solve for the average number of RVQ attempts on a single blocked trunk group, a Markov process model is defined, assuming exponential call holding times and Poisson arrivals of new call attempts. Conditioned on the trunk being busy, the probability that the trunk will still be busy after Tx seconds can be found by numerically solving a system of differential equations. If, after Tx seconds, the call is still blocked, the cycle repeats, so the number of attempts has a geometric distribution with the parameter being the probability of connection after Tx seconds. The average holding time of a trunk call, once it is connected, is 180 seconds. To calculate the arrival rate of call attempts into a trunk, use the relationship

$$\frac{\text{calls} \times \text{holding time}}{100} = \text{CCS}.$$

The holding time used in this calculation should take into account destination busy or trunk busy calls, so the holding time is adjusted to 150 seconds. The busy hour trunk loading of 28 CCS results in an arrival rate of 18.67 calls/hr into a single trunk.

For default values Tx = 10 seconds and trunk group size (TGS) 71, the trunk group becomes available after an average of 1.36 RVQ attempts (RVQA), including the final successful attempt. If system parameters deviate significantly from the default values, a more accurate value for the average number of RVQ attempts can be found in Table 24 which assumes the North American T1 standard for which TGS = $(24 \times TL) - 1$. The rows represent values for Tx while the columns give the number of T1 links which make up the trunk group. The intersection of the appropriate row and column provides the corresponding number of RVQ attempts.

Table 24
Average number of attempts for the number of T1 links in the trunk group

		Number of T1 links									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tx	2	4.80	2.88	2.27	2.00	1.81	1.69	1.61	1.55	1.50	1.46
	4	2.96	2.01	1.71	1.56	1.47	1.41	1.36	1.33	1.30	1.28
	6	2.35	1.72	1.52	1.42	1.35	1.31	1.28	1.25	1.23	1.21
	8	2.04	1.57	1.42	1.34	1.29	1.25	1.23	1.21	1.19	1.18
	10	1.86	1.48	$\boxed{1.36}$	1.29	1.25	1.22	1.19	1.18	1.16	1.15
	12	1.74	1.42	1.31	1.26	1.22	1.19	1.17	1.16	1.14	1.13
	14	1.66	1.38	1.28	1.23	1.20	1.17	1.16	1.14	1.13	1.12
	16	1.59	1.35	1.26	1.21	1.18	1.16	1.14	1.13	1.12	1.11
	18	1.54	1.32	1.24	1.19	1.17	1.15	1.13	1.12	1.11	1.10
	20	1.50	1.30	1.22	1.18	1.16	1.14	1.12	1.11	1.10	1.09
	22	1.47	1.28	1.21	1.17	1.15	1.13	1.12	1.10	1.10	1.09
	24	1.44	1.26	1.20	1.16	1.14	1.12	1.11	1.10	1.09	1.08
	26	1.42	1.25	1.19	1.15	1.13	1.12	1.10	1.09	1.09	1.08
	28	1.39	1.24	1.18	1.15	1.13	1.11	1.10	1.09	1.08	1.08
	30	1.38	1.23	1.17	1.14	1.12	1.11	1.09	1.09	1.08	1.07

From the RVQA numbers shown in Table 24, it can be seen that the minimum retry counter value, 4, is high enough that searching the extended set of trunks has little or no effect on average system performance except in the case of TL = 1 and Tx = 2, since the average number of retries is less than the retry counter value.

Another parameter which is not defined as part of the RVQ feature, but which may have a significant effect on overall system performance is the percentage of customers that have RVQ privileges (PRVQP). Let the default value be 100 percent.

Real-time:

For a given switch in a telecommunications network, let l be the average length of the path required to connect trunk calls originating from the switch, where length refers to the number of hops in the path, or, equivalently, the number of tandem trunk groups traversed by a given call. Assume a single path between originating switch and destination switch. Also, assume that customers accept RVQ offers and do not cancel. These assumptions provide worst case estimates. At each trunk group, the probability of blocking (TGB) is assumed to be 0.1. This value is appropriate for private networks which are most likely to invoke the RVQ feature. The average probability of blocking for an outgoing trunk call is given by $(1 - (1 - 0.1)^l)$ or $(1 - 0.9^l)$. If the call is blocked, there must be a minimum of one trunk group along the path that is busy. Choose any busy trunk group. For default values TGS = 71 and Tx = 10, an average of 1.36 RVQ attempts (RVQA) will be required before that particular trunk group becomes available. Call this the inner loop, with an average duration of 1.36 cycles. Once the trunk group which was busy becomes available, however, at least one other trunk group along the path may be busy with probability $(1 - 0.9^{l-1})$. Define the external loop such that each cycle has a different busy trunk group, compared to the previous cycle. During each cycle of the external loop, an inner loop is required before the busy trunk group becomes available. Assuming a geometric distribution, an average of $1 / 0.9^{l-1}$ cycles will be made before exiting the external loop. Thus, once a call encounters a busy trunk group, the average total number of RVQ attempts required before a call is connected is given by the average number of cycles around the external loop multiplied by the average number of cycles around the inner loop for $(1.36 / 0.9^{l-1})$ total RVQ attempts (TRVQA).

In a private networking environment, typical network calls consist of an originating switch, a tandem switch, and the destination switch, giving a path length $l = 2$. Paths for which $l > 3$ are rare. Let $l = 2$ be the default path length. An average of 1.51 total RVQ attempts is then required for a blocked call to be completed.

Table 25 gives total RVQ attempts for the default path length $l = 2$ for the North American T1 standard.

Table 25
Average total RVQ attempts

		Number of T1 links									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tx	2	5.33	3.20	2.53	2.20	2.01	1.88	1.79	1.72	1.66	1.62
	4	3.28	2.23	1.90	1.73	1.63	1.56	1.52	1.48	1.45	1.42
	6	2.61	1.91	1.69	1.57	1.50	1.45	1.42	1.39	1.37	1.35
	8	2.27	1.75	1.58	1.49	1.43	1.39	1.36	1.34	1.32	1.31
	10	2.07	1.65	1.51	1.43	1.38	1.35	1.33	1.31	1.29	1.28
	12	1.94	1.58	1.46	1.39	1.35	1.32	1.30	1.29	1.27	1.26
	14	1.84	1.53	1.42	1.37	1.33	1.30	1.28	1.27	1.26	1.24
	16	1.77	1.50	1.40	1.34	1.31	1.29	1.27	1.25	1.24	1.23
	18	1.71	1.47	1.38	1.33	1.30	1.27	1.26	1.24	1.23	1.22
	20	1.67	1.44	1.36	1.31	1.28	1.26	1.25	1.23	1.22	1.22
	22	1.63	1.42	1.34	1.30	1.27	1.25	1.24	1.23	1.22	1.21
	24	1.60	1.40	1.33	1.29	1.26	1.25	1.23	1.22	1.21	1.20
	26	1.57	1.39	1.32	1.28	1.26	1.24	1.23	1.22	1.21	1.20
	28	1.55	1.38	1.31	1.27	1.25	1.23	1.22	1.21	1.20	1.20
	30	1.53	1.36	1.30	1.27	1.24	1.23	1.22	1.21	1.20	1.19

Engineering model

Table 26
RVQ parameters

Parameter	Description	Default value
Tx	retry timer (sec)	10
TGS	trunk group size	71
L	average path length (number of hops)	2
TGB	trunk group blocking probability	0.1
PRVQP	percentage with RVQ privilege	100

System parameters

The system parameters and their default values are listed in Table 25. Several other key values can be derived from these parameters. The number of RVQ attempts which is required before the busy trunk group is available, RVQA, can be found by looking in Table 24. If the average path length L= 2, the total number of RVQ attempts required before a path is available can be found in Table 26. Otherwise, TRVQA can be calculated using

$$\mathrm{TRVQA} = \frac{\mathrm{RVQA}}{(1-\mathrm{TGB})^{\mathrm{L}-1}}$$

with a default value of 1.51.

The trunk group call arrival rate is given by

$$\mathrm{TGCAR} = 18.67 \times \mathrm{TGS} \text{ calls/hr}$$

or 1325.57 calls/hr in the default case.

The path blocking probability satisfies

$$\mathrm{PB} = 1-(1-\mathrm{TGB})^{\mathrm{L}} .$$

Substituting the default values gives 0.19.

The number of RVQ calls per hour (NRVQC) can be calculated by using

$$\text{NRVQC} = \text{TGCAR} \times \text{PB} \times \text{PRVQP}/100.$$

The default value for NRVQC is 251.86 calls. NRVQC provides a measure for the penetration of the RVQ feature.

Real-time model

Since basic trunk calls use 111.31 msec real-time and the RVQ setup and completion time total 202.38 msec, the incremental real-time required by each RVQ call (IRTRVQ) is

$$91.07 + 38.64 \times (\text{TRVQA} - 1).$$

For Tx = 10 seconds and TGS = 71, this value is 110.78 msec.

Each RVQ call is equivalent to

$$\frac{\text{IRTRVQ}}{78.49}\ \text{EBC}.$$

For the default configuration, the value is 1.41 EBC.

The total incremental real-time requirement is then given by

$$\text{NRVQC} \times \frac{\text{IRTRVQ}}{78.49}\ \text{EBC}$$

resulting in 355.12 EBC for the default values.

Signaling link model

The incremental traffic on the signaling link is

$$192 + 121 \times (\text{TRVQA} - 1)\ \text{bytes/RVQ call}$$

or 253.71 bytes/RVQ call in the default case. To engineer the signaling link, assume a 70-30 percent direction split on PRI messages and 30 percent spare capacity for traffic peakedness. The incremental bandwidth required for RVQ is then $0.002 \times [192 + (\text{TRVQA} - 1) \times 121]$ bps per RVQ call per hour for a total of

$$\text{NRVQC} \times 0.002 \times [192 + (\text{TRVQA} - 1) \times 121]\ \text{bps}$$

for NRVQC RVQ calls per hour. The default value is 127.80 bps.

Trunking model

For each trunk group, the incremental traffic is NRVQC $\times$ T2/100 CCS which gives [(NRVQC $\times$ T2 / 100) / TGS] CCS per trunk. The number of additional trunks required for RVQ satisfies

$$\text{\# additional trunks} = \frac{\text{TGS} \times 18.67 \times \text{PB} \times \text{T2}/100}{28}$$

where 28 CCS is the default busy hour trunk loading value.

For the default values listed in Table 25, 1.44 additional trunks are required due to RVQ.

Meridian Mail

Meridian Mail traffic calculations and capacity table

Refer to *Site and Installation Planning* (553-7011-200) for a detailed engineering of Meridian Mail, including menu utilization, call duration, storage size, disk size, up requirements, and so on. However, for easy reference, a simplified table is extracted and included here.

Each Meridian Mail Module consists of 16 ports which interface with a DTI type of loop with 24 ports to provide voice channels. In other words, every 16 Meridian Mail ports interface with one ENET loop of 30 timeslots.

As with other traffic calculations, the first step is to determine the average holding time of an MM call. This includes both the time the user is logged on to MM and the time callers are leaving messages for that user. A typical range is 30 to 60 seconds per user depending on the type of application.

The calling rate per MM registered user is about 10 percent of busy hour calls. For example, if a set generates or receives five calls per hour, the MM calls would be 0.5 per hour. If there are 2000 MM users in a switch with average holding time (AHT) of 60 seconds, its MM traffic would be:

MM traffic in CCS = 2000 $\times$ 0.5 $\times$ 60/100 = 600 CCS.

From Table 27, approximately 23 MM ports are needed for this application.

Note that if complicated voice menus are involved for an application, the AHT needs to reflect that fact.

Table 27
Meridian Mail channel capacity

No. of channels	Capacity in CCS
4	54
8	157
12	273
20	522
24	651
28	782
32	915
36	1049
40	1183
44	1318
48	1455
52	1592
56	1729

Table 27
Meridian Mail channel capacity

No. of channels	Capacity in CCS
60	1867
64	2005
68	2143
72	2282
76	2421
80	2561
84	2700
88	2840
92	2980
96	3120

The main objective to present Meridian Mail engineering procedure here is to show how it fits into the overall Call Center engineering in the later section. For a high level MM port requirements estimate, interpolation or extrapolation between entries is permitted.

The major MM parameter which impacts the real-time capacity of a co-located Meridian 1 is the type of signaling between the MM processor and the Meridian 1 CP. For locally generated MM calls, CSL and End to End signaling have significant capacity effects, and have different real-time factors as shown in the real-time calculation worksheet.

There are many voice processing features offered with the Meridian Mail application, all of which present unique characteristics in MM usage. Each specific feature, with varying AHT, will impact the MM port requirement differently. This needs to be considered when engineering a specific MM application. The following are known applications of the MM feature: Voice Mail, Voice Menu, Voice Forms, Auto Attendant, Meridian Interactive Voice Response (MIVR), Host Enhanced Voice Processing (HEVP), Network Message Service, and Third Party Voice Messaging Systems.

Meridian Link

Major Meridian Link applications and their real-time impacts are addressed in this section.

Meridian Link data rate determination

Although the subject of signaling link engineering is a part of the *Meridian Link Engineering Guide* (553-3203-151), it will be useful to extract some data from that document to make this engineering guide more complete, since most Call Center applications involve Meridian Link in the configuration.

Table 28
Data Link capacity for typical ACD/AML applications

Link data rate (D) in kbps	64.0	19.2	9.6	4.8	2.4	1.2
Avg. AML calls/hr	82,202	24,660	12,330	6,115	3,057	1,528

The data rate chosen for a link, if it is within the limit of the Meridian 1 CP capacity, should correspond to an Application Module Link (AML) call capacity value greater than an Meridian 1 is expected to handle.

As long as there are physical I/O ports in the Meridian 1 to interface the AML, there is no practical limit to the number of AML/MLs a system can serve. However, the number of calls corresponding to each application must be added together to determine whether the total is within the CP capacity of that Meridian 1 system.

The data link requirement for the CCR application is only 3.2 percent higher than for the ML. In other words, the entry in Table 28 should be divided by 1.032 for the CCR application. For example, at 1200 bps rate, the link can handle 1480 CCR calls (= 1528/1.032).

When application modules begin using a common base, all applications sharing the same AML can add up message link call requirements by using the following formula:

> AML calls/hour = (Type 1 calls x 1.0 + Type 2 calls x 1.0 + …+ CCR calls $\times$ 1.032)

Then, check the AML calls/hour against the data rate requirement in the above table. At this time the only application with factor other than one is CCR. This may change when message usages of more applications are studied.

Incoming AST calls

In an Associated Telephone (AST), the DN of the set is assigned to be controlled by a host. The AST is a set associated with a computer terminal through a database stored in the host. A host, alerted by messages of an incoming call from the Meridian 1, can bring up customer or sales information on the terminal screen while a connection is made to the AST, which is frequently an ACD agent.

Autodialer calls with transfers (Predictive Dialing)

An Autodialer, controlled by a host, directs the Meridian 1 to make a central office (CO) trunk call. When a potential customer answers, the Autodialer detects the connection and transfers the call to an agent to answer. The average holding time of this type of call is relatively short for the Autodialer compare with a conventional call, thus the frequency of calls can be very high. The number of calls successfully transferred is normally a small percentage (5-20 percent) of total Autodialer calls.

Customer Controlled Routing

Customer Controlled Routing (CCR) is an auxiliary product connected to the Meridian 1 via the AML. Depending on the Controlled Direct Number (CDN) of the incoming call, CCR can route calls based on a variety of attributes, such as Calling Line ID (CLID), Dialed Number Identification Service (DNIS), time of call arrival, and the call processing states of the ACD-DN (queue size, agent number, and so on). The CCR can put a waiting call on a maximum of four queues simultaneously. It also provides the flexibility of routing a call to RAN and Music treatments with conditions.

Host Enhanced Routing

The Host Enhanced Routing (HER) feature intercepts an incoming ACD call based on the CDN dialed, and gives the call special treatment according to the script programmed, such as routing to a specific DN queue, connecting to a RAN or Music. It can also make routing decisions based on the conditions of agent load and the service criterion. The real-time impacts of basic CCR and HER features are similar. Depending on the complexity of scripts, either feature can become very sophisticated and real-time extensive.

Direct Autodialer calls (Preview dialing)

An Autodialer connected to a 2500 type line card is controlled by a host through AML to make calls according to a database in the host. This type of call does not involve an ACD agent. The Autodialer either monitors control points by dialing these numbers periodically, as used in factory automation and sales updates, or is connected to a recording machine to perform customer surveys or market research.

Call Center

The Call Center is an ACD switch, whose calls are mostly incoming or outgoing, with extensive applications features, such as CCR, HER, MIVR, HEVP. A port in the Call Center environment, either as an agent set or trunk, tends to be more heavily loaded than other types of applications.

Based on customer application requirements, such as calls processed in a busy hour, and feature suite such as RAN, Music, and IVR, the system capacity requirements can be calculated.

ACD

Automatic Call Distribution (ACD) is an optional feature available with the Meridian 1 system. It is used by organizations where the calls received are for a service rather than a specific person.

For basic ACD, incoming calls are handled on a first-come, first-served basis and are distributed among the available agents. The agent that has been idle the longest is presented with the first call. This ensures an equitable distribution of incoming calls among agents.

The system is managed or supervised by supervisors who have access to the ACD information through a video display terminal. These supervisors deal with agent-customer transactions and the distribution of incoming calls among agents.

Many sophisticated control mechanisms have been built on the basic ACD features. Various packages of ACD features discussed in this NTP will have real-time impact on the Meridian 1 CP capacity.

ACD-C1 and C2 packages

ACD Management Reporting provides the ACD customer with timely and accurate statistics relevant to the ACD operation. These statistics form periodic printed reports and ongoing status displays so the customer can monitor changing ACD traffic loads and levels of service and implement corrective action where required.

The ACD-C1 package primarily provides status reporting of the system through a TTY terminal. To control and alter the configuration of the Meridian 1 system, the ACD-C2 package is required; it provides the load management commands. The following is a partial list of functions of a supervisor position in the C2 package:

- assign auto-terminating ACD trunk routes
- assign priority status to ACD trunks
- reassign ACD agent positions to other ACD DNs
- set the timers and routes for first and second RAN
- define the overflow thresholds
- specify a night RAN route

ACD-D package

The ACD-D system is designed to serve customers whose ACD operation requires sophisticated management reporting and load management capabilities. It has an enhanced management display as the Meridian 1 is supplemented by an auxiliary data system. The Meridian 1 and the auxiliary processor are connected by data links through SDI ports for communications. Call processing and service management functions are split between the Meridian 1 and the auxiliary processor.

ACD-MAX

ACD-MAX offers a customer managerial control over the ACD operation by providing past performance reporting and current performance displays. It is connected through an SDI port to communicate with the Meridian 1 CP. The ACD-MAX feature makes the necessary calculations of data received from the Meridian 1 to produce ACD report data for current and past performance reports. Every 30 seconds, ACD-MAX takes the last 10 minutes of performance data and uses it to generate statistics for the current performance displays. The accumulated past performance report data is stored on disk every 30 minutes.

The impact of ACD-MAX calls in the capacity engineering will be in the real-time area only. The Meridian MAX is an AP version of the ACD-MAX which uses an AP module instead of an HP computer as an auxiliary processor. To estimate the impact of MAX on the Meridian 1 CP, both versions can be treated the same.

NACD

The majority of tasks in the engineering of Network ACD (NACD) involve the design of an NACD routing table and the engineering of overflow traffic. The process is too complex to be included here. The engineering procedure in this NTP is for single node capacity engineering, which accounts for the real-time impact of NACD calls on a switch either as a source node or remote target node. Therefore, the overall design of a network is not in the scope of this document.

MIVR

The Meridian Interactive Voice Response (MIVR) is a Meridian Mail application in which a third-party module (Voicetek™ machine) controls the operation of an MM through the 9600 baud ACCESS link. The communication between the Meridian 1 and MM continues to use the CSL. Voice ports required for the MIVR feature are MM ports.

In order to provide a balanced configuration among trunks, MIVR ports (or MM ports), and agents in the Meridian 1 overall configuration, a brief summary of some provisioning requirements are in order:

1 Physically, the MIVR port is the same as the MM port, except that it is controlled by the MIVR application module through the 9600 baud ACCESS link (an asynchronous link). The provisioning of MIVR ports is a multiple of 24, just like MM ports. In MIVR release 1, with one ACCESS link, 48 MIVR ports are the maximum. In release 2, a second ACCESS link will be permitted, which can support another 16 MIVR ports.

2 The data link, CSL, which provides signaling between the Meridian 1 and Meridian Mail, is always a 4800 baud synchronous link.

3 The distribution of Holding Times (HTs) for MIVR ports are bimodal, one short HT for calls that are transferred to live agents and one long HT for calls that are served by the MIVR menu.

4 The long HT call occupies a trunk circuit just like any other ACD call. The short HT call has an incremental impact on trunk occupancy. The average HT of a trunk is equal to the sum of the MIVR HT and the agent HT. In other words, all transferred MIVR calls have an incremental impact on trunking requirements.

5 If the default short HT on the MIVR port is 15 seconds, the additional CCS to trunk can be estimated as follows: Incremental MIVR CCS to trunks = Transferred MIVR calls x 15/100.

Host Enhanced Voice Processing

The Host Enhanced Voice Processing (HEVP) feature is similar to the MIVR except that the ACCESS link is replaced by a Meridian Mail link, and the voice processing is controlled by the Meridian Application Module instead of a Voicetek machine.

An HEVP call involves the AML to control a voice mail treatment; its real-time impact on the Meridian 1 is like a combined MM and AML call. HEVP real-time impact can be treated like the MIVR.

Meridian 911

The primary difference between the M911 application and other Application Module link related incoming ACD calls is the requirement of MF Receivers (MFR), which interpret digits received from CO through MF trunks for M911 calls.

The following procedure should be followed to estimate the MFR requirement:

1 Calculate the number of calls from MF trunks:

M911 calls = No. of MF trunksx28 $\times$ 100/180 = 15.56 $\times$ No. of MF trunks.

where the default value of CCS for the trunk is 28 and the average holding time is 180 seconds. These numbers should be replaced by specific values at your site if they are available.

2 Calculate MFR traffic:

MFR traffic in CCS = M911 calls $\times$ 6/100

where the ANI digits of 8 were estimated conservatively to hold up a receiver for 6 seconds.

3 Refer to *Feature Group D: Description and Operation* (553-2901-102) to find the requirements of MFRs. For the purpose of estimating MFR requirements, the DTR table can be applied. Read the number of DTRs (MFRs) corresponding to a CCS entry greater than the above calculated CCS value under the column of 6-second holding time. An abbreviated table is shown here for simple reference.

Table 29
MFR table with 6-second holding time

No. of MF receivers	2	4	6	8	10	15	20	25	30	35	40
Capacity in CCS	3	24	61	106	157	300	454	615	779	947	1117

RAN and Music

The RAN trunk can be treated just like a normal trunk. The only potential capacity impact is for small systems (Options 51C and 61C) which may need to include RAN trunks in blocking or non-blocking calculations to determine the total number of loops or card slots required. Refer to “Service loops and circuits” on page 61 to calculate RAN requirements.

Music in Meridian 1 is provided by broadcasting a music source from a RAN trunk to a conference loop. Therefore, a maximum of 30 users can listen to music at one time. If this is not sufficient, an additional conference loop needs to be provided for each additional 30 simultaneous music users.

The conference loop connects to one half of the TDS/CON card. The second conference loop, if needed, will take another card and card slot, because it cannot be separated from the TDS loop.

Other features

Features such as CCR, HER, and Predictive Dialing are as much a Call Center feature as an AML one. However, since they were already discussed under the Meridian Link umbrella, they will not be repeated here.

Call Center examples

Real time factors are used in the following examples. The same method and procedures can be applied to later releases and faster CPs by substituting the real time factors and EBC capacities used in the examples with their updated counterparts.

A basic Call Center with MIVR

Model: 12,000 calls per hour incoming to MIVR. They all receive on average one 30 sec. cycle of MIRAN RAN and MUSIC before being connected immediately to a live agent. The average hold time (AHT) with the live agent is 150 sec. and the CCS per live agent is 30. We will use PRI trunks, assume trunk/agent ratio of 1.5, with AHT per trunk equalling AHT per agent + the 30 sec. MIRAN cycle, and CCS per trunk such that the model is balanced; i.e., trunk CCS = set CCS. We will need to determine how many MIVR ports and how many live agents, assuming 5% blocking. We will also need to determine the number of PRI loops, given the trunking specs above.

Solution:

MIVR ports: In Table 27 “Meridian Mail channel capacity” on page 114 we can find the number of Meridian Mail ports required to handle a given CCS at 5% blocking. This same table can be applied to MIVR ports. Thus we have:

MIVR CCS = 12,000 calls *(30 secs/call) / 100 = 3,600

The table only shows ports for up to 3120 CCS, but extrapolation is permissible. A linear fit on the last 6 entries in the table yields an R^2 of 1 and a port requirement of 112 ports to support a CCS of 3600.

Live agents: The agent count must be sufficient to support the call rate from the MIVR ports with no blocking. The call rate from the MIVR ports is 12,000 calls per hour. Thus we have:

Live agents = 12,000 calls * 150 secs/call / (30 * 100 secs / agent) = 600

Trunks: We need 1.5 * 600 trunks = 900 trunks. Let this be a European site with 30 PRI channels per loop. Then we need 30 loops. Let’s make sure that this is adequate trunking by determining now what CCS per trunk would be required to balance the model, and verifying that this is less than the 36 CCS that we have available in one hour. We have 12,000 calls per hour, (150 sec agent AHT + 30 sec MIVR treatment) per call, and 900 trunks. So:

per trunk CCS = (12000 calls * 180 secs/call) / (900 trunks * 100 sec/CCS) = 24

Therefore 900 trunks is adequate.

Now that we know all our terminal counts, we can go on to see what physical capacities we need (loop, line card). The live ACD agents will be assumed to be on IPE Aries sets.

1 Loop requirement

Table 30
Worksheet for network loop calculation (example) (Part 1 of 2)

Column A					**Column B (Loops)**
TDS/CON loops	One card (2 loops) per Network Module*				_____6____
BLOCKING:					
ENET loop	Admin. sets		______ x 6 =	______CCS	
	Non-ACD trunks				
		+	______x 26 =	______CCS	
	Subtotal	=		______ ÷ 660	=_______(N_{0e})
XNET loop	Admin. sets		______ x 6 =	______CCS	
	Non-ACD trunks	+	______x 26 =	______CCS	
	Subtotal	=		______ ÷ 875	=_______(N_{0x})

Table 30
Worksheet for network loop calculation (example) (Part 2 of 2)

Column A				Column B (Loops)
NON_BLOCKING:				
(ENET or XNET)	Agent sets		___600___	
	Supervisor sets	+	_________	
	ACD analog and RAN trunks	+	________	
	Subtotal	=	___600_÷ 30	=___20___(N_1)
DTI Trunks		=	_______ ÷ 24	=_______(N_{2d})
PRI Trunks			___900_____	
		+		
		=	___900__ ÷ 30	=___30___(N_{2p})
MIRAN ports		=	___112__ ÷ 30	=____4__(N_{31})
MM/MIVR/HEVP ports			___112__ ÷ 16	=____7__(N_{32})
Total loops (Sum of entries under column B)				=___67___(N_L)

Note: All calculations should be rounded up to the next integer.

*Iterative procedure may be needed, if the number of network modules required was not correctly estimated at the outset.

Conclusion:

N_L <= 26 , Option 51C

16 < N_L <= 32 Option 61C

32 < N_L <= 160 Option 81C

TDS/CON loops = 6	three Network Modules is initially estimated
N_1 = [(600)/ 30] = 20	loops for agent, supervisor sets and trunks
N_{2p} = [(900)/30] = 30	loops for PRI trunks
N_{31} = [112/30] = 4	loops for MIRAN ports
N_{32} = [112/16] = 7	loops for MM (MIVR) ports

Total required loops = 6 + 20 + 30 + 4 + 7 = 67

An Option 81C can have up to 160 loops. With 32 loops per module, our initial estimate of 3 network modules was correct.

Because the configuration requires an Option 81C, it is not necessary to check the card slot limitation.

2 Real-time Requirement

The worksheet has been shortened to include only that features that are being used in this configuration. The charges for Symposium assume the “simple script”, which is defined as “calls routed directly to an agent after receiving one cycle of MIRAN plus MUSIC but no voice processing”. This is exactly the scenario we are modeling.

Feature	**Usage**	×	**Real Time Factor**	**=**	**EBC**
Busy hour calls	12000	×	.20	=	2400
Digital set calls	12000	×	.00	=	0
ACD (Inbound) calls	12000	×	.15	=	1800
Symposium - overhead	12000	×	1.33	=	15960
Symposium - simple treatment with MIRAN	12000	×	2.06	=	24720
MIVR with transfer	12000	×	1.78	=	21360
PRA calls, incoming	12000	×	.15	=	1800
Superloop port involvements	12000	×	–.19	=	-2280

Total real-time impact (add up the EBC column) EBC = 65760.

Total system EBC = 12000 basic + 65760 feature cost = 77760 EBC

Total EBC capacity (70% to allow for peaking.) =

if CP3 processor: 80025

if CP4 processor: 111025

Percent CP usage =

if CP3 processor: 77760 / 80025 = 97.2%

if CP4 processor: 77760 / 111025 = 70.0%

3 Result

This Call Center can be served by an Option 81C CP3 Meridian 1. However, the CP has a spare capacity of only 2.8% when fully loaded.

To keep the next examples short, the loop, card slot, and real-time worksheets will not be used. Instead the calculation procedure is used.

A Call Center with Meridian Link and Predictive Dialing

Model: 200 inbound agents, 40 outbound agents. 650 PRI trunks and 22 D-channels, 80 analog trunks. Center must support 5000 inbound calls and 15000 outbound calls per hour. The outbound calls are placed by 300 2500-type lines, controlled by a predictive dialing application connected through Meridian Link to a host and the Meridian 1. Only 5 percent of calls are answered and transferred to a live agent. All inbound calls are controlled by CCR. There are 500 administrative digital sets with 6 CCS per set. Average holding time per call is 150 seconds. Also determine the data link requirements.

Solution:

1 Loop requirement

TDS/CON loops = 6	the initial estimate of TDS/CON card is three
$N_0 = [(500 \times 6 + 80 \times 28)/875] = 6$	80 analog trunks are placed in superloops
$N_1 = [(200 + 40 + 300)/30] = 18$	autodialer ports and high traffic ports require nonblocking
$N_{2p} = [(650 + 22)/24] = 28$	loops for PRI trunks

Total network loops required = 6 + 6 + 18 + 28 = 58. It is within the capability of an Option 81C with at least 3 network groups. For regular traffic, the CCS can be divided by either 660 or 875 CCS to determine the number of loops needed. It ultimately is decided by whether IPE or EPE has spare loops for this type of traffic without requiring another card slot. In this example, all non-PRI/DTI loops are using IPE.

Because the configuration requires an Option 81C, no checking on the card slot limitation is needed.

2 Real-time requirement (Release 24B factors)

Administrative telephone calls = $(500 \times 6/1.5) \times 0.5$ = 1,000 calls

Basic Call EBC = $(5000 + 15000 + 1000) \times 1$ = 21,000 EBC

Incoming ACD EBC = 5000×0.15 = 750 EBC

CCR (scriptless) EBC = 5000×1.31 = 6,550 EBC

Outgoing ACD EBC = 15000×0.50 = 7,500 EBC

Predictive Dialing EBC (Meridian Link call transfer factor) = $15,000 \times 0.05 \times 1.72$ = 1,290 EBC

Outgoing trunk calls EBC = $15,000 \times 0.19$ = 950 EBC; assumed CO trunks

Incoming PRA EBC = $5,000 \times 0.15 \times (650/(650 + 80))$ = 668 EBC

Outgoing PRA EBC = $15,000 \times 0.25 \times (650/(650 + 80))$ = 3,340 EBC; PRA calls are proportional to the total trunks.

Total EBC used = 21,000 + 750 + 6,550 + 7,500 + 1,290 + 950 + 668 + 3,340 = 42,048

Percent CP usage:

on CP3 processor = 42,048 / 80,025 = 53%

on CP4 processor = 42,048 / 111,025 = 38%

3 Data link requirements

The number of Predictive Dialer calls is 15,000 and the number of CCR calls is 5,000. Together that is 20,000 calls, which is within the 12,331 - 24,660 call capacity range of a 19,200 baud link. With co-residency, one link of 19,200 baud is able to handle all signaling traffic of this application.

4 Result

The required configuration can be handled by an Option 81C CP3 processor. The projected CP load is 53 percent of the rated capacity. A data link at 19,200 baud is needed for the ML and CCR applications.

A Networked Inbound Call Center

This is an example using Release 21 real time factors, and a typical configuration of that vintage. The same principals can be applied to later releases by updating the real time factors and the selection of machine types we have available. Unlike the previous two examples, this illustrates checking the card slot limitation.

Model: 73 agents, 5 supervisors. 64 PRI trunks, 22 analog trunks. There are also 21 TIE trunks to two other centers through NACD interflowed. Center must support 2000 inbound calls per hour. 25 percent of calls are interflowed to the two other centers. There are 48 administrative sets with 6 CCS per set. Meridian Mail (8 ports) is used for non-ACD application. A MAX is included in the Center, every call has a CDR record and 35 percent of calls served have to go through RAN (8 trunks) and Music (30 ports) while queuing. Average holding time per call is 120 seconds.

Solution:

1 Loop requirement

TDS/CON loops = 2	assumed one module (Option 21)
$N_0 = [(48 \times 6 + 21 \times 26)/660] = 2$	admin. sets and tie trunks are lumped together
$N_1 = [(73 + 5 + 22 + 8)/30] = 4$	loops for agents, analog and RAN trunks
$N_{2p} = [(64 + 2)/24] = 3$	loops for PRI trunks
$N_{31} = [30/30] = 1$	loops for Music
$N_{32} = [8/24] = 1$	loops for Meridian Mail ports

Total loops required = 2 + 2 + 4 + 3 + 1 + 1 = 13

The loop requirement can be met by an Option 21.

2 Card slot requirement

With PRI trunks, we will consider only the case with the NT8D35 Network Module included.

TDS/CON = 1	
$[N_0/2] = 2/2 = 1$	ENET loop is proposed for regular traffic
$[N_1/4] = 4/4 = 1$	a full superloop for high traffic ports
$[(N_{2p} + N32)/2] = [(3 + 1)/2] =2$	slots for EPE loops (PRI and Meridian Mail)
CC in Option 21 = 1	tentatively assumed using Option 21
Card for Music = 1	the CON of the second TDS/CON for Music
I/O ports slots = 2	2 MSDL for 2 DCHIs, Meridian Mail, Meridian MAX, and CDR

$S_c = 1 + 1 + 1 + 2 + 1 + 1 + 2 = 9$

This card slot requirement exceeds the capacity of an Option 21. Therefore, an Option 61 is needed.

3 Real-time requirement

Supervisor telephone calls = 5 × 9.2 = 46

Administrative telephone calls = 48 × 6/1.2 × 0.5 = 120

Basic Call EBC = (2,000 + 46 + 120) × 1 = 2166 EBC

Digital set EBC = (2,000 + 46 + 120) × 0.14 = 303 EBC

Incoming ACD EBC = (2,000 + 46) × 0.14 = 286 EBC

NACD Overflowed Call EBC = 2,000 × 0.25 × 2.89 = 1445 EBC

RAN/MUS traffic in EBC = 2,000 × (1 – 0.25) × 0.35 × (0.37 + 0.46) = 436 EBC

MAX EBC = 2,000 × 0.81 = 1,620 EBC

CDR Record (inc.) EBC = 2,000 × 1.25 = 2,500 EBC

Meridian Mail Call EBC = 120 × 1.05 × 0.1 = 13 EBC (assumed 10 percent of non-ACD calls being diverted to MMail boxes and with CSL signaling)

Incoming DTN trunk EBC = 2,046 × 0.11 = 225 EBC

Outgoing tie trunk EBC = 2,000 × 0.25 × 0.15 = 75 EBC

Incoming PRA calls EBC=2,046 × (64/(64 + 22)) × 0.16 = 244 EBC

Total EBC used = 2,166 + 303 + 286 + 1445 + 436+ 1,620 + 2,500 + 13+ 225 + 75 + 244 = 9,313 EBC

Percent CP usage = 9,313/22,500 = 41%

Since we are using Option 61 due to the card slot requirement, the EBC of 22,500 from Real-time Capacity Table for Option 61 is used. Note that even if there is no card slot limitation, the number of required EBC (9,313) exceeds the Option 21's capacity of 5,800 EBC. The system will require a larger system than an Option 21.

4 Result

The required configuration exceeds the capacity of an Option 21 in both card slot and real-time limitations. Therefore, an Option 61 is required which will provide plenty of spare capacity for future growth.

A Call Center with HEVP

This is an example using Release 21 real time factors, and a typical configuration of that vintage. The same principals can be applied to later releases by updating the real time factors and the selection of machine types we have available.

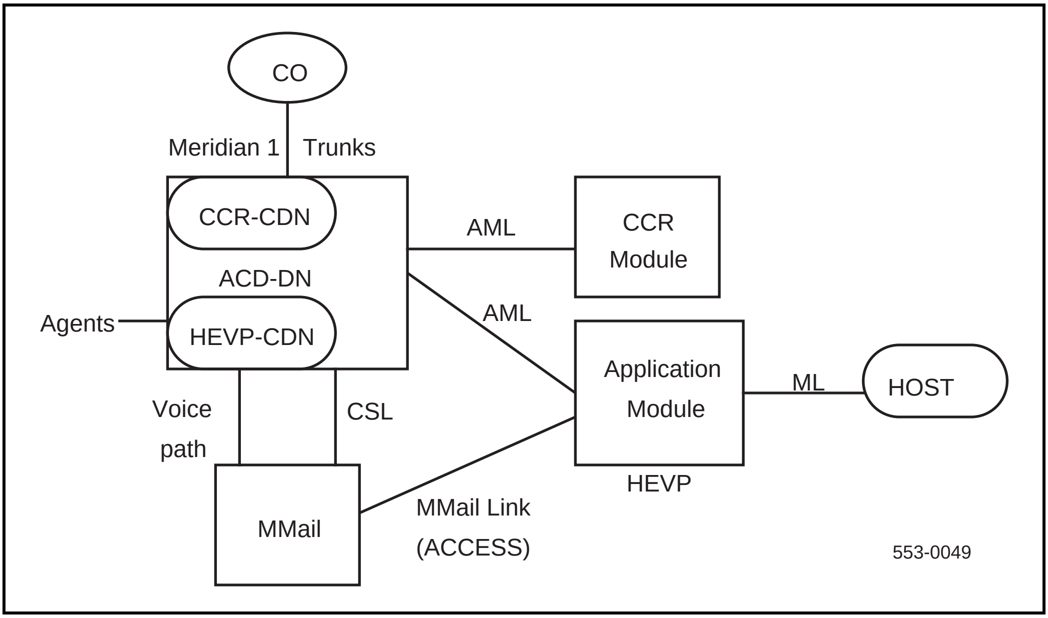
Model: A Call Center with 480 agents, 50 supervisors, 760 trunks of which 510 are PRI. 20 percent of all calls go to HEVP CDN first, half of them use voice menu for 90 seconds and disconnect; the other half will transfer to live agents after using voice ports for 20 seconds and be served. 60 percent of the remaining total calls will terminate on ACD TNs, the remaining 40 percent will terminate on CCR Cottons. Assume that the average service time of a call by live agent is 180 seconds regardless of its source. Although there are some shorter calls, because of queues, average holding time per trunk is also 180 seconds.

Questions to be answered:

- Is this configuration within the loop capacity of a Meridian 1?
- How many incoming calls are to be processed in this scenario?
- How many MM ports are needed to serve this HEVP?
- Which option of Meridian 1 is needed to handle this configuration and at what level of CP load?
- What data rates are required at various signaling links?

The block diagram of a typical HEVP application is given in Figure 8. Note that a common platform for CCR and HEVP applications is not available before X11 release 20.

Figure 8
A simplified HEVP configuration



Solution:

This scenario is simplified to concentrate on HEVP related issues only. Other applications demonstrated earlier can be superimposed on the HEVP feature to give a complete picture of a Call Center application.

We will deal with the questions one by one:

1 Loop capacity

The information to determine loop requirement is not complete until we know how many voice ports on the MM are needed. Item 3 in this solution text indicates 44 ports are needed.

The required number of loops are:

TDS/CON loops = 8	re-calculated after initial estimate
$N_1 = [\{480 + 50 + (760 - 510)\}/30] = 26$	either IPE or EPE will do
$N_{2p} = [(510 + 2)/24] = 22$	card slots for PRI loops
$N_3 2 = [44/16] = 3$	Meridian Mail ports based on HEVP port calculation (item 3 below)
$N_L = 8 + 26 + 22 + 3 = 59$	

Physically, the system has to be a 2-group (4 Network Modules) Option 71 or 81. There is no need to check card slot limitations for a large system.

2 Total system calls

The default CCS per trunk is 28, therefore, calls per trunk is 15.56 (= 28/1.8).

Total incoming ACD calls/hour = $760 \times 15.56 = 11,826$.

HEVP CDN calls = $11,826 \times 0.2 = 2365$

HEVP calls with transfer = $2365 \times 0.5 = 1183$

CCR CDN calls = $11,826 \times (1 - 0.2) \times (1 - 0.6) = 3784$

3 HEVP ports

Traffic calculation:

$$CCS = (2369 \times 0.5 \times 90 + 2369 \times 0.5 \times 20)/100 = 1066 + 237 = 1303$$

From Table 27, 44 voice ports are needed to handle 1303 CCS.

4 CP loading

Basic Call EBC = $1 \times 11{,}826 = 11{,}826$

Digital set calls EBC = $11{,}826 \times 0.14 = 1{,}656$ (assumed all digital)

ACD EBC = $11{,}826 \times 0.14 = 1{,}656$

HEVP EBC = $2{,}365 \times 0.51 = 1206$ (used MIVR factors for HEVP)

HEVP with transfer EBC = $1{,}183 \times 1.78 = 2{,}106$

CCR EBC = $3{,}784 \times 1.31 = 4{,}957$

Incoming trunk calls EBC = $11{,}826 \times 0.11 = 1{,}301$

PRA calls EBC = $11{,}826 \times (510/760) \times (0.16) = 1{,}270$

Total system EBC = 11,826 + 1,656 + 1,656 + 1,206 + 2,106 + 4,957 + 1,301 + 1,270 = 25,978

Percent CP usage = 25,978 / 22,500 = 115%

Option 71 with call capacity of 22,500 EBC (from Table 10) will not be able to handle this configuration. An Option 81C with CP1 processor will be required.

5 Signaling link requirements

According to Table 28, 3,784 CCR calls require a data link of 4800 baud. 2365 HEVP calls need a data link of 2400 baud. The ACCESS link (Meridian Mail Link) is a fixed 9600 baud link. The CSL link is also a fixed 4800 baud link.

Configuration parameters

Design parameters are constraints on the system established by design decisions and enforced by software checks. A complete list is given in the Appendix, with default values, maximums and minimums, where applicable. Although defaults are provided in the factory installed database, the value of some of these parameters are to be set manually, through the OA&M interface, to reflect the actual needs of the customer's application.

For guidelines on how to determine appropriate parameter values for call registers, I/O buffers, and so on, see "Mass storage size" on page 99.

Multi-purpose serial data link

Content list

The following are the topics in this section:

Reference list

The following are the references in this section:

- *Traffic Measurement: Formats and Output* (553-2001-450)
- *Capacity Engineering* (553-3001-149)
- *X11 Administration* (553-3001-311)

The MSDL (Multi-purpose Serial Data Link) I/O card has greatly enhanced the I/O capability of the Meridian 1. Prior to the introduction of the MSDL card, a Meridian 1 system could support a total of 16 I/O ports. Now, a system can support up to 16 MSDL cards, each of which can be flexibly configured to support combinations of SDI, AML, CSL, and DCH on 4 ports, for a total of 64 I/O ports.

With this added flexibility and capability, however, comes additional complexity. Applications that were once relatively isolated from one another are now competing for resources on the MSDL, resulting in new interactions. Problems with a single application have the potential of disabling the entire card, jeopardizing other applications. Meanwhile, the MSDL, is being asked to do more as the core processor has become faster, with the introduction of the 68040 and 68060 processors. It becomes essential, then, to engineer the MSDL card to minimize the risk of performance problems. This document provides guidelines to help the user in engineering the MSDL.

Note that these engineering guidelines assume normal traffic consisting of valid call processing and administrative messages. For example, engineering rules cannot prevent a piece of equipment on the network from malfunctioning and generating spurious messages which overload the MSDL. At this point the recovery mechanism becomes essential. The mechanism should be graceful, not requiring manual intervention, and should provide as much diagnostic information as possible, to help isolate the root cause of the problem. Refinements and improvements to the recovery mechanisms have been introduced over various software releases.

The D-channel expansion feature increases the number of I/O addresses allowable for D-channel application to 16 per network group and 256 per system. The number of non-D-channel applications is still limited to 16 per system (or 64 if all MSDLs are used).

As a result of this expansion, a study was conducted which looked into capacity constraints of configurations utilizing a high number of D-channels. Even though the new limit is set at 256 D-channels, a more realistic upper limit was obtained for practical applications.

The main conclusions of the D-channel expansion impact study are:

- For office/commercial applications: In a fully equipped 8-group Meridian 1, the optimal configuration in terms of port capacity and trunking percentage (15%) will require about 112 D-channels, assuming one D-channel per T1. The same optimal configuration can be reached with fewer D-channels in E1 applications.
- For Call Center applications: About 144 D-channels can be deployed to achieve a trunk to agent ratio of 1.5 and 2,400 agents. The optimal configuration can be reached at 136 D-channels for E1 applications.
- The current MSDL card is used for D-channel expansion. When multiple D-channels are configured on a card, the MSDL engineering guidelines should be strictly followed. Otherwise, there is no direct capacity impact.

As long as feature penetration is accounted for in the Meridian 1 real time engineering model, D-channel expansion has no direct impact on CP capacity.

Overview

Engineering the MSDL requires an understanding of the end-to-end performance characteristics of the system, including the Meridian 1, MSDL, link, and terminating or originating node. Outgoing messages originate from the Meridian 1 CP, are passed to the MSDL, and travel across the appropriate link to the destination. In equilibrium, or over a relatively long period of time, i.e. on the order of several minutes, the Meridian 1 cannot generate messages faster than the MSDL processor can process them, than the link can transmit them, or than the destination can process them. Otherwise, messages will build up at the bottleneck and will eventually be lost. The entity with the lowest capacity will be the system bottleneck. For very short periods of time, however, one or more entities is able to send messages at a higher rate than the system bottleneck, since buffers are available to queue the excess messages. These periods are referred to as bursts. The length of the burst and the size of the burst that can be supported depend on the sizes of the buffers.

Thus, to properly engineer a system, two areas are considered: equilibrium or steady-state performance which requires an analysis of the CP processing capacity of the various components of the system along with link bandwidth; and burst performance which requires an analysis of the buffer utilization of the system. The equilibrium analysis assumes 30% peakedness which is consistent with models for the Meridian 1 CP.

The applications which will be discussed here are: DCH, CSL/AML, and SDI. The Meridian 1 CPs considered include the 68030, 68040, and 68060 processors.

Section provides a brief overview of the MSDL architecture. “DCH” on page 144 through “SDI” on page 159 describe general conditions for equilibrium and peak engineering for key applications. A step-by-step procedure for engineering the MSDL is provided in “MSDL Engineering Procedure” on page 164. Several examples of the engineering procedure are given in “Examples” on page 170.

MSDL Architecture

The MSDL processor is a 68020 processor. The MSDL and Meridian 1 exchange messages using an SRAM and interrupt scheme. To prevent any one application from tying up buffer resources, a flow control mechanism is defined at the Meridian 1 and MSDL/MISP interface level, where Meridian 1 denotes the call processing software running on the Meridian 1 core CP. The flow control mechanism is based on the common window mechanism in which the number of messages outstanding in the transmit or receive direction per socket, or port, cannot exceed T(K) or R(K), respectively. In the transmit direction, for example, a message is considered outstanding from the time the SL-1 software writes it into the transmit ring until all processing of the message by the MSDL is completed. Currently T(K) and R(K) are both set at 30. Each application must queue messages if the flow control threshold is exceeded. Typically, the Meridian 1 task also has a buffer for messages.

An overload control threshold is also implemented in the incoming direction to protect the Meridian 1 CP from excess messages. To account for the new, faster processors, the thresholds have been changed so that MSDL304 is printed if 100 messages in 2 seconds is exceeded, MSDL305 is printed if 200 messages in 2 seconds is exceeded, and MSDL306 is printed and the card is disabled if 300 messages in 2 seconds is exceeded. In both cases Background Audit will bring the MSDL back up if no problems are found. The Port Overload Counter is introduced. If the incoming messages on a single port exceed 200 messages in 2 seconds, the port will be locked out, and an MSDL_port_overload message will be printed. Manual intervention is required to clear the overloaded port. This feature prevents a single port from locking up the whole MSDL card.

Several software tasks exist on the MSDL. Layer 1 message processing operates at the highest priority. If the link is noisy, Layer 1 processing may starve the Layer 2 and Layer 3 processing tasks, resulting in buffer overflows. If such a problem is suspected, the Protocol Log (PLOG) should be examined. PLOG reporting is requested in Overlay 96, as described in the *X11 Administration* (553-3001-311).

DCH

For interfaces including NI-2, Q-SIG, and Euro-ISDN, Layer 3 processing is also performed on the MSDL, so the MSDL performs some functions previously performed by the Meridian 1 core processor, thus reducing the capacity on the MSDL. These interfaces will be referred to as R20+ interfaces. The steady state message rate allowable for D-channel messages is 29 msg/sec for R20+ interfaces.

The SL-1 software output queue for DCH messages is the Output Buffer (OTBF) which is user configurable for between 1 and 127 buffers in Overlay 17. This is a single system resource which is shared by all D-channels.

It is possible to define overload thresholds for R20+ interfaces on a per-D-channel basis. The ISDN_MCNT (ISDN message count), defined in Overlay 17, specifies the number of ISDN Layer 3 call control messages allowed per 5-second interval. Overload control thresholds can be set on a per D-channel basis, ranging from 60 to 350 messages in a 5 second window, with a default of 300 messages. If the overload control threshold is exceeded, DCH421 is output. When the message rate exceeds the threshold for two consecutive 5 second periods, overload control is invoked and new incoming call requests are rejected by the Layer 3 protocol control in the third 5 second time interval. Layer 3 will resume accepting new calls at the end of the third time interval. This flexibility allows the user to regulate the MSDL processing required by a specific R20+ DCH port. Note that the default value implies no overload control since 300 messages/5 seconds exceeds the rated capacity of 29 messages/second.

PRI Network

Equilibrium Analysis

A D-channel can be configured to support up to 383 B-channels (or 382 with a back-up D channel) on a T1 or 480 B-channels on an E1. The bandwidth available for messages is 64 kbps. Assumptions for a typical application are: 8 messages/call, 29 bytes/message, including 18 bytes of Layer 3 data and 11 bytes of Layer 2 overhead, 28 centi-call seconds (CCS)/trunk, and 180 second Average Hold Time (AHT)/call. The Meridian 1 capacity is derived from its call carrying capacity for 100% incoming PRI calls.

Under the traffic assumptions described above, the MSDL is able to support basic call processing messages for 4 D-channels under normal operation (see Table 31).

Table 31
Steady-state requirements and capacities per D-channel (outgoing and incoming)

	Requirement msg/sec	Meridian 1 CP capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	
68060 CP	13(T1)/16(E1)	161	87	212 input 212 output	Limited by traffic requirements
68060E CP	13(T1)/16(E1)	242	87	212 input 212 output	Limited by traffic requirements

Peak Analysis

When there is a link re-start, STATUS messages are sent to all trunks with established calls. Since the SL-1 software task does not implement flow control on this mechanism, a burst of up to several hundred messages can be sent to the MSDL, exceeding MSDL flow control thresholds. When this happens, messages back up on the OTBF buffer, possibly resulting in buffer overflow, as indicated by DCH1030 messages. OTBF overflow is also possible after an initialization since a burst of messages is sent to each D-channel in the system, and the OTBF is a shared system resource.

The Meridian 1 capacity is significantly higher in this scenario than in the previous one because it is sending out D-channel messages which do not involve call processing. MSDL and Link capacities are also higher because, for equilibrium analysis, some capacity is reserved for peaking.

Table 32 illustrates the worst case scenario for a single D-channel. If the Meridian 1 sends messages at its peak rate, OTBF buffer overflow is possible. Also, once the messages are sent, a burst of responses can be expected in the incoming direction, resulting in additional congestion at the MSDL.

Table 32
Peak requirements per D-channel (outgoing)

	Burst Size	Meridian 1 capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	
68060 CP	382(T1)/480(E1)	410	113	276 output	MSDL is bottleneck
68060E CP	382(T1)/480(E1)	615	113	276 output	MSDL is bottleneck

This situation also occurs when a back-up D-channel becomes active, since STATUS messages are exchanged to resynchronize the link.

To reduce the possibility of this problem occurring, limit the number of B-channels supported by a D-channel, separate D-channels onto several MSDL cards so that message bursts are not being sent to four ports on the same MSDL after initializations, and increase the size of OTBF to the maximum value of 127.

The Status Enquiry Message Throttle is implemented. This feature applies only to Meridian 1 to Meridian 1 interface networks and allows the user the configure the number of Status Enquiry messages sent within 128 msec on a per D-channel basis. The parameter, SEMT, is set in Overlay 17, and can range between 1 and 5. The default value is 1. Since this feature provides a flow control mechanism for Status Enquiry messages, the likelihood of buffer overload is reduced.

B-channel Overload

In an ACD environment in which the number of ACD agents plus the maximum ACD queue length is considerably less than the number of B-channels available for incoming calls, a burst of incoming messages may impact the performance of the MSDL as well as the Meridian 1 via the following mechanism: Calls from the CO terminate on a specified ACD queue. When the destination is busy, i.e. the destination set is busy or the ACD queue has reached its maximum limit of calls, the Meridian 1 immediately releases the call. The CO will immediately present another call to the same destination, which is released immediately by the PBX, etc.

The B-Channel Overload Control feature is introduced to address this problem by delaying the release of an ISDN PRI call by a user-configurable time when the call encounters a busy condition. The delay in releasing the seized B-channel prevents a new call from being presented on the same B-channel, decreasing the incoming call rate. The timer BCOT is set in Overlay 16, and falls in the range 0 to 4000 msec.

ISL Network

In an ISL application, a modem is used to transmit ISDN signaling messages. Baud rates are user configurable at the standard RS232/RS422 rates: 300, 1200, 2400, 4800, 9600, and 19200 bps (see Table 33). In this case, the modem baud rate constraint can be the limiting constraint. The messages/second that can be supported by the baud rates are given below, where the values allow for 30% peakedness.

The B-channels that can be supported assume the messaging required for a typical application as described in “Equilibrium Analysis” on page 144.

Table 33
ISL link capacities

Modem Baud Rate	Link capacity msgs/sec	B-channels that can be supported
300	1 input 1 output	46
1200	4 input 4 output	180
2400	7 input 7 output	316
4800	15 input 15 output	382(T1)/480(E1)
9600	29 input 29 output	382(T1)/480(E1)
19200	58 input 58 output	382(T1)/480(E1)

For the baud rates listed in Table 33, the link will be the limiting constraint. The potential peak traffic problems described in Section apply here as well, to an even greater extent since the rate mismatch between the Meridian 1 and the system bottleneck, now the link instead of the MSDL, is greater. To minimize the risk, set the baud rate as high as possible.

VNS Network

The discussion concerning ISL networks applies to VNS networks as well. Up to 4000 VDNs are supported.

NACD Network

A Network ACD (NACD) network is difficult to engineer since performance depends on specific network configuration details including connectivity, routing tables, the number of nodes, the number of queues at each node, and calling patterns.

Diverting calls in NACD is controlled by Routing Tables with timers. Calls diverted by NACD can be answered by the Source ACD DN or any one of up to 20 Target ACD DNs. Each Target can have an individual timer defined, from 0 to 1800 seconds. By using ISDN D-channel messaging to queue Call Requests at remote Target ACD DNs, voice calls are not physically diverted until an idle agent is reserved for that call at the remote Target node.

It is recommended that the Routing Table be designed so that Call Requests cascade to the network with the timers staggered. The node that is most likely to have available agents should have the smallest timer value. Otherwise Call Requests will flood the network, resulting in inefficient use of network and real time resources.

An Active Target is available to accept NACD calls, while a Closed Target is closed to incoming calls. When calls in the Call Request queue exceed the Call Request Queue Size (CRQS) threshold, the status changes to Closed. A Status Exchange message is sent from the Target node to the Source ACD DNs indicating the new status. The Target ACD DN remains Closed to further network call requests until the number of calls in the queue is reduced by the Flow Control Threshold (FCTH).

Equilibrium Analysis

At the source node, for each call queued to the network but not answered, 4 messages are exchanged. For each call queued to the network and answered, 11 messages are exchanged. Likewise, at the target node, a network call that is queued but not answered requires 4 messages while a call that is queued and answered requires 11 messages. Messages average 31 bytes.

From a single D-channel perspective, the most difficult network topology is a star network in which each agent node is connected to a tandem node (see Table 34). All messages to the other nodes are sent across the D-channel connected to the tandem node. As an example, consider a site with 2000 calls arriving locally during the busy hour. The timers in the Routing Table are staggered so that 1000 are answered locally without being queued to the network, 500 are answered locally after being queued to an average of two network target queues, and 500 are answered in the network after being queued to an average of four network target queues. Meanwhile, 200 Logical Call Requests arrive from the network, of which 100 calls are answered.

Table 34
Steady-state requirements and capacities per D-channel with staggered timers (outgoing and incoming)

	Requirement msg/sec	Meridian 1 CP capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	
68060 CP	5	161	87	212 input 212 output	Limited by traffic requirements
68060E CP	5	242	87	212 input 212 output	Limited by traffic requirements

For this same network, assume now that the timers in the Routing Table are not staggered; instead, Logical Call Requests are broadcast to the four target nodes in the network as soon as calls arrive at the local node. Also assume that a total of 4000 calls arrive elsewhere in the network, and are queued at local ACD DNs. Even if the calls are answered exactly where they were before, the number of messages exchanged will increase significantly, to the values provided in Table 35, using the following calculations:

- 1500 calls queued on 4 ACD DNs and not answered * 4 msgs/call/DN = 24000 msgs
- 500 calls answered * 11 msgs/call = 5500 msgs
- 500 calls queued on 3 ACD DNs and not answered * 4 msgs/call/DN=6000 msgs
- 3900 network calls queued on local DN and not answered * 4 msgs/call=15600 msgs

- 100 network calls answered * 11 msgs/call=1100 msgs
- Total 52200 msgs/hr
- (52200 msgs/hr) / (3600 secs/hr) = 14.5 msgs/sec

Table 35
Steady-state requirements and capacities per D-channel with immediate broadcast of Logical Call Requests (outgoing and incoming)

	Requirement msg/sec	Meridian 1 CP capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	
68060 CP	14.5	161	87	212 input 212 output	Limited by traffic requirements
68060E CP	14.5	242	87	212 input 212 output	Limited by traffic requirements

Peak Analysis

When the CRQS threshold is reached, the target queue will broadcast messages to the source ACD DNs informing them that it will no longer accept calls. The size of this outgoing burst of messages depends on the number of source ACD DNs in the network.

Once the FCTH threshold is reached, another Status Exchange message is sent. At that point, Logical Call Request messages are sent by the Source ACD DNs. While the target queue has been closed, many calls may have queued at source ACD DNs, resulting in a burst of Logical Call Request messages once the DN becomes available.

Unlike the PRI network case, there is no specific worst case scenario for peakedness. The examples in Tables 36 and 8 are based on a 5 node network, where each node has three source ACD DNs.

Table 36
Peak requirements for NACD messages (outgoing)

	Burst Size	Meridian 1 capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	
68060 CP	12	410	113	258 output	MSDL is bottleneck
68060E CP	12	615	113	258 output	MSDL is bottleneck

Table 37
Peak requirements for NACD messages (incoming)

	Burst Size	Meridian 1 capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	
68060 CP	40	410	113	258 input	MSDL is bottleneck
68060E CP	40	615	113	258 input	MSDL is bottleneck

If CRQS values are set high, many messages will be exchanged, with the network emulating a single virtual queue. If the CRQS values are lowered, fewer Call Requests will be sent across the network, however, average source delays may be increased. If FCTH levels are set too low, target nodes can ping pong between Active and Closed states, resulting in network congestion and excessive real time utilization. However, if FCTH levels are set too high, a target node may be inundated with Logical Call Request messages once it becomes available. CRQS is configurable for the range [0, 255], while FCTH is configurable for the range [10, 100]. Since the impact of these parameters is so configuration dependent, it is beyond the scope of this document to make recommendations on how to configure them. They should be determined as part of the custom network design process. Contact your local Nortel Networks representative for network engineering services.

Impact of Proper Engineering of B-channels

In the NACD environment another problem arises when insufficient B-channels are configured across the network. When an agent becomes available, an Agent Free Notification message is sent to the source node. An ISDN Call Setup message is sent from the source node to the target node. Since no B-channel is available, the agent reservation timer expires, and an ISDN Cancellation Message is sent from the target node to the source node and an ISDN Cancellation Acknowledge message is sent from the source node to the target node. At this point, the agent is still free, so the process repeats until a trunk becomes available or the target closes. This scenario results in a significant amount of message passing.

Parameter Settings

The following are parameters that can be configured in Overlay 17 for Meridian 1 D-channels. They are listed with their input range and default value in ( ).

OTBF 1 - (32) - 127: Size of output buffer for DCH
This parameter configures how many output buffers are allocated for DCH messages outgoing from the Meridian 1 CP to the MSDL card. The more that are created, the deeper the buffering. Normally a message created in a buffer is sent to the MMIH (Meridian MSDL Interface Handler) and copied into the ring. If the ring is flow controlled, the message occupies a buffer until it can be sent. For systems with extensive D-channel messaging, such as call centers using NACD, the parameter should be set at 127. For other systems with moderate levels of D-channel messaging, OTBF should be set at the smaller of the following two quantities: Total B-channels - (30 * MSDL cards with D-channels) or 127.

For example, if a system in a standard office environment is configured with 7 T1 spans, 2 D-channels which are located on two different MSDLs, and 2 back-up D-channels, the total number of B-channels is (7*24)-4=164. OTBF should be configured to be the smaller of 164-(30*2)=104 and 127 which is 104.

T200 2 - (3) - 40: Maximum time for acknowledgment of frame (units of 0.5 secs)
This timer defines how long the MSDL's Layer 2 LAPD will wait before it retransmits a frame. It if doesn't receive an acknowledgment from the far end for a given frame before this timer expires, it will retransmit a frame. Setting this value too low can cause unnecessary retransmissions. The default of 1.5 seconds is long enough for most land connections. Special connections, over radio, for instance, may require higher values.

T203 2 - (10) - 40: Link Idle Timer (units of seconds)
This timer defines how long the Layer 2 LAPD will wait without receiving any frames from the far end. If no frames are received for a period of T203 seconds, the Layer 2 will send a frame to the other side to check that the far end is still alive. The expiration of this timer causes the periodic "RR" or Receiver Ready to be sent across an idle link. Setting this value too low causes unnecessary traffic on an idle link. However, setting the value too high will delay the system from detecting that the far end has dropped the link and initiating the recovery process. The value should be higher than T200. It should also be coordinated with the far end so that one end does not use a small value while the other end uses a large value.

N200 1 - (3) - 8: Maximum Number of Retransmissions
This value defines how many times the Layer 2 will resend a frame if it doesn't receive an acknowledgment from the far end. Every time a frame is sent by Layer 2, it expects to receive an acknowledgment. If it does not receive the acknowledgment, it will retransmit the frame N200 times before attempting link recovery action. The default (3) is a standard number of retransmissions and is enough for a good link to accommodate occasional noise on the link. If the link is bad, increasing N200 may keep the D-channel up longer, but in general this is not recommended.

N201 4 - (260): Maximum Number of Octets (bytes) in the Information Field
This value defines the maximum I-frame (Info frame) size. There is no reason to reduce the number from the default value unless the Meridian 1 is connected to a system that does not support the 260-byte I-frame.

K 1 - (7): Maximum number of outstanding frames
This value defines the window size used by the Layer 2 state machine. The default value of 7 means that the Layer 2 state machine will send up to 7 frames out to the link before it stops and requires an acknowledgment for at least one of the frames. A larger window allows for more efficient transmission. Ideally, the Layer 2 will receive an acknowledgment for a message before reaching the K value so that it can send a constant stream of messages. The disadvantage of a large K value is that more frames must be retransmitted if an acknowledgment is not received. The default value of 7 should be sufficient for all applications. The K value must be the same for both sides of the link.

ISDN_MCNT (ISDN Message Count) 60 - (300) - 350: Layer 3 call control messages per 5 second interval
It is possible to define overload thresholds for interfaces on a per-D-channel basis. This flexibility allows the user to regulate the MSDL processing required by a specific R20+ DCH port. The default value of 300 messages/5 seconds is equivalent to allowing a single port to utilize the full real time capacity of an MSDL. To limit the real time utilization of a single R20+ DCH port to 1/n of the real time capacity of the MSDL, for n > 1, set ISDN_MCNT to (300 / n) * 1.2 where the 1.2 factor accounts for the fact that peak periods on different ports are unlikely to occur simultaneously. For example, to limit a single port to 1/3 of the processing capacity of the MSDL, ISDN_MCNT is set to (300 / 3) * 1.2 = 120.

If the ISDN_MCNT threshold is exceeded for one 5 second period, error message DCH421 is printed. If the threshold is exceeded for two consecutive periods, incoming call requests arriving in the third 5 second interval are rejected by the MSDL Layer 3 software. At the end of the third 5 second interval, Layer 3 will resume accepting incoming call requests.

AML

The Application Module Link (AML) provides the connection between the Meridian 1 and the CCR, Meridian Link, or Meridian 911 module. The current maximum speed for the link is 19200 baud. CCR is the application addressed here because it is the one that results in the highest level of messaging. The amount of messaging involved depends on the complexity of call handling. Simple call handling results in approximately 10 messages per call, with an average of 45 bytes/message. Statistics messages are sent from the Meridian 1 to the CCR module every 4 seconds for ACD DNs referenced in the CCR variable table or scripts. Thus messaging levels depend not only on the number of calls handled but on the number of ACD DNs with statistics configured. **Current recommendations are that a system be limited to 80 ACD DNs with statistics.**

On the Meridian 1, messages queue in the CSQI and CSQO buffers, command status queue input and output buffers, which are configurable in Overlay 17.

Equilibrium Analysis

For equilibrium analysis, we focus on calls, and assume ten ACD DNs sending statistics messages. The Meridian 1 capacity assumes an inbound call center with simple CCR treatment on 100% of the calls, and Meridian MAX.

For large systems, the CCR module capacity is the system bottleneck see Table 38). Since there is no flow control or overload control available to protect the CCR module, it is essential that the system be engineered to ensure that the CCR module is not overloaded. Otherwise, link failures or other CCR performance problems may result. To engineer the CCR module, refer to the *Meridian Link/Customer Controlled Routing Engineering Guide* (553-3211-520).

Table 38
Steady-state requirements and capacities per AML (outgoing and incoming)

	Meridian 1 CP capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	CCR capacity msg/sec (167 module)	
68060 CP	74	107	41 input 41 output	46	CCR bottleneck
68060E CP	111	107	41 input 41 output	46	CCR bottleneck

Peak Analysis

Since message bursts are most likely to cause buffer overflow, we consider the system with 80 ACD DNs sending statistics messages every 4 seconds. Recall that this is the maximum recommended number for ACD DNs sending statistics. The Meridian 1 capacity is based on the real time required to process CCR statistics messages (see Table 39).

Table 39
Peak capacities for CCR statistics messages per AML (outgoing)

	Burst Size	Meridian 1 capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	CCR capacity msg/sec (167 module)	
68060 CP	80	920	139	53	60	AML bottleneck
68060E CP	80	1380	139	53	60	AML bottleneck

In this scenario, the AML link is the bottleneck. Messages will begin to queue in the MSDL output buffers and possibly the CSQO buffers, if there are many ACD DNs sending statistics messages.

The AML link will disable if 10 consecutive messages do not receive a response within a 4 second window. The CSA105 message is normally output when this occurs. If a message arrives immediately after the statistics messages for the 80 ACD DNs are generated, it may be queued behind these 80 statistics messages. For 80 messages, processing time at the MSDL, queueing time for the AML, and processing time at the CCR module add up to approximately 3 seconds, so it is easy to understand how the 4 second threshold might be exceeded if the MSDL is also processing messages from other applications.

AML can be configured on the Meridian 1 embedded LAN (ELAN). In this configuration, the AML is no longer the bottleneck.

In Meridian Link applications, similar types of problems may occur when the host is too slow and becomes the system bottleneck.

Parameters

On the Meridian 1 side, AML messages are queued in the CSQI/CSQO buffers, which are shared with the CSL. The maximum configurable size of each is 25% of the number of call registers in the system or 255. It is recommended that 68060 CP systems configure the CSQI and CSQO buffers to be 255. CSQO and CSQI sizes are configured in Overlay 17.

The flow control parameters MCNT and INTL for each AML are also set in Overlay 17. This flow control mechanism limits the number of messages sent from the CCR to the Meridian 1 to MCNT [5,9999] in the time interval INTL [1,12] where INTL is measured in units of 5 seconds. When this threshold is violated for one interval, a warning message is sent to CCR requesting that it slow down. If the threshold is violated for two consecutive periods, CCR rejects all new calls back to the Meridian 1 where they will receive default treatment. No new calls will be accepted until the level of traffic is reduced to an acceptable level. If the threshold is exceeded for three consecutive periods, all inbound traffic will be lost. If inbound traffic continues, the link will fail.

Recommended settings for MCNT and INTL are listed in Table 40.

Table 40
Recommended AML flow control values

MCNT	INTL
230	1

This mechanism was originally designed to protect the Meridian 1 from overload. With the faster processors, this flow control threshold is now being used to control traffic levels at the CCR module.

SDI

An asynchronous serial data interface was provided on the MSDL card. Capabilities include interface to TTYs, printers, modems, and CRTs, High Speed Link (HSL) for ACD, Auxiliary Processor Link (APL) for ACD, ACD-C package displays and reports, and CDR TTYs. An SDI port is only configurable on Port 0 of an MSDL. Therefore, only one SDI port can be configured on an MSDL.

Normally, in the output direction, the SDI Application will pass any character received from the Meridian 1 to the Layer 1 Driver to be sent out over the interface. If XON/XOFF Handling is enabled for printing, the SDI Application will buffer up to 500 characters once an XOFF is received. The Meridian 1 is not aware that an XOFF has been received. After the buffer is full, if further output is received, the oldest data will be discarded. Output resumes when an XON is received or 1 minute has passed since the output was halted by an XOFF. At this point, the contents in the buffer will be emptied first, followed by output from the Meridian 1. If any data has been discarded, an error message will be sent.

In the input direction, every character received by the Layer 1 Driver will be passed to the SDI Application. The SDI Application will echo any input character unless it is told not to by the Meridian 1. In Line Editing Mode, the SDI Application will buffer a line of up to 80 characters which can be edited before being sent to the Meridian 1.

Under certain conditions, control characters can cause messages to ping pong between a modem or printer and the Meridian 1, resulting in MSDL305 or MSDL306 conditions. To avoid these situations, configure modems in dumb mode and disable printer flow control.

The Meridian 1 input buffer is the TTY input buffer which can store 512 characters. The Meridian 1 output buffer is the TTY output buffer which can store 2048 characters.

CDR

CDR records are available in two formats: *FCDR=old* and *FCDR=new*. A typical record for the old format is 100 bytes long while a typical record for the new format is 213 bytes long (see Table 41). Due to the nature of the SDI interface, characters are output one at a time, resulting in 100 messages and 213 messages generated for *FCDR=old* and *FCDR=new*, respectively. Each message requires 10 bits. Based on real time measurements, the MSDL rated capacity for processing CDR messages is 16,631 messages/second.

Table 41
Link capacities for CDR application (outgoing)

Modem Baud Rate	Link capacity msg/sec (peak)	Calls/Hour for *FCDR=old*	Call/Hour for *FCDR=new*
300	30	831	390
1200	120	3323	1560
2400	240	6646	3120
4800	480	13292	6241
9600	960	26585	12481
19200	1920	53169	24962
38400	3840	106338	49924

Equilibrium Analysis

The Meridian 1 capacity for messages per second is conservatively based on the assumption of 100% outgoing calls with *FCDR=new*. Typically, CDR records are not generated for 100% of the calls (see Table 42).

Table 42
Steady state requirements for CDR application (outgoing)

	Meridian 1 CP capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	
68060 CP	2044	16631	See Table 41	19200 baud recommended
68060E CP	3066	16631	See Table 41	38400 baud recommended

Peak Analysis

Since each character is sent as a separate message, every time a CDR record is sent, a traffic peak is generated. In Table 43 we consider *FCDR=new*.

Table 43
Peak requirements for *FCDR=new* (outgoing)

	Burst Size	Meridian 1 capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec	
68060 CP	213	3090	21620	See Table 41	38400 baud recommended
68060E CP	213	4635	21620	See Table 41	38400 baud recommended

MSDL real time capacity is not the bottleneck in this case. However, to prevent system buffers from building up, the recommended baud rate should be set. If a lower baud rate is chosen, assume that the CDR application will frequently be in a state of flow control. Note that this is true even if the steady state message rate is low, due to the nature of the SDI interface.

The burst sizes will be even greater if CDR is configured with queue records for incoming ACD calls.

MAT customers with a network connection between their Meridian 1 and MAT PC have the option of bypassing the SDI port and sending the CDR records across the network to the PC for processing by MAT software.

Meridian MAX

The Meridian 1 communicates with Meridian MAX via the HSL (High Speed Link) using 8 bits plus one stop bit. Prior to MAX 8, the HSL bandwidth was 9600 baud. With MAX 8, 19,200 baud is available. Unlike the CDR application, MAX reports are not sent out character by character. The MAX report for a simple call is 5 messages of 20 bytes. The Meridian MAX module capacities are given in Table 44.

Table 44
Capacity of MAX Module in simple calls

	MAX Capacity (simple calls/hour)	MAX Capacity (msg/sec)
Meridian MAX Rls 4	10000	14
Meridian MAX Rls 5	15000	21
Meridian MAX Rls 6	15000	21
Meridian MAX Rls 7	15000	21
Meridian MAX Rls 8	30000	42
Meridian MAX Rls 9	30000	42

Equilibrium Analysis

The Meridian 1 capacity requirements are derived assuming a simple inbound call center with all calls answered by ACD agents and MAX reporting on all calls (see Table 45). Incoming CDR is not turned on.

Table 45
Steady-state requirements for Meridian MAX (outgoing)

	Meridian 1 CP capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec (9600/19200)	MAX module capacity
68060 CP	48	87	41/82	See Table 44
68060E CP	72	87	41/82	See Table 44

The 19,200 baud option for HSL is recommended for 68060 and 68060E CP systems.

Note that Meridian MAX messages queue on call registers. There is no software limit to the number of call registers that can be used to store MAX reports. If the PBX becomes overloaded, MAX messages may build up in the call registers, potentially impacting call processing since call registers may not be available for call setup.

Peak Analysis

Complex calls may require 15 or more messages per call. Depending on the configuration, the MSDL or the link could be the bottleneck. In either of these cases, messages queue in the system buffers (see Table 46).

Table 46
Peak requirements for MAX (outgoing)

	Burst Size	Meridian 1 capacity msg/sec	MSDL capacity msg/sec	Link capacity msg/sec (9600/19200)	MAX capacity
68060 CP	15	189	87	53/106	See Table 44
68060E CP	15	284	87	53/106	See Table 44

MSDL Engineering Procedure

It is important to engineer MSDLs in the context of engineering the entire system, as discussed in previous sections. Refer to *Capacity Engineering* (553-3001-149) and *Traffic Measurement: Formats and Output* (553-2001-450) for information on real time engineering of the Meridian 1. In all cases with a user configurable link rate, it is essential that the link be configured so that the rate is high enough to support steady state requirements and some peakedness. Otherwise these applications messages will occupy system buffers, increasing the chance of buffer overflow.

Table 47 is the high-level worksheet for analysis of MSDL capacity. The appropriate values can be derived from Table 48 through Table 53.

Table 47
MSDL Engineering Worksheet

Port	Application	Real Time Required	Peak Buffer Usage Outgoing	Peak Buffer Usage Incoming
0	____________	________	________	________
1	____________	________	________	________
2	____________	________	________	________
3	____________	________	________	________
Total		________	________	________

Assuming 30% peakedness for the applications, the total real time required should be less than 2,770,000 msec. The projected real time utilization of the MSDL is given by

MSDL_RTU = Total Real Time Required / 2,770,000.

It is recommended that peak buffer usage be less than 60 in each direction. As the peak buffer usage increases over 60, the likelihood of an intermittent buffer full problem increases.

Application Engineering

The following sections provide procedures for calculating the real time required on the MSDL for various applications. In any of these cases, if the calls/hour value is known, insert that value into Column A. Otherwise, follow the guidelines provided. Values in parentheses ( ) are default values. For example, the default number of calls/hr/trunk is 15.6. The value in Column E should be inserted in the Real Time Required column of Table 47 and the appropriate Peak Buffer Usage values should be inserted in the corresponding Peak Buffer Usage columns of Table 47.

DCH Applications

If several applications share a D-channel, the final real time requirements for the applications should be added and then entered in the appropriate entry in Table 48.

Table 48
MSDL real time requirements for D-channel applications

DCH	calls/hr A	msgs/call B	msgs/hr C=A*B	msec/msg** D	msec E=C*D
ISDN Network	trunks/DCH (see note)* calls/hr/trunk (15.6)= _____	8	_____	pre-R20: 8.8 R20+: 26.5	_____
NACD	NACD agents (see note)* calls/hr/agent (18.3)= _____	30	_____	pre-R20: 8.8	_____
NMS	NMS ports (see note)* calls/hr/port (65)= _____	10	_____	pre_R20: 8.8	_____

Note: For clarification of the terms “pre-R20” and “R20+,” refer to “DCH” on page 144

The calculations described for NACD provide a simplified approximation of a “typical” NACD network. If call flows can be predicted or estimated, they can be used to develop a more accurate model using the number of messages described in Section . When this is done, the msgs/hr is computed directly, so columns A and B are not used. See “Examples” on page 170 for a detailed example of how this can be done.

If a live system is being modeled, add the “number of all incoming messages received on the D-channel” and the “number of all outgoing messages sent on the D-channel” field from a busy hour TFS009 report to derive the entry for Column C. See *Traffic Measurement: Formats and Output* (553-2001-450) for details.

Table 49
MSDL peak buffer requirements for D-channel applications

DCH	Outgoing	Incoming
ISDN Network	Prior to R24: B-channels/DCH= ______ R24+: SEMT (1) * 8	Prior to R24: B-channels/DCH= ______ R24+: SEMT (1) * 8
NACD	Source ACD DNs + 5 = ______	Network congestion level: Low: 10 Medium: 20 High: 30
NMS	10	10

In the case of an ISL D-channel, ensure that the baud rate of the connection is greater than

(C msgs/hr * 29 bytes/msg * 8 bits/byte) / 3600 sec/hr

where C comes from column C in Table 48.

If the baud rate is too low to meet requirements, performance of the entire MSDL card may be jeopardized since 30 of the MSDL output buffers will be occupied with ISL D-channel messages and the real time spent processing these messages will increase due to additional flow control and queueing logic.

Depending on the application, it may be too conservative to engineer an MSDL for link restarts. In that case, the ISDN Network peak outgoing and incoming buffer requirements can be set at 15 for 68060 CP systems.

AML Applications

If an existing system is being modeled, add the number of incoming messages, messages in the IMSG category, and outgoing messages, messages in the OMSG category, from a busy hour TFS008 report and enter the value in Column C. For a quick approximation of the number of incoming messages, add the number of messages of priority 1 to 4, as provided in TFS008. For more details, refer to *Traffic Measurement: Formats and Output* (553-2001-450).

Table 50
MSDL real time requirements for AML applications

AML	calls/hr A	msgs/call B	msgs/hr C=A*B	msec/msg D	msec E=C*D
CCR	agents * calls/agent/hr (18.3)* %calls with CCR=_____	simple: 10 medium: 20 complex: 30	A*B + 900 ACD DNs w/ statistics = _____	7.2	____
HER/AST	agents * calls/agent/hr (18.3)* % calls with HER/AST=____	10	_____	7.2	_____
M911	M911 agents * calls/agent/hr (18.3)= ____	6	_____	7.2	_____
Meridian Mail voice mail	MM ports * calls/hr/port (65)= _____	10	_____	7.2	_____
Meridian Mail voice menu	agents * calls/agent/hr (120) = _____	10	_____	7.2	_____
Meridian Mail announcements	agents * calls/agent/hr (150)= _____	5	_____	7.2	_____

Table 51
MSDL peak buffer requirements for AML applications

AML	Outgoing	Incoming	Minimum Baud Rate
CCR	CDNs with statistics= _____	68060 CP: 20 68060E CP:30	(msgs/hr * 45 bytes/msg * 8 bits/byte)/(3600 sec/hr)=_____
HER/AST	68060 CP: 12 68060E CP: 18	68060 CP: 12 68060E CP: 18	(msgs/hr * 45 bytes/msg * 8 bits/byte)/(3600 sec/hr)=_____
M911	68060 CP: 5 68060E CP: 8	68060 CP: 5 68060E CP:8	(msgs/hr * 45 bytes/msg * 8 bits/byte)/(3600 sec/hr)=_____
Meridian Mail voice mail	68060 CP: 8 68060E CP: 12	68060 CP: 8 68060E CP: 12	(msgs/hr * 38.5 bytes/msg * 8 bits/byte)/(3600 sec/hr)=_____
Meridian Mail voice menu	68060 CP: 12 68060E CP: 18	68060 CP: 12 68060E CP: 18	(msgs/hr * 38.5 bytes/msg * 8 bits/byte)/(3600 sec/hr)=_____
Meridian Mail announcements	68060 CP: 15 68060E CP: 22	68060 CP: 15 68060E CP: 22	(msgs/hr * 38.5 bytes/msg * 8 bits/byte)/(3600 sec/hr)=_____

For Meridian Mail 1 through Meridian Mail 9, the CSL link was 4800 baud. Beginning with Meridian Mail 10, the link is 9600 baud. Meridian Mail 11 supports a maximum of 96 ports. Previous releases supported 48 ports.

SDI Applications

In the HSL analysis, include live agents, automated agents, and Meridian Mail agents in the agent total. This will compensate for the assumption of simple calls, since transferred calls will generate additional MAX messages.

Table 52
MSDL real time requirements for SDI applications

SDI	calls/hr A	msgs/call B	msgs/hr C=A*B	msec/msg D	msec E=C*D
CDR	calls/hr with reports= _____	FCDR=old:100 CDR=new: 213	_____	0.05	_____
HSL-Meridian MAX	agents * calls/agent/hr (18.3)= _____	5	_____	8.8	_____
TTY	NA	NA	15000	0.05	_____

There are no traffic reports that provide information on the number of SDI messages directly. For CDR records, determine whether CDR is enabled for incoming, outgoing, and/or internal calls. The number of incoming, outgoing, internal, and tandem calls is available from TFC001. Tandem calls are considered both incoming and outgoing. Alternatively, the number of CDR records can be counted directly. MAX reports can also be counted directly.

Table 53
MSDL peak buffer requirements for SDI applications

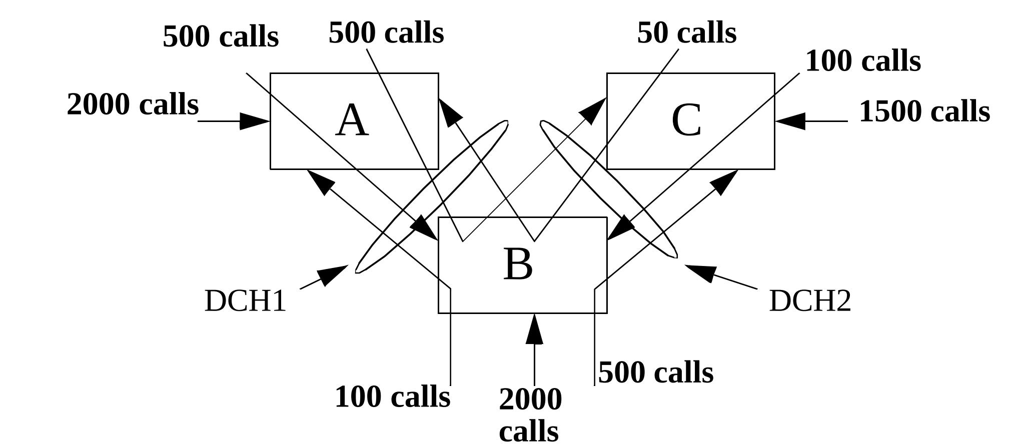
SDI	Outgoing	Incoming	Minimum Baud Rate
CDR	30 if baud rate is less than recommended in Table 41 otherwise 68060 CP: 20 68060E CP:	1	(msgs/hr * 10 bits/msg)/ (3600 sec/hr)= _____
HSL - Meridian MAX	Msgs per call simple: 5 medium: 10 complex: 15	1	(msgs/hr * 20 bytes/msg * 9 bits/byte) /(3600 sec/hr)= _____
TTY	10	10	

Examples

NACD Network with CDR Reports

Consider an NACD network with the topology given in Figure 9. The call flow is provided, where arrows indicate where calls enter the network and where they are answered.

Figure 9
NACD network



Each node has a single ACD DN and calls are queued to the network target DNs as soon as they arrive.

For this network, we wish to determine whether a single MSDL on Node B can support DCH1, DCH2, and an SDI port for CDR records on Port 0.

Since we have detailed call flow information, we can develop a messaging model for DCH1 and DCH2 (see Table 54).

Table 54
NACD Message Model

Originating Node	Total Queued	Queued and answered	Queued but not answered	Total messages	DCH1	DCH2
Node A to Node B	3000	500	2500	15500	x	x
Node A to Node C	3000	500	2500	15500	x	x
Node B to Node A	2600	100	2500	11100	x	
Node B to Node C	2600	500	2100	13900		x
Node C to Node A	1650	50	1600	6950	x	x
Node C to Node B	1650	100	1550	7300	x	x

The DCH1 and DCH2 columns indicate whether the messages should be included in the DCH1 and DCH2 message count, respectively. For each row, multiply the entry in the “Queued and answered” column by 11 messages and multiply the entry in the “Queued but not answered” column by 4 messages. The sum of these two values is provided in the “Total messages” column. By summing the rows which should be included for DCH1 and DCH2, we derive the total messages for DCH1: 56350 msg/hr and DCH2: 59150 msg/hr. Note that these messages do not include the impact of CRQS and FCTH which are beyond the scope of this analysis (see Table 48).

Table 55
MSDL real time requirements for D-channel applications

DCH	calls/hr A	msgs/call B	msgs/hr C=A*B	msec/msg D	msec E=C*D
NACD DCH1	NA	NA	56350	pre-R20: 8.8	495880
NACD DCH2	NA	NA	59150	pre-R20: 8.8	520520

Assuming that no non-NACD calls are carried, Node B carries 3750 calls/hour.

Table 56
MSDL real time requirements for SDI applications

SDI	calls/hr A	msgs/call B	msgs/hr C=A*B	msec/msg D	msec E=C*D
CDR	calls/hr with reports=3750	FCDR=old: 100 FCDR=new: 213	798750 (FCDR=new)	0.05	39938

The total MSDL requirements can then be computed:

Table 57
MSDL Engineering Worksheet

Port	Application	Real Time Required	Peak Buffer Usage Outgoing	Peak Buffer Usage Incoming
0	CDR	39938	10	1
1	DCH-NACD	495880	7	10
2	DCH-NACD	520520	7	10
3				
Total		1056338	24	21

The projected MSDL utilization is 1056338 / 2770000 = 38%. Assuming low network congestion, incoming and outgoing peak buffer usage are below 60, so a single MSDL is able to support this configuration. However, due to the potentially high messaging impact of NACD, this MSDL should be re-engineered periodically to determine whether the call volumes or call flow patterns have changed.

MAX, CCR, and D-channel

An Option 81C call center with a 68040 processor running Release 23 which carries 10,000 inbound calls per busy hour would like to configure MAX, AML, a D-channel that provides signaling for 5 T1s, and a D-channel that provides signaling for 3 T1s on a single MSDL. Of the 10,000 inbound calls, 60% receive medium complexity CCR treatment with 40 ACD DNs reporting statistics to the CCR module. Can the configuration be supported?

In the case of the D-channels, assume that a back-up D-channel is configured, so that the number of trunks is (5 * 24) -2 = 118 and (3 * 24) - 2 = 70, for the first and second D-channel respectively.

Table 58
MSDL real time requirements

	calls/hr A	msgs/call B	msgs/hr C=A*B	msec/msg D	msec E=C*D
HSL- Meridian MAX	10000	5	50000	8.8	440000
CCR	6000	simple: 10 medium: 20 complex: 30	120000 + (900 * 40) = 156000	7.2	112320 0
ISDN Network	trunks/DCH * calls/hr/trunk (15.6)= 1841	8	14728	pre-R20: 8.8 R20+: 19.2	129606
ISDN Network	trunks/DCH * calls/hr/trunk (15.6)= 1092	8	8736	pre-R20: 8.8 R20+: 19.2	76877

Table 59
MSDL Engineering Worksheet

Port	Application	Real Time Required	Peak Buffer Usage Outgoing	Peak Buffer Usage Incoming
0	Meridian MAX	440000	5	1
1	CCR	1123200	40	10
2	DCH	129606	10	10
3	DCH	76877	10	10
Total		1769683	65	31

While the MSDL supporting this configuration is projected to operate at only 1769683 / 2770000 = 64% of real time capacity, there is a concern that link delays may be a problem due to peakedness of outgoing traffic. It is recommended that the AML or a D-channel be off-loaded to another MSDL.

CLASS network engineering rules

Content list

The following are the topics in this section:

In a single group network Meridian 1 system, the network internal blocking is determined by the concentration ratio of equipped ports on peripheral equipment and the number of interfaced loops or superloops. Depending on traffic engineering, a non-blocking network is achievable.

In a multi-group system, intergroup junctors are required to switch calls between two network groups. Due to the concentration of time slots from a network group to that of inter-group junctors, blocking may occur. This is true for a multi-group Meridian 1 with or without CLASS (Custom Local Area Signaling Service) sets. However, since the CLASS feature depends on a voice path to deliver CND (Calling Name and Number Delivery) to a set, excessive congestion at the inter-group junctor could block the delivery of CND and diminish the usefulness of the feature, as well as impact the grade of service of the existing equipment on the system.

The following sections will examine the inter-group junctor blocking issue and recommend engineering rules to alleviate potential network congestion problems.

In general, the engineering effort for the CLASS feature can be classified into three categories:

- A new site following engineering rules in section on page 180 requires no inter-group junctor traffic check-off.
- An existing or new site with relatively low inter-group junctor traffic, will require only one XCMC (Extended CLASS Modem Card) IPE card that can serve all CLASS sets in a multi-group system.
- An existing site with heavy inter-group junctor traffic will require either moving trunks/sets around between network groups when only one XCMC card is equipped or providing an XCMC card (or cards) for each group.

This engineering guide recommends that users follow all engineering rules so that network group engineering is not needed. However, if that is not practical for an existing site (or even a new site), the engineering guide will show users when a single XCMC card can serve a multi-group system with or without re-configuration, and when one card (or cards) for each group is required.

Meridian 1 multi-group network

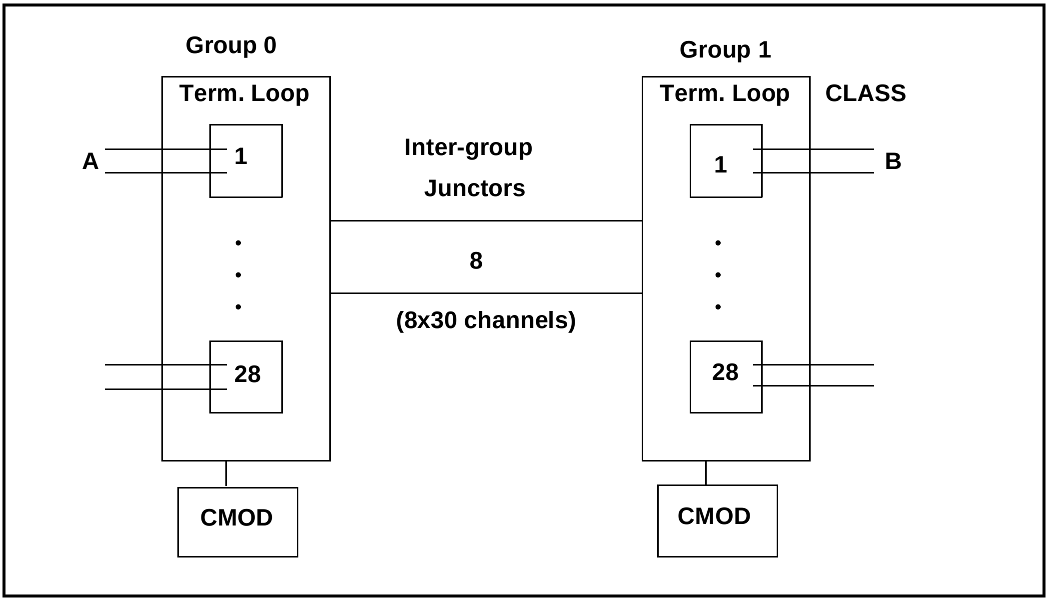
The Option 11C has a network architecture different from the rest of the Meridian 1 Options. It has a non-blocking network and does not require any network engineering (except to use Table 54 CMOD (CLASS MODem) capacity table to find the number of modems needed). A single group Meridian 1 system does not have inter-group junctors; special engineering on junctor is not applicable. Therefore, this document is only relevant to a Meridian 1 Option with a multi-group network.

In general, inter-group junctor blocking is most severe when there are only two groups, since under typical traffic distribution assumptions, 50% of calls will stay in the originating group and 50% will terminate on the second group through junctors, unless a Community Of Interest (COI) is known and taken into consideration in engineering to minimize inter-group traffic.

Under the assumption of even distribution of traffic, the percentage of traffic to an inter-group junctor will drop to 33.3% of the total group traffic for a 3-group system. Similarly, the junctor traffic will be 25% of group traffic for a 4-group system and 20% for a 5-group system.

A simplified Meridian 1 with two-group network and CLASS sets is shown in Figure 10.

Figure 10
Meridian 1 with a two-group network



Note that traffic to a CLASS set can be originated from a non-CLASS set, another CLASS set or an incoming trunk. Since trunks have more traffic impact on junctor blocking, they are used to illustrate the feature operation, however, both sets and trunks can be traffic sources to CLASS sets.

The maximum size Meridian 1 comprises of 5 network groups. Each group has 32 loops of which 28 can be terminal loops, the rest are service loops (TDS loops for tones, conference and music).

From Group 0 to Group 1 as shown in Figure 10, there are 8 one-way junctors. Similarly, there are another 8 one way junctors from Group 1 to Group 0. For practical purposes, they can be treated as 8 two-way junctors. A two-way path is equal to a voice channel. A junctor has 30 voice traffic channels as on a loop. Each two-way channel represents a conversation path. A channel is also used to deliver the CND from the CMOD to a CLASS set.

CLASS Feature Operation

A call originated from Set A (or trunk A) seeks to terminate on a CLASS set B. When B starts to ring, A will hear ringback. A unit in CMOD (CLASS Modem) is assigned to collect originator's CND information and waits for the CND delivery interval. After the first ring at B, a silence period (deliver interval) ensues, the CMOD unit begins to deliver CND information to the CLASS set.

The CND information of a traffic source (A) is a system information, which is obtained by the system when a call is originated. During the 2-second ringing period of the CLASS set B, A's CND is delivered to CMOD via SSD messages (using signaling channel only). When the CND information is sent from CMOD to CLASS set B, it is delivered through a voice path during the 4-second silence cycle of set B. The CMOD unit is held for a duration of 6 seconds.

If the XCMC (Extended CLASS Modem Card) IPE card, which provides up to 32 CMOD units, is located in the IPE of Group 0, the CMOD unit in the card will receive CND data through the SSD messages and use one of the voice channels of the inter-group junctor to deliver it to CLASS set B in Group 1.

If the XCMC IPE card is located in Group 1, the system will deliver SSD messages containing CND information to CMOD and then send it to Set B during the delivery interval through a voice path, which is an intra-group channel not involving an inter-group junctor.

When CMOD units and CLASS sets are co-located in the same network group, there are no voice paths on the inter-group junctor required to deliver CND information; when they are equipped on different groups, inter-group junctors must carry CND traffic. The resource allocation algorithm will search for a CMOD unit located in the same group as the terminating CLASS set first before it attempts to use a CMOD unit from a different group.

Fiber Network Fabric

Multi-group networks are inter-connected with fiber optic rings. The OC-12 fabric has such a large capacity that all channels from expanded eight network groups can be inter-connected without junctor blocking. Therefore, engineering of the CLASS feature is reduced to the equivalent of a single group case. The only engineering needed is to find the required number of CMOD units from Table 60 to serve a given number of CLASS sets. Capacity limit due to network group size can be ignored.

Table 60 is the CMOD capacity table. It provides the number of CMOD units required to serve a given number of CLASS sets with the desired grade of service (P.001). The required number of CMOD units should have a capacity range whose upper limit is greater than the number of CLASS sets equipped in a given configuration.

Table 60
CMOD Unit Capacity Table (P.001)

CLASS Set	1-2	3-7	8-27	28-59	60-100	101-150	151-206	207-267
CMOD Unit	1	2	3	4	5	6	7	8
CLASS Set	268-332	333-401	402-473	474-548	549-625	626-704	705-785	786-868
CMOD Unit	9	10	11	12	13	14	15	16
CLASS Set	869-953	954-1039	1040-1126	1127-1214	1215-1298	1299-1388	1389-1480	1481-1572
CMOD Unit	17	18	19	20	21	22	23	24

Table 60
CMOD Unit Capacity Table (P.001)

CLASS Set	1-2	3-7	8-27	28-59	60-100	101-150	151-206	207-267
CLASS Set	1573-1665	1666-1759	1760-1854	1855-1949	1950-2046	2047-2142	2143-2240	2241-2338
CMOD Unit	25	26	27	28	29	30	31	32
CLASS Set	2339-2436	2437-2535	2536-2635	2637-2735	2736-2835	2836-2936	2937-3037	3038-3139
CMOD Unit	33	34	35	36	37	38	39	40
CLASS Set	3140-3241	3242-3344	3345-3447	3448-3550	3551-3653	3654-3757	3768-3861	3862-3966
CMOD Unit	41	42	43	44	45	46	47	48
CLASS Set	3967-4070	4071-4175	4176-4281	4282-4386	4387-4492	4493-4598	4599-4704	4705-4811
CMOD Unit	49	50	51	52	53	54	55	56
CLASS Set	4812-4918	4919-5025	5026-5132	5133-5239	5240-5347	5348-5455	5456-5563	5564-5671
CMOD Unit	57	58	59	60	61	62	63	64

General Engineering Guidelines

Non-Call Center Applications

In a non-call center application, there is no significant number of agent sets. Therefore, no agent set to regular set conversion is needed.

Configurations following engineering rules (no re-configuration required)

- The following engineering rules should be followed to avoid the need to re-configure a switch to accommodate the CLASS feature.
- Provide the number of CMOD units serving all CLASS sets in the system based on the capacity table (Table 54).
- Equip all CLASS sets in one network group.
- Equip the XCMC IPE card on the network group with CLASS sets.

If the system is a single group system, or if above rules are fully met, no further engineering is necessary. However, in case of an existing multi-group site upgrading to provide CLASS feature, we may need to re-configure the system in order to satisfy rules.

When above rules are not fully met, continue the system engineering by following the procedure in the next subsection.

Re-configuration may be required (when engineering rules are not fully followed)

When the above rule can not be satisfied in a new site or an existing one, the following guidelines are designed to (1) minimize network blocking, and (2) determine whether a re-configuration (to move trunks and sets around), or the provisioning of an XCMC card per group is necessary.

- To use Table 60 to estimate CMOD unit requirements, consider only CLASS sets (no trunks or non-CLASS sets).
- If CLASS sets are equipped in more than one group, locate the XCMC IPE card in the group with the most CLASS sets.
- Use Table 60 to decide whether re-configuration is required. For a network group with trunks, regular sets and CLASS sets, convert trunks to sets by using the formula: 1 trunk = 4 sets (called equivalent sets), and then add up the total.
- Check threshold in Table 60. If the number of equivalent sets is less than 1760 (e.g., for a 2-group system), there is no need to re-configure the system.
- If the number is greater than 1760, we need to (1) move some of the CMOD units to a second XCMC IPE card on another group (when CLASS sets are scattered in two groups), or (2) move some sets or trunks from one group to another group to satisfy the threshold.

The following examples will show some of the engineering details of dealing with various alternatives.

To simplify discussion, the network group 0 has a minor number of CLASS sets. The majority of CLASS sets are in group 1 (refer to Figure 2).

Engineering Examples

One XCMC card serving a single group system

No special engineering rule is needed for a single group system (Meridian 1 Option 51C or 61C). Refer to Table 60 to find the required number of CMOD units to serve the given CLASS sets. For example, to serve an Option 61C with 400 CLASS sets, use Table 60 to find the number of CMOD units serving a range that includes 400 sets. The result is 10 units which can serve from 333 to 401 CLASS sets.

One XCMC card serving a 2-group system

Example 1: No re-configuration

A 2-group Meridian 1 system serving an office is expected to convert 400 analog sets to CLASS sets. Currently, 100 of them are located in group 0, where all incoming trunks are located, and the remaining 300 sets are in group 1. Assume that group 1 is also equipped with 800 non-CLASS sets. How many CMOD units are needed to serve this application and does the customer need to re-configure the switch (move sets and trunks between group 0 and group 1) to do the upgrade?

Solution:

- The table lookup indicates that 400 CLASS sets need 10 CMOD units. Since one card provides 32 units, one XCMC card is sufficient for this customer.
- Group 1 is equipped with 300 CLASS sets which is greater than the 100 sets in group 0, the card should be installed in group 1.
- The total equipped ports in group 1 is 1100 (=800+300). For a 2-group system, the second group is allowed to have 1760 sets (from Table 60) without junctor traffic concerns, therefore, there is no need for the customer to re-configure the switch.

Example 2: Re-configuration

A similar application as in the last example, except that there are 1600 non-CLASS sets and 100 trunks in group 1.

Solution:

- The same number of CMOD units (10), since the number of CLASS sets in the system is the same.

- The number of total equivalent sets in group 1 is 2300 (=1600 +300 +100x4) which is greater than the 1760 threshold in the Table 60 for a 2-group system.
- The customer will have a number of alternatives to resolve the junctor blocking issue, depending on the situation: (1) move the 100 CLASS sets from group 0 to group 1, so all CLASS sets are served by the XCMC card in group 1, or (2) move the 300 CLASS sets and the XCMC card to group 0, or (3) move 540 non-CLASS sets (=2300-1760) from group 1 to group 0, or (4) move 100 CLASS sets from group 1 to group 0 and split the 10 CMOD units to 5 for group 0 and 5 for group 1; however, this will require another XCMC card to be equipped in group 0. The cost of this approach is not trivial. It can be justified only when growth plan indicates a need for a second card in the near future anyway.

The final decision depends on the specific situation of a site.

Call Center Applications

Configurations following engineering rules (no re-configuration required)

The following engineering rules should be followed to avoid the need to re-configure a switch to accommodate the CLASS feature for call center environment.

- Convert an agent set to regular set by using 1 agent CLASS set = 4 sets (called equivalent sets)
- Sum up the total number of regular CLASS sets and equivalent CLASS sets and find the number of CMOD units required based on the capacity table (Table 54).
- Equip CLASS agent sets in the group where trunks carrying incoming traffic to agent sets are located.
- Equip non-agent CLASS sets in the same group as the agent CLASS sets.
- Equip the XCMC IPE card on the network group with CLASS sets.

If the system is a single group system, or if above rules are fully met, no further engineering is necessary.

In case of an existing multi-group site upgrading to provide CLASS feature, re-configuring the system may be necessary.

When above rules are not fully met, continue the system engineering by following the procedure in the next subsection.

Configurations do not fully meet engineering rules (re-configuration may be required)

When above rules can not be satisfied in a new site or an existing one, the following guidelines are designed to (1) minimize network blocking, (2) determine whether a re-configuration (to move trunks and sets around) is necessary, or (3) determine whether separate XCMC cards are necessary to serve the multi-group system.

- Convert an agent set to regular set by using 1 agent CLASS set = 4 sets.
- Sum up the total number of equivalent CLASS sets and find the number of CMOD units required based on the capacity table (see Table 60).
- Equip the XCMC IPE card on the network group with most CLASS sets (or equivalent sets).
- Limit the number of agent CLASS sets to be 200 or less per group.
- Limit the number of regular CLASS sets in a group without XCMC card to be 100 or less.
- Convert trunks (1 trunk = 4 sets), and agent set (1 agent set = 4 sets) to equivalent sets before using Table 60 to find junctor traffic threshold.
- If the threshold in Table 60 is greater than the total number of equivalent sets, traffic in the system is balanced, and there is no need for further network engineering.
- If the number of equivalent set is greater than the threshold, one or all of the following engineering rules should be followed to reduce junctor traffic:

    Move sets (CLASS or non-CLASS) or trunks to another group to satisfy the above engineering rules.

    Equip XCMC card in more than one group to serve local CLASS set traffic.

- When a trunk route is known to serve only agent sets, and these trunks and agent sets are in the same group, exclude them from the set count in Table 60 threshold (e.g., do not include trunks and agent sets with known COI when using Table 60, since they do not generate traffic to junctors).

The following examples will show some of the engineering details of dealing with various alternatives.

To simplify discussion, the network group with most trunks is called group 0, consequently, a majority of CLASS sets, if not all, are in group 1. If most agent CLASS sets and XCMC card are in group 0, there will ne no need for further engineering.

Engineering Examples

One XCMC card serving a single group system

No special engineering rule is needed for a single group system. Look up Table 60 to find the required number of CMOD units to serve the given CLASS sets. For example, to serve an Option 61C with 300 agent CLASS sets, use Table 60 to find the CMOD units that can serve 1200 equivalent sets (=300x4). The result is 20 units.

One XCMC card serving a 2-group system

Example 1: No re-configuration required

A 2-group Meridian 1 system serving a call center is expected to upgrade 300 analog sets (100 administrative sets and 200 agent sets) to CLASS sets. The 100 administrative sets are located in group 0, where are also located all incoming trunks. The 200 agent sets are in group 1, which will continue to be used as agent sets after upgrading. Assume that group 1 is also equipped with 500 non-CLASS sets. How many CMOD units are needed to serve this application and does the customer need to re-configure the switch (move sets and trunks between group 0 and group 1) to do the CLASS feature upgrade?

Solution:

- The table lookup indicates that 900 equivalent CLASS sets (=100+200x4) need 17 CMOD units. Since one card provides 32 units, one XCMC card is sufficient for this customer.

- Group 1 is equipped with 200 agent CLASS sets or 800 equivalent sets which is greater than the 100 sets in group 0, the card should be installed in group 1.

The total equipped ports in group 1 is 1300 (=200x4+500). For a 2-group system, the second group is allowed to have 1760 sets (from Table 60) without junctor traffic concerns, therefore, there is no need for the customer to re-configure the switch.

- In addition, both “100 CLASS sets in a group without CMOD units (group 0)”, and” 200 agent CLASS sets in a group separate from incoming trunks (group 1)” statements are within engineering rules, therefore, no re-configuration is necessary.

Example 2: Re-configuration required

A similar application as in the last example, but there are 1600 non-CLASS sets in group 1.

Solution:

- The same number of CMOD units (17) is required, since the number of equivalent CLASS sets (900) in the system is the same.
- Equip the 17 CMOD units in group 1, since the XCMC card should be equipped in the group with the most CLASS (equivalent) sets.
- The number of total equivalent sets in group 1 is 2400 (=1600+200x4) which is greater than the 1760 threshold in the Table 60 for a 2-group system.

- The customer will have a number of alternatives to resolve the junctor blocking issue, depending on the situation:

  Move the 100 CLASS sets from group 0 to group 1. Or

  Equip the 200 CLASS agent sets and the XCMC card in group 0. Or

  Move 640 non-CLASS sets (=2400-1760) from group 1 to group 0 to avoid threshold violation. Or

  Move 100 CLASS sets from group 1 to group 0 and split the 17 CMOD units to 10 for group 0 and 7 for group 1; however, this will require another XCMC card to be equipped in group 0. Or

  Move 160 trunks with COI to agent sets from group 0 to group 1, so that the total equivalent sets in group 1 will become 1760 (=1600+(200-160)x4), since this way the 160 trunks and an equal number of agent sets will not generate traffic to junctors.

The final decision depends on the specific situation of a site.

Example 3: Mixed sets, trunks in both groups and re-configuration required

A 2-group Meridian 1 system serving a call center is expected to equip 200 administrative CLASS sets in group 0 and 400 CLASS agent sets in group 1. 500 trunks carrying incoming traffic to agents are located in group 0, 60 trunks serving local CO non-ACD traffic are equipped in group 1. Assume that group 1 is also equipped with 300 non-CLASS sets. Can this configuration meet engineering rules? How many CMOD units are needed?

Solution:

- The equivalent CLASS sets in system = 200 + 400x4 = 1800. From Table 54, 27 CMOD units are needed. It requires the XCMC card to be equipped in group 1.

- When we equip the XCMC card in group 1, there are three violation of rules: (1) the number of CLASS sets in the group without CMOD units (group 0) is greater than 100, (2) the number of agent sets in a group without incoming trunks (group 1) is 400 which exceeds the 200 per group limit, and (3) the violation of threshold in Table 60 for group 1 (=400x4+60x4+300=2140>1760). Several alternatives are available to make this configuration meeting engineering rules:

  Move 100 CLASS sets and 400 incoming trunks from group 0 to group 1; all above 3 violations are removed by this re-configuration: (1) CLASS sets in group 0 is 100, (2) 400 CLASS agent sets and 400 incoming trunks with COI are in the same group (group 1), (3) the number of equivalent sets in group 1 for threshold check-off is reduced to 640 (=100+60x4+300=640) which is certainly within the limit (1760).

  However, it is impractical to put almost all trunks and agent sets in one group (group 1). With so many rule violations, the most realistic approach is to move 200 CLASS agent sets to group 0 and equip approximately 15 CMOD units in group 0 and 12 units in group 1.

One XCMC card serving a 3-5 group system

Chances of groups larger than 3 requiring special engineering are slim, since the threshold in Table 60 limiting the number of sets per group is much higher.

If the rule of co-locating CLASS sets and CMOD units in the same group is not fully met, as long as the basic rule of putting XCMC card in the group with the most CLASS sets is followed, perhaps, no re-configuration between any two groups is necessary.

If in doubt, isolate any two groups at one time, and go through the 2-group engineering procedure to re-configure the system two groups at a time. Ignore the rest of system during the engineering process, except for calculating the total number of CMOD units, which should cover the need of all CLASS sets in the system. However, during a 2-group engineering, only the number of CMOD units attributable to the 2-group at hand should be used in calculations.

Also remember to use 2933 (equivalent) sets per group for threshold check-off for the 3-group system, and their respective number for 4- and 5-group systems (see Table 60).

The complete check-off of set thresholds between any two groups in a multi-group system can be represented by the following combinations (a number denotes the group number: e.g., 1-2 represents group 1-group 2):

3-group: 1-2, 1-3, 2-3.

4-group: 1-2, 1-3, 1-4, 2-3, 2-4, 3-4.

5-group: 1-2, 1-3, 1-4, 1-5, 2-3, 2-4, 2-5, 3-4, 3-5, 4-5.

It should be noted that although CMOD units are equipped according to the traffic requirement of CLASS sets in a network group for the inter-group junctor traffic consideration, they are a system resource shared by the whole system.

Worksheets

Content list

The following are the topics in this section:

Reference list

The following are the references in this section:

- “System capacities” on page 33

Each of the following subsections contains a worksheet with which the system engineer can assess the total system impact of a given configuration on the specified capacity. These worksheets implement the algorithms described in “System capacities” on page 33. The result of the worksheet is a number or set of numbers, in the units of the capacity being assessed, as defined in “System capacities” on page 33. A simplified table of capacity limits is given to provide easy determination of feasibility and the size of system required.

Network loop traffic capacity worksheet

	Column A				Column B (Loops)
TDS/CON Loops	One card (2 loops) per Network Module*				________
BLOCKING:					
ENET Loop	Admin. Sets		______ × 6 =	______CCS	
	Non-ACD trunks	+	______ × 26=	______CCS	
	Subtotal	=		______÷ 660	=_______(N_{0e})
XNET Loop	Admin. Sets		______ × 6 =	______CCS	
	Non-ACD trunks	+	______ × 26=	______CCS	
	Subtotal	=		______÷ 875	=_______(N_{0x})
NON_BLOCKING:					
(ENET or XNET)	Agent Sets		__________		
	Supervisor Sets	+	__________		
	ACD Analog and RAN Trunks	+	__________		
	Subtotal	=	_______ ÷ 30		=________(N_1)
DTI Trunks		=	_______÷ 24		=_______(N_{2d})
PRI Trunks			__________		
		+	2		
		=	_______÷ 24		=_______(N_{2p})
Music Ports		=	_______÷ 30		=_______(N_{31})
MM/MIVR/HEVP Ports			_______÷ 24		=_______(N_{32})
Total loops (Sum of entries under column B)					=________(N_L)

Note: All calculations should be rounded up to the next integer.

*Iterative procedure may be needed if the number of network modules required was not correctly estimated at the outset.

Conclusion:

N_L <= 16 Option 51C
16 < N_L <= 32 Option 61C
32 < N_L <= 160 Option 81C

160 <N_L <256 Option 81C/FNF

Option 11C Card Slot Calculation

Perform this calculation to determine the physical slot requirement of a given configuration.

Table 61
Worksheet for Option 11C Card Slot Calculation

Column A	Column B
Agent Sets __________	
Supervisor sets + __________	
Admin. sets + __________	
Subtotal = __________ ÷16 (round up)	= _________
Analog trunks = __________ ÷8 (round up)	= _________
PRI trunks __________	
+ 2	
= __________ ÷ 24 (round up)	= _________
DTI trunks ___________ ÷ 24 (round up)	= _________
Meridian Mail (enter 1 for yes, 0 for no)	= _________
RAN/MUS (enter 1 for yes, 0 for no)	= _________
CCR/HER/Symposium/AML (enter 1 for yes, 0 for no)	= _________
CDR,MAX,SDI ports (enter 1 for 3 ports, else 0)	= _________
Total card slots (Sum of entries under column B)	= _________ (S)
Conclusions:	
— S≤9 One cabinet	
— 9<S≤29 Two to three Cabinets	
— 29<S≤49 Option 11C with line expansion	

Physical Slot Calculation Example

Calculate the number of calls for each feature according to earlier procedures before using the worksheet.

Table 62
Worksheet for Option 11C Card Slot Calculation (Example)

Column A					Column B
Agent Sets		64			
Supervisor Sets	+	5			
Admin. Sets	+	50			
Subtotal	=	119	÷16	(round up)	= 8
Analog Trunks	=	15	÷ 8	(round up)	= 2
PRI Trunks		60			
	+	2			
	=	62	÷ 24	(round up)	= 3
DTI Trunks		_______	÷ 24	(round up)	=_________
Meridian Mail (enter 1 for yes, 0 for no)					= 1
RAN/MUS (enter 1 for yes, 0 for no)					= _________
CCR/HER/Symposium/AML (enter 1 for yes, 0 for no)					= 1
CDR,MAX,SDI ports (enter 1 for 3 ports, else 0)					= _________
Total Card Slots (Sum of entries under column B)					= 15 (S)

Conclusion:

— 9<S≤29 two to three Cabinets

Physical capacity worksheets

The procedure for card slot calculation for Options 51C and 61C is different. Users should make a first guess as to which system is the right candidate for the application. Otherwise, both worksheets must be filled out.

Table 63
Worksheet for Option 51C* card slot calculation

	Column A (Loop/card)		Column B (Slots)
TDS/CON	One/Network Module		=__________
Music Loop	One TDS/CON provides one Music		=_____(N_{31})
QPC414 ENET	Blocking Loops	_______(N_{oe})	
	DTI Loops	+_______(N_{2d})	
	PRI Loops	+_______(N_{2p})	
	MMail Loops	+_______(N_{32})	
	Subtotal	=________ ÷ 2	=_________
Clock Controller	= 1 (If N_2 > 0; else = 0)		=_________
NT8D04 XNET	Blocking Loops	________(N_{0x})	
	Non-blocking Loops	+________(N_1)	
	Subtract 4 for NT8D18 NET	-____4_______	
	Subtotal	=_________ ÷ 4	=_____(Sx)
NT8D18 NET/DTR	= 1 (always equipped)		=___1_____
I/O cards**			=_________
QPC720 DTI/PRI	= 2 × N_2, if no NT8D35 module; else = 0		=_________
Total # of card slots (Sum of entries under column B)			=______(S_c)
Conclusion: $S_c \le 7$ Option 51C $7 < S_c \le$ Option 61C $16 < S_c$ Option 81C			
Note: All calculations should be rounded up to the next integer. A negative loop number should be set to zero. *Iterative procedure may be needed, if using Option 51C or 61C was not clear at the outset. **Refer to Table 3, "I/O interface for applications," on page 50 to find the number of I/O cards needed for applications.			

Table 64
Worksheet for Option 61C card slot calculation

Column A (Loop/card)			Column B (Slots)
TDS/CON	One/Network Module*		=__________
MUSic Loop	One TDS/CON provides one MUSic		=_____(N_{31})
QPC414 ENET	Blocking Loops	_______(N_{oe})	
	DTI Loops	+_______(N_{2d})	
	PRI Loops	+_______(N_{2p})	
	MMail Loops	+_______(N_{32})	
	Subtotal	=________ ÷ 2	=__________
NT8D04 XNET	Blocking Loops	________(N_{0x})	
	Non-blocking Loops	+________(N_1)	
	Subtotal	=_________ ÷ 4	=_____(Sx)
I/O cards**	Must be $\geq S_x$		=__________
QPC720 DTI/PRI	$= 2 \times N_2$, if no NT8D35 module; else = 0		=__________
Total # of card slots (sum of entries under column B)			=______(S_c)

Conclusion:
- $S_c \leq 7$ Option 51C
- $7 < S_c \leq 16$ Option 61C
- $16 < S_c$ Option 81C

Note: All calculations should be rounded up to the next integer. A negative loop number should be set to zero.

*Iterative procedure may be needed, if the number of modules to use was not clear at the outset.

**Refer to Table 1, “Intelligent peripheral equipment,” on page 25 to find the number of I/O cards needed for applications.

Table 65
System power consumption worksheet

Module	Quantity		Power Consumption (watts)		
NT6D44	______	×	400	=	______
NT8D34	______	×	300	=	______
NT8D35	______	×	270	=	______
NT8D37	______	×	460	=	______
Pedestals	______	×	50	=	______
			Total power	=	

Processor load worksheet

Software Release ______________

Table 66
Processor load worksheet (Part 1 of 5)

Feature	Usage	×	Real Time Factor (25)	=	EBC
Busy hour calls	________	×	1.20	=	________
500, 2500 set calls	________	×	.00	=	________
Digital set calls	________	×	.12	=	________
BRI voice calls	________	×	.12	=	________
CLASS set calls	________	x	.24	=	________
Data calls	________	×	.14	=	________
CPND characters	________	×	.01	=	________
CDP calls	________	×	.12	=	________
MCE - MM (CSL) calls	________	×	1.91	=	________
MCE - MM (EES on DTMF on) calls	________	×	2.38	=	________
MM (CSL) calls	________	×	1.10	=	________
MM (EES on DTMF on) calls	________	×	4.12	=	________
MM (EES on DTMF off) calls	________	×	1.36	=	________
MM-Play prompt from MMail	________	×	1.68	=	________
MM-Transfer after play prompt	________	×	2.00	=	________
MM-NMS (Main) calls	________	×	0.75	=	________
MM-NMS (Remote) calls	________	×	3.05	=	________
MM-CCR-Announcement	________	x	.57	=	________
MM-Express Messaging	________	×	.95	=	________
MM-Auto Attendant w/ transfer calls		×	.64	=	

Table 66
Processor load worksheet (Part 2 of 5)

Feature	Usage	×	Real Time Factor (25)	=	EBC
MM-Voice Menus		x	.69	=	
MM-Voice Forms (leave 1)		x	.60	=	
MM-Voice Forms (login)		x	1.03	=	
MM-Voice Forms (retrieve 1)		x	1.62	=	
ACD (Inbound) calls		×	.26	=	
ACD-D/MAX calls		×	.81	=	
ACD - Multiple Q Assignment		x	.37	=	
NACD Ovflowed calls		×	2.89	=	
Meridian Link calls		×	.60	=	
MLink status messages		×	.57	=	
MLink call transfers		×	1.72	=	
HER calls		×	.91	=	
CCR - scriptless overhead		x	.91	=	
CCR calls (“simple” script)		x	.44	=	
CCR calls (“medium” script)		x	4.12	=	
CCR calls (“complex” script)		x	4.56	=	
Symposium - scriptless overhead		x	1.33	=	
MIRAN Broadcast RAN		x	.48		
Symposium calls (MIRAN, “basic” script)		×	1.33	=	
Symposium calls (MIRAN, “simple” script)		x	2.06	=	
Symposium calls (MIRAN, “typical” script)		x	5.74	=	

Table 66
Processor load worksheet (Part 3 of 5)

Feature	Usage	×	Real Time Factor (25)	=	EBC
IVR Broadcast RAN (“IVRbRAN”		x	1.70	=	
Symposium calls (IVRbRAN, “basic” script)		x	1.33	=	
Symposium calls (IVRbRAN, “simple” script)		x	3.28	=	
Symposium calls (IVRbRAN, “typical” script)		x	6.96	=	
Autodialer		x	1.17	=	
Predictive Dialer		×	1.72	=	
MIVR without transfer		×	0.57	=	
MIVR with transfer		×	1.41	=	
MIVR without transfer Symposium		×	0.32	=	
MIVR with transfer Symposium		×	1.07	=	
PMSI Room Status Update		x	1.71	=	
Conference or transfer		x	1.59	=	
11C - Internal CDR calls - QSDI TTY		×	.39	=	
11C - Outgoing CDR calls - QSDI TTY		×	.32	=	
11C - Incoming CDR calls - QSDI TTY		×	.32	=	
11C - Tandem CDR calls - QSDI TTY		x	.36	=	
Internal CDR calls - QSDI TTY - (51C/61C/81C)		×	.32	=	
Outgoing CDR calls - QSDI TTY- (51C/61C/81C)		×	.36	=	

Table 66
Processor load worksheet (Part 4 of 5)

Feature	Usage	×	Real Time Factor (25)	=	EBC
Incoming CDR calls - QSDI TTY- (51C/61C/81C)		×	.40	=	
Tandem CDR calls - QSDI TTY- (51C/61C/81C)		×	.67	=	
Internal CDR calls - MSDL TTY		x	2.74	=	
Outgoing CDR calls - MSDL TTY		x	2.34	=	
Incoming CDR calls - MSDL TTY		x	2.42	=	
Tandem CDR calls - MSDL TTY		x	2.11	=	
Authorization Code calls		×	1.15	=	
Off-Hook Queuing calls		×	1.83	=	
Tandem (analog)		x	0.27		
Tandem (PRI)		x	0.29		
Tandem (DTI)		x	1.82		
Trunk Calls, incoming DTN		×	0.18	=	
Trunk Calls, outgoing TIE		×	0.16	=	
Trunk Calls, outgoing CO		×	0.16	=	
Trunks, RAN		×	0.63	=	
Trunks, Music		×	0.25	=	
BARS/NARS calls		×	0.13	=	
NFCR calls		×	1.44	=	
VNS - in		x	0.57	=	
VNS - out		x	0.63	=	
DASS - in		x	0.33	=	
DASS - out		x	0.22	=	

Table 66
Processor load worksheet (Part 5 of 5)

Feature	Usage	×	Real Time Factor (25)	=	EBC
DPNSS - in		x	0.31	=	
DPNSS - out		x	0.40	=	
QSIG - in		x	0.55	=	
QSIG - out		x	0.60	=	
DTI calls, incoming		×	0.48	=	
DTI calls, outgoing		×	1.10	=	
PRA calls, incoming		×	0.07	=	
PRA calls, outgoing		×	0.29	=	
RVQ calls		×	1.41	=	
Superloop calls		×	–0.23	=	
Total Real Time Impact (add up the EBC column)___________EBC					

Table 67
Real time factors by release (Part 1 of 5)

Feature	**X11 Release**
	25
Digital telephone calls	0.12
BRI voice calls	0.12
CLASS set calls	0.24
Data calls	0.14
CPND characters	0.01
CDP calls	0.12
MCE - MM (CSL) calls	1.91
MCE - MM (EES, dtmf off) calls	2.38
MM (CSL) calls	1.10
MM (EES, dtmf on) calls MM (EES, dtmf off) calls	n/a 1.36
NMS (Main) calls	0.75
NMS (Remote) calls	3.05
Auto Attendant calls	0.64
MM - voice menues	0.69
MM - voice forms (leave 1)	0.60
MM - voice forms (login)	1.03
MM - voice forms (retrieve 1)	1.62

Table 67
Real time factors by release (Part 2 of 5)

Feature	X11 Release
	25
ACD (Inbound) calls - NT5D10 CP card	0.26
ACD (Inbound) calls - 11C	
ACD (Inbound) calls - NT5D03 CP card and CP PII	
ACD-D/MAX calls	0.81
NACD Overflowed calls	2.89
Meridian Link calls	0.60
MLink status messages	0.57
MLink Call Transfers	1.72
HER calls	0.91
CCR scriptless overhead	0.91
Symposium scriptless overhead	1.33
CCR - simple script	0.44
CCR - medium script	4.12
CCR - complex script	4.56
MIRAN Broadcast RAN	0.48
Symposium with MIRAN basic treatment	1.33
Symposium with MIRAN simple treatment	2.06
Symposium with MIRAN typical treatment	5.74
IVR Broadcast RAN (IVRbRAN)	1.70

Table 67
Real time factors by release (Part 3 of 5)

Feature	**X11 Release**
	25
Symposium with IVRbRAN basic treatment	1.33
Symposium with IVRbRAN simple treatment	3.28
Symposium with IVRbRAN typical treatment	6.96
MIVR (no transfer)	0.57
MIVR (with transfer)	1.41
MIVR (no transfer) Symposium	0.32
MIVR (transfer) Symposium	1.07
Autodialer	1.17
Internal CDR calls - QSDI TTY - NT5D10	0.32
Outgoing CDR calls - QSDI TTY - NT5D10	0.36
Incoming CDR calls - QSDI TTY - NT5D10	0.40
Tandem CDR calls - QSDI TTY - NT5D10	0.67
Internal CDR calls - QSDI TTY - NT5D03	0.32
Outgoing CDR calls - QSDI TTY - NT5D03	0.36
Incoming CDR calls - QSDI TTY - NT5D03	0.40
Tandem CDR calls - QSDI TTY - NT5D03	0.67
Internal CDR calls - QSDI TTY - 11C	0.39

Table 67
Real time factors by release (Part 4 of 5)

Feature	X11 Release
	25
Outgoing CDR calls - QSDI TTY - 11C	0.32
Incoming CDR calls - QSDI TTY - 11C	0.32
Tandem CDR calls - QSDI TTY - 11C	0.29
Internal CDR calls - MSDL TTY	2.74
Outgoing CDR calls - MSDL TTY	2.34
Incoming CDR calls - MSDL TTY	2.42
Tandem CDR calls - MSDL TTY	2.11
Tandem (analog) calls	0.27
Tandem (PRI) calls	0.29
Tandem (DTI) calls	1.82
Authorization Code calls	1.15
Off-Hook Queuing calls	1.83
Trunk Calls, incoming DIP or DTN	0.18
Trunk Calls, outgoing TIE	0.16
Trunk Calls, outgoing CO	0.16
Trunks, RAN	0.63
Trunks, Music	0.25
BARS/NARS calls	0.13
NFCR calls	1.44
VNS - in	0.57
VNS - out	0.63

Table 67
Real time factors by release (Part 5 of 5)

Feature	**X11 Release**
	25
DASS - in	0.33
DASS - out	0.22
DPNSS - in	0.31
DPNSS - out	0.40
QSIG - in	0.55
QSIG - out	0.60
DTI calls (incoming) - 11C	0.48
DTI calls (outgoing) - 11C	1.10
DTI calls (incoming) - NT5D10	0.48
DTI calls (outgoing) - NT5D10	1.10
DTI calls (incoming) - NT5D03 and CP PII	0.48
DTI calls (outgoing) - NT5D03 and CP PII	1.10
PRA calls (incoming)	0.07
PRA calls (outgoing)	0.29
RVQ calls	1.41
Superloop calls	-0.23

Copy the factors needed from the column in this table corresponding to the correct release into the “Real Time Factor” column of Table 66. Compare the resulting sum from Table 63 (A) to the capacity of the proposed system as determined from Table 68 (B). If A is greater than B, the system does not have sufficient capacity to handle the proposed feature load.

Table 68
Meridian 1 real time capacity by release (EBC)

X11 release	25
Option 51C/61C/81C w/NT5D10 CP card : CP3	62,450
Option 51C/61C/81C w/NT5D03 CP card : CP4	86,625
Option 81C with CP PII	259,875
Option 11C	40,125

Memory size worksheet

Software Release: ___________

Table 69
PDS calculation worksheet (Part 1 of 5)

Feature	Usage	X	PDS factor*	=	Memory (SL-1 words)**
Fixed Address Globals	1	X		=	
500/2500 telephones*		X		=	
M2006 telephones*					
M2216/2616 telephones*					
M2317 telephones*					
M3900 telephones					
M3901 telephones					
M3902 telephones					
M3903 telephones					
ACD telephones					
Consoles					
Add-on Modules					
Templates					
Displays					
DS/VMS Access TNs:					
Meridian Mail Ports					
Data Only Ports					

* See “Protected Memory for Terminals: Detail” on page 229.

Table 69
PDS calculation worksheet (Part 2 of 5)

Feature	Usage	X	PDS factor*	=	Memory (SL-1 words)**
ISDN BRI:					
MISP cards					
DSLs					
TSPs		X		=	
BRI Line cards		X		=	
Analog trunks		X		=	
Trunk Routes:					
Constant term	1				
Trunk routes					
ISDN PRI/PRI2/ISL:					
D-channels					
PRI Trunks					
ISL 5runks					
ISDN DTI/DTI2/JDMI:					
DTI Loops					
DTI2 Loops					
DISA DN’s		X		=	
Network:					
Groups		X		=	
Local Loops		X		=	
Remote loops		X		=	

Table 69
PDS calculation worksheet (Part 3 of 5)

Feature	Usage	X	PDS factor*	=	Memory (SL-1 words)**
ODAS:					
Meridian Mail Ports		X		=	
Data Only Ports		X		=	
Sets (total number)		X		=	
Analog Trunks		X		=	
Customers:					
Constant Term	1	X		=	
Number of Customers		X		=	
Tone and Digit Switch		X		=	
MF Sender		X		=	
Conference Card		X		=	
Digitone Receiver		X		=	
Tone Detector		X		=	
DN Translator:					
DNs		X	5.8	=	
ACD DNs		X	4	=	
ACD Positions		X	2	=	
DISA DNs		X	2	=	
Consoles		X		=	
Dial Intercom Groups		X	1	=	

Table 69
PDS calculation worksheet (Part 4 of 5)

Feature	Usage	X	PDS factor*	=	Memory (SL-1 words)**
DIG translator:					
Maximum number of DIGs		X	1	=	
DIGs		X	2	=	
Number of Sets within DIGs		X	2	=	
Authorization Code:					
Constant Term	1	X		=	
Authorization Codes		X	1.52	=	
History File	1	X		=	
FGD ANI Database:					
Constant Term	1	X		=	
NPA Codes		X		=	
CDP:					
Constant Term	1	X		=	
Steering Codes		X	3	=	
Route lists		X	8	=	
Number of Entries in Route Lists		X	3	=	
CPND:					
Trunk Routes		X	1	=	
Consoles		X	1	=	
ACD DNs		X	1	=	
Digital Set DNs		X	1	=	
CPND Names		X	20	=	
1 digit DIG Groups		X	11	=	
2 digit DIG Groups		X	101	=	

Table 69
PDS calculation worksheet (Part 5 of 5)

Feature	Usage	X	PDS factor*	=	Memory (SL-1 words)**
ACD/NACD:					
ACD DNs		X		=	
NACD DNs		X		=	
ACD Positions		X		=	
ACD Agents		X	1	=	
Customers		X	11	=	
BARS/NARS:					
Constant term	1	X	5684	=	
NPA Codes		X	31.21	=	
NXX Codes		X	1.06	=	
LOC Codes		X	1.06	=	
SPN Codes		X	1.06	=	
FCAS Tables		X	2	=	
Total PDS Impact (add up the Memory column) ___________SL-1 words					
*From Table 71, “PDS factors by X11 release—units are SL-1 words,” on page 220.					
**SL-1 words of data store are 2 bytes in size. One SL-1 word of data occupies and entire SL-1 word of memory, even if the word size for the CP type is greater than 2 bytes. For example, one 2-byte SL-1 data word uses up one 4-byte word of Option 81C/61C/51C memory.					

Table 70
UDS calculation worksheet (Part 1 of 5)

Feature	Usage	X	UDS factor **	=	Memory (SL-1 words)**	Reference
Fixed Addr. Globals & OVL data	1	X		=		
500/2500 telephones		X		=		
M2006/2008 telephones		X		=		
M2016/2216/2616 telephones		X		=		
M2317 telephones		X		=		
M3900		X		=		
M3901		X		=		
M3902		X		=		
M3903		X		=		
M3904		X		=		
Consoles		X		=		
Add-on-Modules		X		=		
Displays		X		=		
DS/VMS access TNs						
Meridian Mail Ports		X		=		
Data Only Ports		X		=		
ISDN BRI telephones:						
Constant Term	1					
MISP boards						
DSLs						

Table 70
UDS calculation worksheet (Part 2 of 5)

Feature	Usage	X	UDS factor **	=	Memory (SL-1 words)**	Reference
Analog Trunks:						
RAN Trunks		X		=		
RLA Trunks		X		=		
RLA Trunks		X		=		
AUTOVON Trunks		X		=		
ADM		X		=		
Other Analog trunks		X		=		
Trunks (CDR)		X	9	=		
BRI Trunks		X		=		
Trunk Routes:						
Trunk Routes		X		=		
Trunks (total)		X	0.063	=		
DTI/DTI2/JDMI:						
DTI Loops		X		=		
DTI2 Loops		X		=		

Table 70
UDS calculation worksheet (Part 3 of 5)

Feature	Usage	X	UDS factor **	=	Memory (SL-1 words)**	Reference
PRI/PRI2:						
D-Channels (PRI)		X		=		
D-Channels (PRI2)		X		=		
Output Request Buffers		X	5	=		
PRI Trunks		X	2	=		
ISL Trunks			2	=		
Teletypes:						
Teletypes (total)		X		=		
CDR links		X		=		
HS Links		X		=		
APL Links		X		=		
PMS Links		X		=		
Other Links		X		=		
Local Loops		X		=		
Remote Loops		X		=		
Secondary Tapes		X		=		
Customers		X		=		
Tone and Digit Switch		X		=		
MF Sender		X		=		
Conference Cards		X		=		
Digitone receiver		X				
Tone Detector		X				
Attendants						
Peripheral Signaling cards						
Background Terminals						
MSDL Cards						

Table 70
UDS calculation worksheet (Part 4 of 5)

Feature	Usage	X	UDS factor **	=	Memory (SL-1 words)**	Reference
LPIB		X	4	=		
HPIB (number of Groups)		X	128	=		
PBXOB (number of PS Cards)		X	640	=		
BCSOB (number of PS Cards)		X	640			
AML:						
Constant Term	1	X		=		
AML Links		X				
ACD:						
ACD DNs		X	298	=		
ACD Positions		X	34	=		
ACD-C: (add’l memory)						
ACD-C routes		X	46	=		
ACD-C Positions		X	44	=		
ACD-C DN’s		X	80	=		
ACD-C Customers		X	240	=		
ACD-C Trunks		X	1	=		
ACD CRT		X	30	=		
BARS/NARS/CDP:						
Customers		X	216	=		
Route Lists		X	90	=		
Routes with OHQ		X	20	=		
NCOS defined		X	24	=		

Table 70
UDS calculation worksheet (Part 5 of 5)

Feature	Usage	X	UDS factor **	=	Memory (SL-1 words)**	Reference
Call Registers:						
ISDN Fact.		X	1	=		L
Number of Calls Overflowed						
to all Target ACD DN’s (A)		X	2.25	=		A
Number of Calls Overflowed to						
Local Target DN’s (B)		X	-1.8	=		B
Number of expected Calls						
Overflowed from source (C)		X	0.2	=		C
Snacd+Tnacd (= A + B + C)		X	1	=		D
Number of CR’s (Traffic >3000)						
Total voice loop traffic (CCS)		X	0.04	=		E
ACD Inc. Trunks		X	0.18	=		F
Number of CR’s (=(D+E+F)*L)		X	1	=		G
Number of CR’s (Traffic <=3000)						
System equipped ports		X	0.94	=		I
ACD Inc. Trunks		X	0.06	=		J
ACD Agent Sets		X	-0.94	=		K
Number of CR’s (=(D+I+J+ K)*L)						
***Memory for Call Registers		X	1	=		

Total PDS Impact (add up the Memory column) ___________SL-1 words

*From Table 72, “UDS factors by X11 release—units are SL-1 words,” on page 223.

**SL-1 words of data store are 2 bytes in size. One SL-1 word of data occupies and entire SL-1 word of memory, even if the word size for the CP type is greater than 2 bytes. For example, one 2-byte SL-1 data word uses up one 3-byte word of Option 71 memory and one 4-byte word of Option 81/61C/51C memory.

***Use only the last line from the Call Registers Part. **Call register count should still remain below the recommended maximum for the machine type and memory type configured.**

Table 71
PDS factors by X11 release—units are SL-1 words (Part 1 of 3)

Feature	X11 Release 25
Fixed Address Globals	11019
500/2500 telephones*	57
CLASS sets	57
M2006/2008 telephones*	104
M2216/2616 telephones*	114
M2317 telephones*	130
M3900 telephones	130
ACD telephones	16
Add-on-Modules	32
Templates	16
Consoles	236
DS/VMS Access TNs	14.5
ISDN BRI:	
MISP cards	542
DSLs	153
TSPs	180
BRI DNs	47
Analog Trunks	54
* See “Protected Memory for Terminals: Detail” on page 229.	

Table 71
PDS factors by X11 release—units are SL-1 words (Part 2 of 3)

Feature	X11 Release 25
Trunk Routes:	
Constant term	1024
Trunk Routes	238
ISDN PRI/PRI2/ISL:	
D-Channels	137
ISDN DTI/DTI2/JDMI:	
DTI Loops	70
DTI2 Loops	153
DISA DNs	18
Network:	
Groups	49
Local Loops	91
Remote Loops	95
ODAS	3
Customers:	
Constant Term	1000
Customers	502
Tone and Digit Switch	2
MF Sender	2
Conference Card	2
Digitone Receiver	12
Tone Detector	3

Table 71
PDS factors by X11 release—units are SL-1 words (Part 3 of 3)

Feature	X11 Release
	25
DN Translator (Consoles)	125
Author. Code (Custom.)	199
FGD ANI Database:	
Constant Term	43
NPA Codes	547
CDP (Constant Term)	637
ACD/NACD:	
ACD DNs	92
NACD DNs	174 src 115 dest
ACD Positions	30

Table 72
UDS factors by X11 release—units are SL-1 words (Part 1 of 3)

Feature	X11 Release
	25
Fixed Address Globals	27948
500/2500 telephones	40.5
M2006/2008 telephones	61
M2216/2616 telephones	92
M2317 telephones	83.25
M3900 telephones	91
i2004 telephones	92
Consoles	141
Add-on-Modules	24
Displays	2
DS/VMS access TNs	16.5
ISDN BRI telephones	
Constant Term	298
MISP cards	2270
DSLs	255
BRI line cards	85

Table 72
UDS factors by X11 release—units are SL-1 words (Part 2 of 3)

Feature	X11 Release
	25
Analog Trunks:	
RAN trunks	74
Broadcast RAN trunks	
RLA Trunks	48
AUTOVON Trunks	146
ADM	154
Other Analog Trunks	139
Trunk Routes	150
BRI trunks	159
DTI/DTI2 JDMI:	
DTI Loops	109
DTI2 Loops	97
PRI/PRI2:	
D-Channels (PRI)	836
D-Channels (PRI2)	850
Teletypes:	
Teletypes (total)	3704
CDR links	128
HS links	143
APL links	311
PMS links	130
Other links	512
Local loops	69
Remote loops	93

Table 72
UDS factors by X11 release—units are SL-1 words (Part 3 of 3)

Feature	X11 Release 25
Secondary Tapes	539
Customers	243
Tone and Digit Switch	59
MF Sender	59
Conference Cards	191
Digitone receiver	12
Tone Detector	12
PS Cards	59
Background terminals	89
MSDL cards	1377
AML (CSL):	
Constant term	143
AML Links	514
Call Registers	220

Default queuing buffer sizes

Use Table 73 as a guide to buffer size.

Table 73
Default buffer sizes for various Meridian 1 Options

Option	HPIB	LPIB	500B (PBX)	SL1B (BCS)	CSQI	CSQO
51C/61C/81C w/ NT5D10, NT5D03, CP PII CP card <= 5 groups	2200	2200	800	255	255	255
81C w/ NT5D03 CP card > 5 groups	3300	3300	800	255	255	255
81C w/ CP PII CP card > 5 groups	3500	3500	800	255	255	255
11C	450	450	N/A	N/A	80	80

Note 1: In a system with MM.AML, ML and CCR, add the number of CSQI and CSQO to the CR requirement obtained from feature impact calculations.

Note 2: The above buffer estimation was based on relatively conservative scenarios which should cover most practical applications in the field. However, since most mathematical models deal with “average traffic”, so do the models. When traffic spikes occur, buffer overflow could still happen. In that case, you should raise the buffer size somewhat, depending on the availability of Call Registers (CRs). The maximum number of buffers allowed for CSQI and CSQO is 255 each.

The buffer limit is the maximum number of CRs which can be used for that function out of the total CR pool. If the designated number is larger than needed, and there are still spare CRs, the unused CRs will not be tied up by this specific function. Therefore, there is little penalty of over stating the limit of buffer size (we might run out of CRs, if limits are not properly sets). As long as the system has a relatively large memory (CRs),a more generous allocation of buffers that the number recommended above is not discouraged.

For example, an Option 81C Call Center (Max 20,000 CRs) and with a lot of applications (Meridian Mail, ML, CCR), it would be a good idea to set its CSQI/CSQO to a higher value, even up to 255.

The above recommendation provides a relative requirement of various buffers. It should be viewed as a minimum buffer size needed to cover most applications under the constraint of a tight memory availability. When increases are to be made, they should be proportional to the above values except CSQI/CSQO which is relatively independent of other buffers and can be increased without affecting others.

Computing memory used

Use the following worksheets to compute memory used:

Table 74
Memory used—Option 61C/51C w/ NT5D10, NT5D03, CP PII CP cards and Option 11C* (Note 6)

Memory item	x	Factor	Operation	Reference
PDS words	x	pf bytes/word	+	Notes 1 and 2
UDS words	x	pf bytes/word	+	Note 3
Code MB	x	1024 x 1024 bytes/MB	+	Note 4, Note 6
Patching and OS overhead MB	x	1024 x 1024 bytes/MB	+	Note 4
OS dynamic heap MB	x	1024 x 1024 bytes/MB	+	Note 4
		Sum	____bytes	
	x	1.10		Note 5

Note 1: PDS is protected data store, as computed using Table 69, “PDS calculation worksheet,” on page 210.

Note 2: PF is the packing factor—the number of bytes of memory occupied by a single SL-1 data word. For Option 61C/51C, pf = 4.

Note 3: UDS is Unprotected data store, as computed using Table 70, “UDS calculation worksheet,” on page 215.

Note 4: These fields are taken from Table 15, “Program store size (MB) for Option 51C/61C/81C CP/CP32/CP3/CP4,” on page 87 and Table 17 “Patching, Overhead and OS Heap (MB) for Option 11C DRAM” on page 88 .

Note 5: A 10% margin is included to account for differences between releases and other variations too detailed for the scope of this document.

Note 6: For CP3,4 Processor and Option 11C, compute DRAM used (EPROM is for code and is not affected by user. DRAM is for data.) by performing all the calculations in the table except “Code”.

Determining whether system memory is adequate

Determine the amount of system memory by using Table 12, “Memory sizes (MB),” on page 84. Convert this quantity to bytes (x 1,024 x 1,024). In order for the system to have adequate memory for its feature load, Available memory minus Memory used must be greater than zero.

Protected Memory for Phone Sets: Detail

The protected data blocks for the various set types use varying amounts of memory according to what keys/features are configured on the set. The memory requirements shown in the tables above show only a “typical” (as determined by looking at a sampling of sites) size for the given set type. The tables below can be used to arrive at a precise memory requirement if the details of the feature configurations are known. The maximum size permitted for any set’s protected data block is 356 words.

PBX sets

The size of the protected line block for PBX sets is determined from the following (sizes are in SL-1 words):

Table 75
Size of protected line block for PBX sets—units are SL-1 words

Feature	SL-1 Compool Variable(s)	Size
Basic Line Block	PPBXBLOCK (words 0-23)	24
Template Area	PBX_TEMPL_AREA (words 24-511 of PPBXBLOCK)	0-488
Card Block Component	1/4 PCARDBLOCK (=9/4)	2.25

The key layout portion of the template requires

(4 + nf)/rs words

where “nf” is the number of features defined for the set, and “rs” is the number of sets sharing the same template.

In addition to the basic line block, each feature requires extra data space as follows (sizes are in SL-1 words):

Table 76
Data space requirements for PBX set features—units are SL-1 words (Part 1 of 2)

Feature	SL-1 Compool Variable(s) and/or comment	Size
ACD	P_ACD_KEY_DATA	16
Associate Set (AST)		2
Authcode	.AUTH_TEMPL_SIZE = .NAUT_MAX(6) * (((.AUTH_LEN_MAX(14) - 1)>>2)+1)	6-24
Automatic Wakeup	HM_STRUCT	5
Call Forward Number	CFW_STRUC (4-24 digits/4)	1-8
Call Park	CALL_PARK_STRUC	2
Call Party Name Display	PBX_NAME_ENTRY	1
CFCT		2
CFNA/Hunting Number	CFNA_ENTRY	4
Dial Intercom Group	PBX_DIG_STRUC	2
DN	PBX_DN_STRUC	3
EFD DN	EFD_STRUC	4
EHT DN	EHT_STRUC	4
Enhanced Hot Line DN	((# digits in DN) / 4) + 1 : 4 - 36 digits	2-10
FAXS	FAXS_BLK	17
FFC SCP PASS	FFC_SCPW_STRUC	2
Hot Line DN	((# digits in DN) / 4) + 1 : 4 - 36 digits	2-10
HUNT	HUNT_STRUC	4
Internal Call Forward		19
Last Number Redial	# digits in LNR DN / 4 : (4 - .MAX_LNR_SIZE=32) / 4	1-8

Table 76
Data space requirements for PBX set features—units are SL-1 words (Part 2 of 2)

Feature	SL-1 Compool Variable(s) and/or comment	Size
Manual Line		2
Message Center DN		2
Message Registration	MR_SET_METER	1
Offhook Interdigit Index	OHAS_INDEXES	1
Pretranslation Enhancement	1/2 word (for 255 calling groups)	1/2
SCI/CCOS/RMS		2
Speed Call Controller	SPEED_CALL_STRUC	1
Speed Call User	SPEED_CALL_STRUC	1
Stored Number Redial	# digits in SNR DN / 4 : (4 - .MAX_SNR_DIGITS=32) / 4	1-8
System Speed Call User	SPEED_CALL_STRUC	1
Tenant Number	TENANT_NUMBER	1

Digital sets

The size of the protected line block for SL-1 sets is determined from the following (size in SL-1 words):

Table 77
Size of protected line block for SL-1 sets—units are SL-1 words

Feature	SL-1 Compool Variable(s)	Size
Basic Line Block	PBCSBLOCK (words 0-45)	46
Template Area	BCS_DATA (words 46-511 of PBCSBLOCK)	0-465
Card Block Component	1/4 PCARDBLOCK (9/4)	2.25

The key layout portion of the template for the SL-1 basic set requires (4 + the number of key lamp strips * 10)/rs words where rs = the number of sets sharing the same template. For digital sets, the requirement is as follows:

M2006 10 + (#of non-key features)/rs

M2008 10 + (#of non-key features)/rs

M2216 20 + 30 x (#AOM) + (#of non-key features)/rs

M2616 20 + 30 x (#AOM) + (#of non-key features)/rs

M2317 34 + (#of non-key features)/rs

M3900 34 + (#of non-key features)/rs

where rs = the number of sets sharing the same template, and #AOM = the number of add-on modules.

In addition to the basic line block requirement, each feature requires extra data space as follows (sizes are in SL-1 words):

Table 78
Data space requirements for SL-1 set features—units are SL-1 words (Part 1 of 6)

Feature	SL-1 Compool Variable(s), service change format, and/or comment	Size
ACD Agent and ID Key	.acd_agent p_acd_key_data KEY xx ACD xxxx(xxx)* yyyy(yyy) *(xxx) - up to 7 digs w/DNXP pkg	16
ACD Display Calls Waiting Key	acd_dwc_ext KEY xx DWC yyyy(yyy)	2
ACD Agent Key (for supervisor)	acd_agt_ext KEY xx AGT yyyy(yyy)	2
ACD Enable Interflow Key	acd_eni_ext KEY xx ENI yyyy(yyy)	2
ACD Night Service DN	acd_nsvc_struc KEY xx NSVC yyyy(yyy)	2
Associate Set (AST)	bcs_ast_struc AST xx yy	3
Authcode (non-key)	.auth_templ_size (6) * (((.AUTH_LEN_MAX (14) - 1)>>2)+1) AUTH n xxxx	6-24
Autodial Key	(4-32 digits/4) .max_adl_size=31 KEY xx ADL yy (zzzz)	1-8
Busy/Forward Status Key	bfs_struct KEY xx BFS tn	1
Call Forward Key	cfw_struc : (.cfw_default (4) or (.MAX_CFW_SIZE=31 + 1)digits/4)	1-8
No Hold Conference and Autodial	(same as autodial) KEY xx CA yy zzzz	1-8

Table 78
Data space requirements for SL-1 set features—units are SL-1 words (Part 2 of 6)

Feature	SL-1 Compool Variable(s), service change format, and/or comment	Size
No Hold Conference and Direct Hotline	(htl_dn_size + 3 >>2) + wordoffset(bcs_hot_ter_dn) = (3:34)>>2 + 4 = 4-12 KEY xx CH D yy xxxx	4-12
No Hold Conference and Hotline List	wordoffset(bcs_hot_ter_dn) = 4 KEY xx CH L yyyy	4
No Hold Conference and Speed Call	speed_call_struc KEY xx CS yyyy	1
Dial Intercom Group Key	bcs_dig_struc KEY xx DIG xxxx yy R/V	2
DID Route Control	BCS_DRC_STRUC KEY xx DRC yyy	1
Group Call Key	bcs_grcal_entry KEY xx GRC yy	1
Hotline - One Way, Two Way or Intercom	(htl_dn_size + 3 >> 2) + wordoffset(bcs_hot_ter_dn) = 3:34>>2 + 4 = 4-12 KEY xx HOT D dd yyyy(yyy) KEY xx HOT D dd num DN m KEY xx HOT D nn x...x yyyy(yyy) KEY xx HOT I dd num m	4-12
Hotline - One Way or Two Way List	wordoffset(bcs_hot_ter_dn) KEY xx HOT L bbb KEY xx HOT L bbb yyyy(yyy)	4
Internal Call Forward Key	.cfw_default (1) or ((#digs(31) - 1)/4 + 1) : max 8 .max_cfw_size=31 KEY xx ICF 4-(16)-31 xxxx	1-8
Loudspeaker	bcs_dn_struc KEY xx LSPK yyyy	3

Table 78
Data space requirements for SL-1 set features—units are SL-1 words (Part 3 of 6)

Feature	SL-1 Compool Variable(s), service change format, and/or comment	Size
Multiple Call Non-ringing DN Key	bcs_dn_entry KEY xx MCN yyyy(yyy)	3
Multiple Call Ringing DN Key	bcs_dn_entry KEY xx MCR yyyy(yyy)	3
Message Registration Key	mr_set_meter KEY xx MRK	1
Message Waiting Key	mwc_entry KEY xx MWK yyyy(yyy)	4
Call Park Key	call_park_struc KEY xx PRK	2
Private Line Non-ringing Key	bcs_dn_entry KEY xx PVN yyyy	3
Private Line Ringing Key	bcs_dn_entry KEY xx PVR yyyy	3
Stored Number Redial Key	.max_rdl_size (31): (1+#saved dn digs(3-31))/4 + 1 KEY xx RDL (yy)	2-8
Ringing Number Pickup Key	bcs_rnpg_entry KEY xx RNP	1
Radio Paging	bcs_dn_entry KEY xx RPAG	3
Speed Call Controller Key	speed_call_struc KEY xx SCC yyyy	1
Single Call Non-ringing DN	bcs_dn_entry KEY xx SCN yyyy	3
Single Call Ringing DN	bcs_dn_entry KEY xx SCR yyyy	3

Table 78
Data space requirements for SL-1 set features—units are SL-1 words (Part 4 of 6)

Feature	SL-1 Compool Variable(s), service change format, and/or comment	Size
Speed Call User Key	speed_call_struc KEY xx SCU yyyy	1
Signalling Key	bcs_dn_entry KEY xx SIG yyyy(yyy)	3
System Speed Call Controller Key	speed_call_struc KEY xx SSC yyyy	1
System Speed Call User Key	speed_call_struc KEY xx SSU uu	1
Voice Call Key	bcs_dn_entry KEY xx VCC yyyy	3
	Non-key Features	
Data Equipment Mode (flex voice/data tn)	dtm_struc DEM DTE (DCE)	1
Flexible CFNA DN for External Calls	efd_struc EFD xxxx	4
Hunt DN for External Calls	eht_struc EHT xxxx	4
Flexible Call Forward No Answer	afdn_struc FDN xxxx	4
Offhook Alarm Security DN Index for Forced Out ofSservice	ohas_indexes FSVC (0) - 9	1
Hunt DN (chain) for Internal Calls	hunt_struc HUNT xxxx	2
Alternate Hunt DN (chain) for Internal Calls	ahnt_struc AHNT xxxx	4

Table 78
Data space requirements for SL-1 set features—units are SL-1 words (Part 5 of 6)

Feature	SL-1 Compool Variable(s), service change format, and/or comment	Size
Alternate Hunt DN for External Calls	aeht_struc AEHT xxxx	4
Alternate Flexible CFNA DN for External Calls	aefd_struc AEFD xxxx	4
Number of Key Lamp Strips	1 word per KLS in range KLS 1-7	1-7
Last Number Redial Size	.lnr_default(4) or ((xx+1)/4) LNRS xx (4-(16)-32)	1-8
Second DN Sharing Voice Mailbox	bcs_dn_struc SECOND_DN xxxx(xxx)	3
Station Control Password	ffc_scpw_struc SCPW xxxxx	2
Tenant	tenant_number TEN 1-511	1
template area users for which commands are implicit or entered outside of LD 11		
Ringing Change Key	supp_features	5

Table 78
Data space requirements for SL-1 set features—units are SL-1 words (Part 6 of 6)

Feature	SL-1 Compool Variable(s), service change format, and/or comment	Size
Notification Key Lamp	nkl_data	1
Hospitality Data	hsp_set_data	2
Hotel/Motel Info	hm_struct	5
Campon Priorities	povr_struc	1
Sar Group	save_bcs_sgrp	1
Boss-Secretary Filtering - boss	boss_struc	3
Boss-Secretary Filtering - sec'y	sec_struc	1
Call Party Name Display	PBX_NAME_ENTRY	1
FAXS	FAXS_BLK	17
Xdata Unit Downloadable Parameters	xdata_sc_parms	2

Mass Storage size worksheet

Auxiliary processors

Table 79 shows available space on auxiliary processor storage media.

Table 79
Mass storage space available on auxiliary processors

Product name	System tape 155 MB		Applications tape 155 MB		Hard disk		
	MB Used	MB Avail.	MB Used	MB Avail	MB Used	MB Avail	Disk Size
Meridian Link Module	38	117	6.5	148.5	44.5	127.5	172
Customer Controlled Routing	38	117	10.5	144.5	48.5	123.5	172
911 services	38	117					
Meridian MAX4 MiniMAX	25	130	28	127	82	90	172
Meridian MAX5	45	110	25	130	123	397	520
Interactive Voice Response	45	110	75	80	155	85	240

Design parameters

Content list

The following are the topics in this section:

This appendix lists a set of parameters which set an upper bound on certain system capacities by design. Changes to these parameters generally require a revision to the software, are constrained by other basic capacities, such as memory, and constrain other capacities such as traffic or system load. They have been set to provide the best possible balance between these two limits.

System parameters

Table 80
System parameters

System parameters	Maximum value	Comments
customers	100	
display messages for background terminal	255	
input/output ports (e.g. TTYs, printers)	16	each MSDL counts as one device; a history file counts as one device
AML/CSL links	16	with MSDL
TNs	64kB	software design limit, actual number of TNs will be constrained by physical capacity, real time, memory, and ISM limits

Customer parameters

Table 81
Customer parameters

Customer parameters	Maximum value	Comments
Tenants	512	
Dial Intercom Groups	2046	
Members per Dial Intercom Group	100	
Ringing Number Pickup groups	4095	Call Pickup Group 0 = no pickup group
Listed Directory Numbers (direct inward dialing only)	6	
DISA DNs	240	

Console and telephone parameters

Table 82
Console/telephone related parameters

Console/telephone parameters	Maximum value	Comments
consoles per customer	63	
lamp field arrays per customer	1	may be repeated once on another console
lamps per array (all numbers must be consecutive)	150	
feature keys per attendant console M1250 M2250	 10 20	
incoming call indicators per console	20	
trunk group busy indicators per console M1250 M2250	 16 20	
additional key/lamp strips console telephones	 2 6	
add on modules M2x16	 2	
protect bcs block length	512	

Trunk and route parameters

Table 83
Trunk and network related parameters (Part 1 of 2)

Trunk/network parameters	Maximum value	Comments
trunk routes per customer	512	
members per trunk route	510	
RAN trunks per RAN route	10	
trunk access restriction groups	32	
locations in an ESN network	256	
basic authorization codes	4096	
length of basic authcode	14 digits	
network authorization codes	20,000	ESN networks
length of network authcode	7 digits	fixed length defined per customer
NCOS CDP BARS/NFCR NARS/NSIG/AUTOVON	 3 7 15	
route lists CDP BARS NARS	 32 128 256	
route list entries	64	

Table 83
Trunk and network related parameters (Part 2 of 2)

Trunk/network parameters	Maximum value	Comments
NFCR trees	255	New Flexible Code Restriction
IDC trees	255	Incoming DID Digit Conversion
ISDN D-channels	64	with MSDL
ISDN B-channels per D-channel	382 or 359	16 T1's with a D-channel and backup D-channel, subject to members per trunk route limitations and physical limitations 15 T1's with a single D-channel, subject to members per trunk route limitations and physical limitations

ACD feature parameters

Table 84
ACD feature parameters

ACD parameters	Maximum value	Comments
ACD DNs per customer	240	
agent positions per DN	1200	real-time and physical capacity constraints may limit this further
agent priorities	48	
agent IDs per customer	9999	
agents logged in at one time per system	9999	real-time constraints may limit this further
CDNs per customer	240	
AST DNs per telephone	2	
number of ACD-ADS customers	5	
terminals and printers on CCR	8	
links per VASID	1	

Special feature parameters

Table 85
Non-ACD feature parameters (Part 1 of 2)

Feature parameters	Maximum value	Comments
speed call lists per system	8191	
number of DNs in speed call list	1000	
multiple appearances of the same directory number	30*	limited by watchdog timer * see steps in a hunting group
steps in a hunting group	30*	marketing objective, limited by watchdog timer * in combination with MADN, each hunt step with more than 16 appearances is counted as two, so the maximum combination of MADN and hunt steps is 30 MADN and 15 hunt steps
number of Call Party Name Display names defined	variable	limited by the number of DNs defined and available space in the Protected Data Store
CPND length		
SL-1 protocol	27	software design limit
ISDN protocol	24	display IE limitation (DMS switches have a display IE limit of 15)

Table 85
Non-ACD feature parameters (Part 2 of 2)

Feature parameters	Maximum value	Comments
AWU calls in 5 minutes	500	marketing objective, constrained by ring generator
Group Call Feature groups per customer stations per group	 64 10	
BRI application protocol parameter set groups per system terminal service profiles (per DSL) DSLs	 16 16 32kB	 software design limit, actual number is constrained by the number of TNs in the system: each DSL occupies 2 TNs
LTIDs	640kB	software design limit, each DSL can have a max of 20 LTIDs; the max number of LTIDs is limited by the number of DSLs, memory, and real time

Hardware and capacity parameters

The software design limits are not typically the binding constraints. The number of items of a particular type is usually determined by a combination of loop and slot constraints, if the item requires loops, or slot constraints alone.

Table 86
Physical capacity/hardware related parameters

Physical capacity/hardware parameters	Maximum value	Comments
multifrequency sender cards	64	software design limit, each MFS card requires 2 loops
XCT cards	64	provides TDS, CONF, and MFS functionality, requires 2 loops (TDS and MFS share timeslots on one loop, CONF uses the other loop)
total service and terminal loops Option 61C/51C	32	
	160	each XNET card requires 4 loops each MISP card requires 2 loops
digitone receivers	255	software design limit
multifrequency receivers	255	software design limit
tone detectors	255	software design limit

Memory related parameters

Table 87
Memory related parameters (Part 1 of 2)

Parameters	System Type	
	51C/61C/81C/CP3/CP4	**11C**
low priority input buffers (recommended default)	96–7500 (1850)	96-1000 (150)
high priority input buffers (recommended default)	16–7500 (1850)	16-1000 (150)
input buffer size (words)	4	4
500-set, trunk and digital set output buffer size per PS card (messages) (recommended default)	16–7500 (800)	NA
SL-1 set output buffer size per PS card (messages) (recommended default)	16–255 (255)	NA
message length (words)	4	4
D-channel input buffer size (bytes)	261	261
D-channel output buffer size (bytes)	266	266
TTY input buffer size (characters)	512	512
TTY output buffer size (characters)	2048	2048

Table 87
Memory related parameters (Part 2 of 2)

Parameters	System Type	
	51C/61C/81C/CP3/CP4	**11C**
number of call registers (expected max)	26–20000 (2000/ 4000/ 10000)	26-2047 (1000)
call registers assigned to SL-1/AUX	26–255	26-255
number of AML msg call registers	20—the minimum of 25% of total call registers or 255, default 20	
call registers for CSL input queues	20—the minimum of 25% of total call registers or 255, default 20	
call registers for CSL/AML output queues	20—the minimum of 25% of total call registers or 255, default 20	
auxiliary input queue	20—the minimum of 25% of total call registers or 255, default 20	
auxiliary output queue	20—the minimum of 25% of total call registers of 255, default 20	
history file buffer length (characters)	0–65535	0–65535
overlay cache memory blocks (19Kw segments)	NA	NA

Glossary

AML

Application Module Link

CCAR

Call Capacity Reporting Feature (TFS004) (Release 18)

CCR

Customer Controlled Routing

CCAR

Enhanced Call Capacity Reporting Feature (TFS004) (Release 24)

CDR

Call Detail Recording

CE

Common Equipment

CSL

Command and Status Link

ENET

Enhanced Network Card, a card in EPE

EPE

Enhanced Peripheral Equipment

HER

Host Enhanced Routing

HEVP

Host Enhanced Voice Processing

HSL

High Speed Link

IPE

Intelligent Peripheral Equipment

MISP

Multi-purpose ISDN Signaling Processing (card)

MIVR

Meridian Interactive Voice Response

ML

Meridian Link

MSDL

Multi-purpose Serial Data Link (card)

MUS

Music on hold

RAN

Recorded Announcement (trunk)

TDS/CON

Tone and Digit Switch/Conference (card)

UEM

Universal Equipment Module

XNET

Superloop Network Card, a card in IPE

XUT

Extended Universal Trunk (card)

Index

Meridian 1

Capacity Engineering

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