iSeries Disk Arm Requirements Based on Processor Model Performance

Larry Whitley and Clark Anderson
iSeries System Architecture and Performance
IBM Rochester Lab
June 29, 2001

As higher capacity disk devices (Direct Access Storage Devices, or DASDs, or arms, or drives) for the iSeries @server™ and AS/400™ systems become available, *fewer arms* are needed to satisfy the *capacity* requirements. This *can lead to configuring too few disk arms to meet the workload* placed on them. **A lack of disk arms can bottleneck the processor's performance.** To avoid such a bottleneck, a *minimum number of disk arms is needed for optimum performance* on each processor level. This number is independent of the quantity of drives needed to meet the desired storage capacity.

The worksheets in this guide are used to determine the minimum number of disk arms needed to potentially minimize the DASD bottleneck on iSeries and AS/400 computers running multi-user environments. This guide is organized as follows:

After learning the concepts presented, in order to relieve you of the tedium of using the worksheet and tables with pencil and paper, an "On-line Disk Arms Calculator (ODAC)" has been made available via the World Wide Web at:
http://www.as400service.ibm.com/supporthome.nsf/document/23122320 .

1 Why is it Important to Have Enough Disk Arms ?

As stated on the first page, a lack of disk arms can bottleneck processor performance. There are several reasons this occurs. This section attempts to clarify a few of them.

- A physical disk drive (non-cached) can only perform a certain number of disk accesses each second before performance starts to be impacted.

  While today's technology allows a disk to perform in excess of 100 operations each second, performance is impacted far before that number of disk accesses is reached. The impact starts to be dramatically felt when the number of disk accesses reaches about 40% of the maximum. This can be explained by Queuing theory.

  If more accesses are requested than can be completed in given period of time (often a fraction of a second), some requests must wait in a queue while the previous requests are processed. This occurs because disk requests occur in random time intervals, and take varying amounts of time to complete. The greater the number of disk requests each second and/or the longer they take to be processed, the more queuing occurs. For those requests that must spend time in a queue, the total response time equals not only the time for the drive to service the access request, but also the time spent waiting in the queue.

  To keep things at their optimum (very few disk requests needing to wait), the drive should probably not need to do more than about 30 requests/second (depending on the disk drive, the controller, the protection approach, and other variables). Once the disk gets to 40% utilization, performance is already starting to fall off (too many requests can be waiting in the queue).

- Performance problems can occur if a customer sizes a server based strictly on capacity. They may specify too few disk arms. As an example:

    For simplicity, we will ignore RAID in this discussion. Let's assume a customer needs 175 GB of capacity. They also need to perform 600 disk accesses each second. In this example, these accesses must occur at the disk level, *after* accounting for the iSeries self-cacheing capabilities (which are discussed on the following page).

    Using 17.5 GB drives, only 10 disks would be required. This means that each disk would need to do about 60 accesses each second. At this rate, performance could be a problem (due to the amount of queuing). However, if 8.5 GB disks were used, the customer would have 21 disks, and with less than 30 disk requests per second, performance should be quite good (very little queuing).

  Therefore, if a customer wants good performance while using 17.5 GB disks, he or she cannot simply use 10 disk drives. Options would include:
  1) Install 20 of the 17.5 GB disks (which gives them more capacity than they need).
  2) Do something to reduce the number of disk requests going to the disks each second.

    With iSeries single level store architecture, the best way to reduce the number of requests going to the disks is to increase the amount of memory installed on the system. With single level store, additional system memory acts as a cache for all disk requests and the reduction in the number of physical disk requests can be dramatic. Usually, adding system memory is more effective until the system is at its maximum memory

capacity. At that point, if disk performance is still an issue, adding a read cache between the system and the disk drives may be worth investigating.

Note: File accesses by an Integrated xSeries Server (IXS) are NOT cached by iSeries single level store algorithms. Therefore a cache between the system and the disks can provide a benefit if disk response times are an issue.

The net is, just because a 17.5 GB drive is double the size of an 8.5 GB drive does not mean you can use half as many. Performance could be impacted. However, sometimes by using 17.5 GB disks and adding a little additional capacity, the performance goals can be met, while minimizing the cost. For example, from a capacity standpoint, a customer may have needed ten 17.5 GB drives or twenty 8.5 GB drives. While 10 drives might not provide sufficient disk speed, 12 disks might. The total cost of 12 of the 17.5 GB drives (including controllers, towers, etc.) is far less than 20 of the 8.5 GB disks and the customer gets more capacity as part of the bargain.

v   The faster the processor, the more disk accesses it can request each second. This is obvious, but needs to be stated. The people who feel they should be able to merely size the disk based on capacity do not recognize the processing power of the iSeries. For example, even the smallest 820 has the potential to issue in excess of 1,000 disk requests per second, when running a database-intensive application that has been very efficiently programmed.

The reality is that usually only a fraction of this number of requests is issued. This is due to several factors, including: compute-intensive applications running at the same time as database-intensive applications; and not having sufficient workload to run the processor at its full capacity.

The worksheets in this document attempt to take several of these factors into account.

v   The iSeries has a very efficient "self-cacheing" capability implemented in the single level store architecture. Basically, when an iSeries has sufficient memory, up to 80% (and often more) of the (potentially tens of thousands of) disk accesses may not need to physically occur at the disk level. The data is already in memory. Therefore, with sufficient memory, the number of disks required for good performance can decrease. *However,* at the disk level, the drive itself can still only perform a given number of accesses each second !

Some customers feel that using an external read cache will allow more disk accesses to occur each second. While this is true, the effectiveness of the external disk cache decreases as the size of the memory on the iSeries increases. Therefore, an 8 GB external cache may be very effective if iSeries only has 1/2 GB of memory, but if the iSeries had for example 4 GB of memory, the effectiveness of the external cache would be severely limited. A high percentage of the accesses that were cached within the disk subsystem would never be requested, because the data was already in the iSeries' memory. In technical terms, the hit-to-miss ratio of the external cache becomes unacceptably high -- and performance suffers.

The net of this discussion is that to provide balanced performance, a system needs a sufficient number of disk drives. This document will help ensure that you do have sufficient disk resources to meet the performance -- not just capacity -- requirements of your application.

4

2   Relationship to Other Sizing Tools

The information in the accompanying worksheets and tables is based on studies done by the Rochester Lab for specific sets of transactions and assumptions. The benchmarks used to produce the tables may not accurately reflect your specific environment. Unique customer applications may generate more or less disk activity than the applications used to produce the tables. *Two other iSeries - AS/400 sizing tools provide the most accurate configuration projections*. They consider not only the processor and disk speeds, but also application requirements, memory capacity, existing drive utilization, etc.

    a. **The Workload Estimator assists IBM approved IBM Business Partners, and customers in projecting an iSeries or AS/400 model that meets capacity requirements within CPU % utilization objectives. The Workload Estimator for AS/400 is available online at** http://as400service.ibm.com/estimator**.**

    b. **The BEST/1 capacity planning tool, in conjunction with actual customer measurements on an existing system/application, usually provides more accurate information than these worksheets and tables, since it can rely on the customer's actual workload. BEST/1 is recommended for final configurations.**

Also, the information in the worksheets is intended to be used as a **GUIDELINE** and *NOT AS UNALTERABLE RULES*. Without data available for particular application scenarios, it is impossible to give definitive, specific rules on numbers of disk arms required in all customer cases. The information here is a best attempt to provide a general recommendation that should apply in many customer situations. It is important to realize that the specifics of individual application scenarios can cause variation in the appropriate number of disks required for each case. Additional information about each specific customer's system, coupled with experience and judgment, can alter the correct recommendation. Individual cases can differ from the general guidelines listed in the tables.

3   Recent Worksheet Updates

This guide provides worksheets that can be used to calculate the arm requirements. This edition includes several new V5R1 processor features for models 8xx and 270. In addition, the worksheets allow the arm requirements to be calculated for systems using the new features #2778 PCI RAID Disk Unit Controller, #4778 PCI RAID Disk Unit Controller, #9778 Base PCI RAID Disk Unit Controller, #2766 PCI Fibre Channel Disk Controller and two IBM Enterprise Storage Server (also referred to as 'ESS' or code named 'Shark') external disk units (2105-F10 and 2105-F20).

Also note the appendices on Capacity Upgrade on Demand, ESS (a.k.a. Shark) and Memory vs. Disk Arms.

4   Understanding the Worksheets

The worksheets use a simple step-by-step approach to calculating the number of disk arms required. All of the data needed to perform the calculations is contained in tables associated with the specific iSeries-AS/400 models, and in a separate table which provides adjustment factors for the various

combinations of Input/Output Processors/Adapters (IOP/IOAs), DASDs and protection methods. The data in these tables is based upon the following set of assumptions:

- "Typical" Commercial OLTP or Client/Server transactions are executed.
- The processor generates physical disk accesses as rapidly as the applications and the speed of the processor permit.
- A limitation of **70% processor utilization** is imposed to match the published recommendations for good interactive performance.
- It is assumed that enough memory is installed to meet the recommended paging rates.
- The values generated apply to a single OS/400 partition. The number of disks required by the system is the sum of the number of disks required for each partition on the system.

   Note: Additional memory can decrease the number of disk arms needed. See "Appendix C".

Installing at least the number of disk arms calculated using the worksheets ensures that DASD utilization will not exceed the recommended guidelines. Be cautious, however, when configuring models with "low levels" of interactive performance. The "non-interactive" performance can be used for either data-intensive or compute-intensive functions. The table values selected for use in calculations need to accurately reflect the manner in which the non-interactive processing power is used.

To use the worksheets, one must know or make assumptions about information that includes:

- The System (1) model type, (2) processor feature number, and where applicable, the (3) interactive feature (see section "6.6 **Interactive Features**" on page 13).
   The faster the processor, the more likely it will need to "wait" on the disk, therefore the more arms it needs to "keep busy".
- The (4) IOP/IOA type
- (5) DASD protection method.
   RAID-5, Mirroring or No Protection. And if mirroring disk drives, (6) DASD read-to-write access ratios. See section "6.3 **Mirrored Environments**" on page 12 for details.
- The (7) DASD device type
   The tables assume all devices are the same type and capacity. See section "6.2 **Mixing Disk Features**" on page 12 for more information.
- For non-interactive processing, the mix of data-intensive or compute-intensive functions, the (8) "type" of workload.
   "Traditional" Server activities, such as PC file/print serving, e-Mail or Notes/Domino serving, and static-page Internet serving require fewer disk accesses and are primarily sequential. In contrast, OLTP (On-Line Transaction Processing), where "green screen" types of applications have been rewritten to take advantage of client-server features, perform a lot of random disk accesses for each transaction. See section "5 Workload Discussion -- Processor and Interactive CPW" on page 9 for more details.
   Note: The On-line Disk Arms Calculator assumes a certain fixed workload mix.
- The (9) estimated CPU utilization during peak periods of operation.
   This can be used to prorate the number of arms calculated from the worksheets relative to the 70% utilization assumed. This may be especially appropriate for new systems. For example, on a new processor upgrade, where the CPU is not expected to exceed 35% for the first few months of operation, only half the arms calculated would be required. As CPU usage rises above this amount over time, more arms would be needed. Eventually, at full system capacity, a requirement for the full number shown in the table would be expected. See section "6.4 **CPU Utilization Considerations**" on page 13 for additional discussion.
   Note: The On-line Disk Arms Calculator assumes 70% CPU utilization.

*The example below illustrates most of these considerations and shows how **selecting the number of disk drives based solely on their capacity** (and the lowest price for the desired capacity) **could result in inadequate performance.***

Desired system disk capacity: 80 GB (usable capacity), plus RAID-5 parity capacity
CPU model: 820-2396, Interactive feature 1522
Expected CPU utilization: 70%
Expected Server workload: Traditional Client/Server, Light disk usage
Proposed DASD device: # 4318 (17 GB, 10,000 RPM)
IOP type: # 2763 PCI RAID Disk Unit Controller, RAID-5 Mode

Selection of disk drive feature # 4318 (17 GB, 10000 RPM) might be the first choice, as it meets system capacity needs and requires the minimum number of disks and supporting features, which in turn produces the lowest price. Based only on capacity, 5 disk arms would be sufficient for usable data plus parity in a single RAID-5 array. To determine whether 5 arms are also sufficient for performance, it is necessary to use the worksheet for Model 820, found on page 18. The worksheet is duplicated below, with the values filled in for this example.

Example for 820-2396, interactive feature 1522, with #4318 DASD and #2763 IOA

Worksheet for Model 820 **DASD Arms required for performance**	
1. In Table 6, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1) 950
2. In Table 6, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3) 880 *(950-70)*
4. In Table 7, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4) 16
5. In Table 7, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5) 59
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6) 4.4 *(70/16)*
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7) 14.9 *(880/59)*
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8) 19.3 *(14.9+4.4)*
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9) 1.19
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10) 17 *(19.3/1.19)*

In the worksheet, two types of values are used from the Model 820 tables. On lines 1 and 2, the CPW values are entered for the selected processor and interactive features. On lines 4 and 5, arm factors are entered for the interactive and server workloads. The arm factors represent, for a #2763 IOA and #4318 disk, the CPW rating for which a single disk arm can handle the disk operations generated by the selected workload. The arm factors are affected by the characteristics of the individual AS/400 models. In the worksheet, an adjustment factor from the IOP/IOA/DASD Adjustment table on page 14 is used to adjust the number of disk arms for the selected hardware and protection method.

From the worksheet, we find that 17 #4318 disk arms are required to satisfy the minimum performance requirement with a #2763. **Therefore,** 5 Arms would provide sufficient capacity for usable data plus parity in a single RAID 5 Array, **but** do **NOT** satisfy the minimum performance requirement of 17 arms.

By using feature # 4318 (17 GB, 10,000 RPM), 17 arms provide sufficient capacity (usable data plus parity in 2 separate RAID-5 Arrays), *and* provide acceptable performance. Alternatively, we could replace the IOA feature #2763 with IOA feature #4778, and use device feature #4317 (8.58 GB, 10,000 RPM). This would lead to the calculations shown in the worksheet below.

Example for 820-2396, interactive feature 1522 with #4317 DASD and #4778 IOA

Worksheet for Model 820 DASD Arms required for performance	
1. In Table 6, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1) 950
2. In Table 6, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3) 880 *(950-70)*
4. In Table 7, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4) 16
5. In Table 7, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5) 59
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6) 4.4 *(70/16)*
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7) 14.9 *(880/59)*
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8) 19.3 *(14.9+4.4)*
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10) 13 *(19.3/1.56)*

Using IOA feature #4778, and device feature #4317 (8.58 GB, 10, 000RPM), 13 disk arms provide sufficient capacity (usable data plus parity in 2 separate RAID-5 Arrays), *and* provide acceptable performance.

From this we can conclude that using either #2763 IOAs with 17 #4318 disk devices, or #4778 IOAs with 13 #4317 disk devices will satisfy both the capacity and performance requirements of the system. Either of the options can be selected, and the final choice may be made based on other considerations, such as the price of the entire configuration.

5   Workload Discussion -- Processor and Interactive CPW

Most often, the performance of iSeries systems is specified with two numbers, "Processor" and "Interactive" CPW. The Processor CPW is a metric that indicates the relative performance of the system when running commercial processing workloads, these workloads may be database intensive or compute intensive and may or may not use SQL. A portion of the total Processor CPW can be designated for traditional 5250 terminal (green screen) use via an Interactive Feature Card. The Interactive CPW is a metric that indicates the relative performance available to the system when running 5250 ("green screen") workloads.

When an iSeries system is acting as a server to other workstations (PCs, Macs or UNIX workstations communicating over TCP/IP would be examples - these workstations are not doing 5250 emulation) or systems, there will be one or more applications receiving requests across a communications network from those workstations and/or systems. These applications will only use "Processor CPW", but are highly variable in the amount of disk performance each require.

- Some applications place a relatively small, predominantly sequential workload on the disks. These types of applications include: PC file/print serving; Internet serving of "Static" pages (especially those with high graphical content); Lotus Notes/Domino mail serving; and any activity that performs relatively few random disk accesses. Some of these types of activities heavily exercise the CPU, others do not.

- Some applications perform heavy random disk activity while using relatively little CPU power. These programs typically perform On-Line Transaction Processing (OLTP).

  - When running OLTP applications some programs will use "Green Screen" approaches and will run against the level of "Interactive CPW" purchased. They will usually have a relatively low amount of CPU performance available to them (lower CPW number), but still perform large numbers of random disk accesses. The amount of disk activity generated in this mode is usually limited by the available CPU resource and the number of users actively using the workstations.

  - There are also OLTP applications that have been written to take advantage of client-server features. They perform many random disk accesses for each transaction. Because they are not running as 5250 applications, the full processing power of the system available to them. Applications like these can generate the same disk workload requirements as those generated by the 5250 applications, but these applications will typically have more (processor) CPW available for their use.

- Query applications, especially those processing through an alternate access path (secondary index to the data), and data warehousing applications, especially when performing "drill down" activities, can also generate large numbers of random disk accesses. These applications take advantage of the higher levels of "processor" performance and can therefore generate heavy disk activity.

To address the various requirements the tables present arm factors for three different server-oriented workloads: Light, Heavy and Mixed. They should not be used blindly. It will often be necessary to "weight" two of the values to obtain a result that matches the customer's actual environment.

5.1.1 *Light Disk Workload Environments:*

A "Light" disk access rate was determined when running *only* server applications (i.e., no interactive, green screen applications) that are *compute-intensive* and generate relatively few, sequential oriented disk accesses. Applications such as Lotus Notes/Domino; Internet Web serving of "static" pages, images, and graphics; and some SAP R3 environments fit this category (note that production environments of SAP can sometimes be heavier in disk load than what is created by the Industry Benchmark applications for SAP R3. The Industry Benchmark scenario is aligned with the "Light" concept for SAP R3). These applications produce less load on disk arms than "Interactive" types of applications. Even with relatively high CPU power provided in "server/batch" mode processing, the light use of disk by these applications limits the load on the arms. *Note:* File/Print Serving of PC files also generates relatively little disk activity, but since most of this activity uses an Integrated xSeries Server (IXS), there is relatively little iSeries-AS/400 CPU activity.

5.1.2 *Heavy Disk Workload Environments:*

This value evaluates processors running *OLTP types of transactions* that have been *written to run in the faster, client/server or "batch" mode (larger CPW value).* These types of transactions can use the entire CPW performance capability of the processor and therefore can generate a significant disk workload. The types of programs were discussed earlier. They perform extensive random access processing, often via SQL or ODBC for OLTP apps running on the "non-5250" side.

Because the programs can generate heavy disk activity, and there is a significant amount of processing power available (processor level of CPW), the "Heavy Disk Workload" values generate a requirement for a relatively large number of disk arms.

5.1.3 *Mixed Disk Workload Environments:*

The arm factor value for mixed workloads is based on a 50/50 weighted mix of the number of disk arms required for the "Light" and "Heavy" Disk Workload values. It is used primarily as an example, and is a "compromise" number. It was created by determining the number of disk arms required for a light workload and heavy workload, and then finding the arm factor that would yield a 50/50 weighting of those values.

It is suggested that you *do not use* this value, but *instead, weight the number of arms required to support the Server CPW for "Light" and "Heavy" workload values in a manner that is appropriate for your specific workload.*

10

The following example shows how this would be done. It uses the same system used in the earlier example. Using a filled in copy of the worksheet on page 18 we see that 14.9 arms are needed to support a light workload, and 55 arms are needed for a heavy workload. These are the values that are calculated on line 7, assuming the associated workload. For a 50/50 Mixed Workload, we can calculate that (50% x 14.9) + (50% x 55) = 35 ("unadjusted") arms are required. This value is then used on line 7 to complete the computations. The end result is the total number of arms required to support an OLTP workload using the interactive CPW plus the mixed workload on the server CPW.

Example:Mixed Workload on Model 820-2396/1522, with #4317 DASD and #4778 IOA

Worksheet for Model 820 — DASD Arms required for performance	
1. In Table 6, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1) 950
2. In Table 6, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3) 880 *(950-70)*
4. In Table 7, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4) 16
5. In Table 7, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5) 59 (Light) 16 (Heavy)
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6) 4.4 *(70/16)*
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7) 14.9 (Light) 55.0 (Heavy) 35.0 (50%)
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8) 39.4
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10) 26

One should weight the 2 extreme values for *"Heavy"* and *"Light"* whenever possible by the percentage appropriate to your specific combination of "Light" and "Heavy" Disk workload activity on the system. If you have no idea of the workload balance, 50% values shown in the tables may be used as a compromise. Recognize however, that depending on the situation, additional disks may need to be added once the workload balance has been determined.

IMPORTANT: *Do NOT* use the Mixed Disk Workload values if the server does Heavy Disk Workload activity during certain periods of time, and Light Disk activity at other times. In this situation, you *must size for the "worst" case*, and use the Heavy Disk Workload value. The *Mixed Disk Workload* value is appropriate *only* when the CPU is used *concurrently* for both *"Heavy" and "Light" workloads*.

When sizing for SAP R3, consider that many customers have experienced heavier disk traffic in production vs. that generated by the Industry Benchmark. Thus, actual production SAP environments can span the range of "Light" to "Mixed", depending on each unique customer installation (for second tier). When sizing for SAP in a 3 tier environment, the server workload for the third tier server SAP "database server" is "Heavy".

6 Additional Considerations When Using the Tables

6.1 Load Source Drive

For proper Disk protection on systems prior to the 6x0 and Sx0 models, the first drive on the system (usually called the "**load source drive**") had to be mirrored, and used a much slower controller than the RAID-capable controllers. All newer models allow use of a faster controller that also allows this drive to be used in a RAID-5 array. The tables account for the potential speed difference of the "load source drive" (and it's mirror, where indicated). They *assume all other arms* on a system *have the same speed and capacity.*

6.2 Mixing Disk Features

The tables do not attempt to address performance for **mixtures of disk feature capacities** or types. To project performance capabilities on mixed disk-capacity installations, refer to the discussion in Chapter 14 (DASD Performance) of the "iSeries Performance Capabilities Reference V5R1" (available at http://publib.boulder.ibm.com/pubs/html/as400/online/chgfrm.htm in the AS/400 online library). The chapter contains charts showing "Operations per Second per Gigabyte" (Ops/sec/GB) for various types of drives and controllers. This data can be used to guide decisions on each arm's capacity and mixtures of arms in a particular installation.

6.3 Mirrored Environments

In a *mirrored environment*, *writes* must occur *on both disk drives*. This increases the number of writes that are generated. Therefore, in a mirrored environment, the number of arms required must be increased by the percentage of DASD accesses (for an unmirrored system) that are disk writes. For example, assume a system with a read-to-write ratio of 3-to-1. This means the system does 3 reads for every write (which totals 4 disk accesses). In a mirrored environment, an extra disk access is required for every "write" -- 5 accesses occur (3 reads plus *2 writes)*. This is 25% more activity than the tables show for the "unprotected" environment.

The IOP/IOA/DASD Adjustment Table values for mirroring are based on the assumption that the read-to-write ratio is 2-to-1. This value gives a 33% increase in the amount of disk traffic, and therefore yields a 33% increase in the number of disk arms required.

If possible, when calculating the appropriate number of arms for a system that will employ mirroring, you should adjust the IOP/IOA/DASD adjustment value from Table 1 based on the read-to-write ratio for the system. The read and write information for the system is shown in the Performance Reports. The correct IOP/IOA/DASD adjustment value can be determined by multiplying the value for unprotected systems by the anticipated read percentage. For example, in a system that uses #2778 IOP/IOAs and #6717 disk devices, the IOP/IOA/DASD adjustment value from Table 1 for an unprotected system is 2.07. If the system has a read percentage of 55%, then the correct adjustment value to use when calculating the number of disk arms required, when using mirroring with this system and IOP/IOA/DASD combination, is 2.07 * 0.55 , which is 1.14.
If the read-to-write ratio information is not available, the value from Table 1 for mirroring may be used. Recognize however, that depending on the situation, additional disks may need to be added once the actual read-to-write ratio has been determined.

Note: While the On-line Disk Arms Calculator assumes a 2-to-1 read-to-write ratio, some measurements of server applications such as Lotus Notes/Domino and SAP-R3 use read-to-write ratios as high as 40%-50% (in part due to very efficient internal caching of the reads).

6.4 CPU Utilization Considerations

The simple assumption for the table is that the CPU is running near its recommended limit for interactive activity -- 70% during peak periods. It is recognized that in many cases, systems are not pushed to this limit particularly in new installations. If it is known that full CPU capacity is not expected to be used when the DASD configuration is installed, then the table value for arms required may be prorated. For example, on a processor model upgrade, where additional work is not expected to be added to the system for some time, it might be projected that the CPU for interactive work is not to exceed 35% during peak periods. In this case, the number of arms required would be half of the table value.

CAUTION: Ensure that the highest planned system usage is considered over time. As additional work is added to the system, **more disk arms** are required. If a prorated number of disks is selected (instead of the values shown in the table); when the total work exceeds the peak usage amount assumed in this planning exercise, DASD hardware upgrades will likely be required The listed information assumes that the total number of arms needed as the system approaches its full interactive capacity matches the values shown.

> *Note:* The On-line Disk Arms Calculator assumes a 70% CPU utilization value.

6.5 Journaling

The numbers of disk arms listed in the table do **NOT** include drives for journal receiver arms in separate, dedicated ASPs. Arms configured specially for journal activity are in addition to those listed in the tables.

The speed of journal arms is greatly reduced by non-journaling disk traffic directed to the same disk arms. This is due to the sequential nature of journaling operations. Therefore, for best performance, journal receiver arms should be placed in a separate, dedicated ASP. The performance of journal receiver arms can be improved further if this ASP is mirrored, rather than protected using RAID-5. Parity operations generated by RAID-5 can interfere with the sequential nature of journaling traffic.

6.6 Interactive Features

The worksheet calculations assume that the full CPW available with the selected interactive feature will be used for interactive OLTP workloads. In some cases, such as systems with the smallest available interactive feature, this assumption may not apply. If it is known the system will run *only* client-server applications that are *compute-intensive* and generate relatively few, sequential disk accesses, then the computation of the disk arm requirements for the interactive CPW can be omitted.

In this case, enter 0 (zero) for the interactive CPW on line 2 of the worksheets for the server models.

13

7 IOP/IOA/DASD Adjustments to Arm Requirements

The number of disk arms required to support a given workload on any CPU model will be affected by the combination of controller (IOP/IOA) and DASD features selected. The number of disk arms required will also be affected by the use of RAID-5 or mirroring capabilities. The table on this page gives adjustment factors for each combination of IOP/IOA, DASD, and protection method. This adjustment factor is used to adjust the model-specific disk-arm recommendations on the following pages for differences in the selected hardware configuration.

Table 1 - IOP/IOA/DASD Adjustment Factors

Controller:	MFIOP, 9728, 9767, or 6530		65x2/3 /2726/2740,2741, 2763, 975x, 9337 4xx/59x: 6501		2748, 4748, 2778, 4778, 9778		2766
Drive Model / Capacity or 9337 Model:	6605 - 1GB xx06 - 2GB xx07 - 4GB xx13 - 8GB xx14 -17GB xx24 -17GB	xx17 - 8GB xx18 - 17GB	6605 - 1GB xx06 - 2GB xx07 - 4GB xx13 - 8GB xx14 - 17GB xx24 -17GB 9337- 4xx 9337 - 5xx	xx17 - 8GB xx18 - 17GB	6605 - 1GB xx06 - 2GB xx07 - 4GB xx13 - 8GB xx14 - 17GB xx24 - 17GB	xx17 - 8GB xx18 - 17GB	2105 Fx0
	Hardware Adjustment Factor						
No Protection	1.00	1.15	1.38	1.59	1.59	2.07	n/a
RAID-5	N/A	N/A	1.04	1.19	1.19	1.56	1.56
Mirroring	0.75	0.86	1.04	1.19	1.19	1.56	n/a

Notes:

1. The adjustment factors for mirroring assume a read-to-write ratio of 2-to-1, and therefore represent a 33% decrease from the adjustments for no protection. If the read-to-write ratio for the system is different, the correct adjustment factor should be selected by *decreasing* the adjustment factor from the "No Protection" row of the table by the appropriate amount. See " **Mirrored Environments**" on page 12 for details

2. For detailed information on the performance characteristics of these DASD arms, refer to Chapter 14 (DASD Performance) in the **iSeries Performance Capabilities Reference V5R1** available online at http://publib.boulder.ibm.com/pubs/html/as400/online/chgfrm.htm

8 DASD Arms Required for Performance Worksheets

Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See "***Mixed Disk Workload Environments:***" on page 10 for details). Heavy Disk Load scenarios apply to the percentage of time the system runs OLTP types of applications that have been written to run in the faster, client/server "batch" mode. Light Disk Load scenarios apply to the percentage of time the system runs newer server applications that are more compute-intense, and run in client/server "batch" mode. See section " Workload Discussion -- Processor and Interactive CPW" starting on page 9 for more details on these concepts.

DASD Arms Required for Performance iSeries Model **840**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 840, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 840 **DASD Arms required for performance**		Example: Model 840-2420/1540 , Light server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 840-2420/1540 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 2, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 16500	1) 16500
2. In Table 2, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 120	2) 120
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 16380	3) 16380
4. In Table 3, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 22	4) 22
5. In Table 3, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 111	5) 22
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6)	6) 5.5	6) 5.5
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7)	7) 147.6	7) 744.7
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 153.1	8) 750
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 99	10) 481

Table 2 - Model 840 CPW

Processor Feature	Processor CPW	Interactive Features								
		1548	**1547**	**1546**	**1545**	**1544**	**1543**	**1542**	**1541**	**1540**
2461	20200	20200	16500	10000	4550	2000	1050	560	240	120
2354 Max	20200	20200	16500	10000	4550	2000	1050	560	240	120
2354 Min	16500	N/A	16500	10000	4550	2000	1050	560	240	120
2353 Max	16500	N/A	16500	10000	4550	2000	1050	560	240	120
2353 Min	12000	N/A	N/A	10000	4550	2000	1050	560	240	120
2352 Max	12000	N/A	N/A	10000	4550	2000	1050	560	240	120
2352 Min	9000	N/A	N/A	N/A	4550	2000	1050	560	240	120
2420	16500	N/A	16500	10000	4550	2000	1050	560	240	120
2418	10000	N/A	N/A	10000	4550	2000	1050	560	240	120
2419 Max	16500	N/A	16500	10000	4550	2000	1050	560	240	120
2419 Min	13200	N/A	N/A	10000	4550	2000	1050	560	240	120
2417 Max	13200	N/A	N/A	10000	4550	2000	1050	560	240	120
2417 Min	10000	N/A	N/A	10000	4550	2000	1050	560	240	120
2416 Max	10000	N/A	N/A	10000	4550	2000	1050	560	240	120
2416 Min	7800	N/A	N/A	N/A	4550	2000	1050	560	240	120

Table 3 - Model 840 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2461	22	112	37	22
2354 Max	22	112	37	22
2354 Min	22	111	37	22
2353 Max	22	111	37	22
2353 Min	22	111	37	22
2352 Max	22	111	37	22
2352 Min	22	111	37	22
2420	22	111	37	22
2418	22	111	37	22
2419 Max	22	111	37	22
2419 Min	22	112	37	22
2417 Max	22	112	37	22
2417 Min	22	111	37	22
2416 Max	22	111	37	22
2416 Min	22	111	37	22

For Processor CPW values and Arm Factors for Capacity Upgrade on Demand (CUoD) Processor Features, the previous 2 tables list only the values for the BASE number of processors ("Min") as well as values that represent the full capacity (BASE + ON DEMAND) of the server for all processors active ("Max"). For values associated with each incremental processor activation see "Appendix A: Capacity Upgrade on Demand (CUoD) Feature Adjustments" on page 29.

DASD Arms Required for Performance iSeries Model **830**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 830, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 830 **DASD Arms required for performance**		Example: Model 830-2402/1533 , Light server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 830-2403/1533 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 4, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 4200	1) 7350
2. In Table 4, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 240	2) 240
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 3960	3) 7110
4. In Table 5, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 19	4) 17
5. In Table 5, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 93	5) 17
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6)	6) 12.6	6) 14.1
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7)	7) 42.6	7) 418.2
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 55.2	8) 432.3
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 36	10) 278

Table 4 - Model 830 CPW

Processor Feature	Processor CPW	Interactive Features						
		1537	**1536**	**1535**	**1534**	**1533**	**1532**	**1531**
2403	7350	4550	2000	1050	560	240	120	70
2402	4200	N/A	2000	1050	560	240	120	70
2400	1850	N/A	N/A	1050	560	240	120	70

Table 5 - Model 830 Arm Factors

Processor Feature	Workload			
	Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
2403	17	88	29	17
2402	19	93	31	19
2400	17	62	26	17

DASD Arms Required for Performance iSeries Model **820**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 820, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.   Several versions of the 820 exist for marketing purposes. A separate worksheet is provided for each.

Worksheet for Model 820 **DASD Arms required for performance**		Example: Model 820-2396/1522 , Light server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 820-2398/1522 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 6, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 950	1) 3200
2. In Table 6, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 70	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 880	3) 3130
4. In Table 7, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 16	4) 16
5. In Table 7, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 59	5) 16
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6)	6) 4.4	6) 4.4
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7)	7) 14.9	7) 195.6
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 19.3	8) 200.0
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 13	10) 129

Table 6 - Model 820 CPW

Processor Feature	Processor CPW	Interactive Features						
		1527	**1526**	**1525**	**1524**	**1523**	**1522**	**1521**
2438	3700	2000	1050	560	240	120	70	35
2437	2350	N/A	1050	560	240	120	70	35
2436	1100	N/A	N/A	560	240	120	70	35
2435	600	N/A	N/A	N/A	240	120	70	35
2398	3200	2000	1050	560	240	120	70	35
2397	2000	N/A	1050	560	240	120	70	35
2396	950	N/A	N/A	560	240	120	70	35
2395	370	N/A	N/A	N/A	240	120	70	35

Table 7 - Model 820 Arm Factors

Processor Feature	Workload			
	Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
2438	20	97	33	20
2437	16	78	26	16
2436	16	58	25	16
2435	16	55	24	16
2398	16	78	26	16
2397	16	77	26	16
2396	16	59	25	16
2395	16	53	24	16

DASD Arms Required for Performance iSeries
CPU Intensive Dedicated Server Model <u>820</u>

In order to determine the number of disk arms needed for optimum performance for an iSeries CPU Intensive Dedicated Server Model 820, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for CPU Intensive Model 820 **DASD Arms required for performance**		Example: Model 820-0152, Light server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 11, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 3700
2. In Table 12, for the selected processor feature, find the arm factor for workload. Enter the value on line 2.	2)	2) 93
3. Divide line 1 by line 2. Enter the result on line 3. This is the unadjusted number of arms required to support the interactive workload on a base IOP.	3)	3) 39.78
4. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 4.	4)	4) 1.56
5. Divide line 3 by line 4 and round the result up to the nearest whole number. Enter the result on line 5. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	5)	5) 26

Table 11 - CPU Intensive Model 820 CPW

Processor Feature	Processor CPW
0152	3700
0151	2350
0150	1100

Table 12 - CPU Intensive Model 820 Arm Factors

Processor Feature	Workload
	Server - Light
0152	93
0151	73
0150	55

DASD Arms Required for Performance iSeries
Dedicated Server for **Domino Model 820**

In order to determine the number of disk arms needed for optimum performance for an iSeries Dedicated Server for Domino Model 820, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Domino Model 820 DASD Arms required for performance		Example: Model 820-2427, MCU workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 11, find the processor feature for the desired model. Enter the corresponding processor "Mail and Calendaring Users" (MCU) on line 1.	1)	1) 9890
2. In Table 12, for the selected processor feature, find the arm factor for Domino workload. Enter the value on line 2.	2)	2) 225
3. Divide line 1 by line 2. Enter the result on line 3. This is the unadjusted number of arms required to support the interactive workload on a base IOP.	3)	3) 43.96
4. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 4.	4)	4) 1.56
5. Divide line 3 by line 4 and round the result up to the nearest whole number. Enter the result on line 5. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	5)	5) 29

Table 11 - Domino Model 820 MCU

Processor Feature	Processor MCU
2458	11810
2457	6660
2456	3110
2427	9890
2426	5610
2425	2570

Table 12 - Domino Model 820 Arm Factors

Processor Feature	Workload
	DOMINO
2458	295
2457	208
2456	156
2427	225
2426	234
2425	151

DASD Arms Required for Performance iSeries Model **270**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 270, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load. A separate worksheet is provided for the Domino version of the 270.

Worksheet for Model 270 **DASD Arms required for performance**		Example: Model 270-2252/1519 , Light server workload, 4748 IOP, 4317 DASD, RAID-5
1. In Table 8, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 950
2. In Table 8, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 50
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 900
4. In Table 9, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 16
5. In Table 9, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 56
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6)	6) 3.1
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7)	7) 16.1
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 19.2
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 13

Table 8 - Model 270 CPW

Processor Feature	Processor CPW	Interactive Features				
		1520	1519	1518	1517	1516
2434	2,350	70	N/A	N/A	N/A	0
2432	1,070	N/A	50	N/A	N/A	0
2431	465	N/A	N/A	30	N/A	N/A
2253	2,000	70	N/A	N/A	N/A	0
2252	950	N/A	50	N/A	N/A	0
2250	370	N/A	N/A	30	N/A	0
2248	150	N/A	N/A	N/A	25	N/A

Table 9 - Model 270 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2434	16	78	26	16
2432	16	59	25	16
2431	15	58	24	15
2253	16	83	26	16
2252	16	56	25	16
2250	16	46	24	16
2248	11	50	18	11

DASD Arms Required for Performance iSeries Dedicated Server for
Domino Model <u>270</u>

In order to determine the number of disk arms needed for optimum performance for an iSeries Dedicated Server for Domino Model 270, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Domino Model 270 **DASD Arms required for performance**		Example: Model 270-2423, MCU workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 13, find the processor feature for the desired model. Enter the corresponding processor "Mail and Calendaring Users" (MCU) on line 1.	1)	1) 2570
2. In Table 14, for the selected processor feature, find the arm factor for Domino workload. Enter the value on line 2.	2)	2) 151
3. Divide line 1 by line 2. Enter the result on line 3. This is the unadjusted number of arms required to support the interactive workload on a base IOP.	3)	3) 17.02
4. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 4.	4)	4) 1.56
5. Divide line 3 by line 4 and round the result up to the nearest whole number. Enter the result on line 5. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	5)	5) 11

Table 13 - Domino Model 270 MCU

Processor Feature	Processor MCU
2454	6,660
2452	3,070
2424	5,050
2423	2,570
2422	1,600

Table 14 - Domino Model 270 Arm Factors

Processor Feature	Workload
	DOMINO
2454	230
2452	171
2424	210
2423	151
2422	200

DASD Arms Required for Performance AS/400 Model **250**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 250, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 250 DASD Arms required for performance		Example: Model 250-2295, light server workload, 9767 IOP, 6817 DASD, Mirroring
1. In Table 10, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 50
2. In Table 10, find the Interactive CPW for the desired model. Enter it on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 15
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 35
4. In Table 10, for the desired model, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 8
5. In Table 10, for the desired model, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 25
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 1.88
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 1.4
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 3.28
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 0.86
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 4

Table 10 - Model 250 CPW and Arm Factors

Processor Feature	Processor CPW	Interactive CPW	Arm Factors by Workload			
			Interactive	Server - Light	Server - Mixed	Server - Heavy
2296	75	20	10	38	16	10
2295	50	15	8	25	12	8

DASD Arms Required for Performance AS/400 Model **740**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 740, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 740 DASD Arms required for performance		Example: Model 740-2069/1510, Light server workload, 6533 IOP, 6613 DASD, RAID-5	
1. In Table 15, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1)	3660
2. In Table 15, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2)	1050
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3)	2610
4. In Table 16, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4)	16
5. In Table 16, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5)	81
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6)	65.6
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7)	32.2
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8)	97.8
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9)	1.04
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10)	95

Table 15 - Model 740 CPW

Processor Feature	Processor CPW	Interactive Features				
		1513	1512	1511	1510	1514
2070	4550	4550	3660	2000	1050	120
2069	3660	N/A	3660	2000	1050	120

Table 16 - Model 740 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2070	14	71	24	14
2069	16	81	27	16

DASD Arms Required for Performance AS/400 Model **730**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 730, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 730 DASD Arms required for performance		Example: Model 730-2067/1509, Heavy server workload, 2748 IOP, 6717 DASD, RAID-5
1. In Table 17, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 2000
2. In Table 17, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 560
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 1440
4. In Table 18, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 13
5. In Table 18, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 13
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 43.1
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 110.8
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 153.9
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 99

Table 17 - Model 730 CPW

Processor Feature	Processor CPW	Interactive Features					
		1511	1510	1509	1508	1507	1506
2068	2,890	2,000	1,050	560	240	N/A	70
2067	2,000	2,000	1,050	560	240	N/A	70
2066	1,050	N/A	1,050	560	240	120	70
2065	560	N/A	N/A	560	240	120	70

Table 18 - Model 730 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2068	15	72	24	15
2067	13	65	21	13
2066	13	48	21	13
2065	13	47	21	13

DASD Arms Required for Performance AS/400 Model **720**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 720, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 720 DASD Arms required for performance		Example: Model 720-2062/1502, Light server workload, 6533 IOP, 6717 DASD, Mirroring
1. In Table 19, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 420
2. In Table 19, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 120
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 300
4. In Table 20, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 14
5. In Table 20, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 53
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 8.6
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 5.7
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 14.3
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.19
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 13

Table 19 - Model 720 CPW

Processor Feature	Processor CPW	Interactive Features					
		1505	1504	1503	1502	1501	1500
2064	1600	1050	560	240	120	N/A	35
2063	810	N/A	560	240	120	N/A	35
2062	420	N/A	N/A	240	120	70	35
2061	240	N/A	N/A	N/A	120	70	35

Table 20 - Model 720 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2064	14	53	23	14
2063	14	51	22	14
2062	14	53	21	14
2061	12	48	19	12

DASD Arms Required for Performance AS/400 Model **170**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 170, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 170 DASD Arms required for performance			Example: Model 170-2386, light server workload, 2740 IOP, 6707 DASD, RAID-5
1. In Table 21, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 460	
2. In Table 21, find the Interactive CPW for the desired model. Enter it on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 70	
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 390	
4. In Table 21, for the desired model, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 13	
5. In Table 21, for the desired model, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 46	
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 5.4	
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 8.5	
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 13.9	
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.04	
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 14	

Table 21 - Model 170 CPW and Arm Factors

Processor Feature	Processor CPW	Interactive CPW	Arm Factors by Workload			
			Interactive	Server - Light	Server - Mixed	Server - Heavy
2388	1090	70	15 (See note 1)	57 (See note 1)	See note 1	See note 1
2386	460	70	13 (See note 1)	46 (See note 1)	See note 1	See note 1
2385	460	50	13 (See note 1)	46 (See note 1)	See note 1	See note 1
2292	220	30	10 (See note 1)	44 (See note 1)	See note 1	See note 1
2291	115	25	10	38	16	10
2290	73	20	10	37	16	10
2289	50	15	8	25	12	8
2183	319	67	11 (See note 1)	64 (See note 1)	See note 1	See note 1
2176	319	40	11 (See note 1)	64 (See note 1)	See note 1	See note 1
2164	210	29	10 (See note 1)	42 (See note 1)	See note 1	See note 1
2160	114	23	11	38	17	11
2159	73	16	10	36	16	10

Notes:

1. This system is limited to a maximum of 10 DASD arms. This number is insufficient to support either a heavy server workload or an interactive workload using the full capabilities of the CPU. If using the MFIOP/9728, only 4 disk arms are supported. With only 4 arms, only VERY light DASD load applications are supported with full CPU power.

2. Four arms are required for the minimum RAID-5 protected configuration.

Additional performance information and tuning suggestions are available in the IBM "iSeries Performance Capabilities Reference V5R1" (340+ pages, 1.5MB Adobe Acrobat format) on the internet at: http://publib.boulder.ibm.com/pubs/html/as400/online/chgfrm.htm

Questions relating to the information in this document should be directed to
    Clark Anderson (clarkand@us.ibm.com),
    Larry Whitley (ldw@us.ibm.com),
    or Richard Odell (rjodell@us.ibm.com).

The authors would like to thank all the people, too numerous to list, who have reviewed this document. And a special thanks to Brian Podrow, who contributed the majority of the first section.

This document last updated: 6/29/2001.

Appendix A: Capacity Upgrade on Demand (CUoD) Feature Adjustments

If you require values associated with each incremental processor activation, you can calculate the approximate values associated with each processor by using the following worksheet. This may be complicated by the fact that CUoD machines are often used in Logical Partitioning (LPAR) environments. When using LPAR you must address only those processors used in each partition. Note: Each LPAR partition has its own disks dedicated for use in that partition. The total number of disks required by the system is the sum of those required for each partition.

Worksheet to adjust CUoD Feature DASD Arms required for performance		Example: Model 840-2419/1540 w/22 processors , Light server workload, 4748 IOA, 4317 DASD, RAID-5
1. Following the normal instructions, complete the DASD Arms Required for Performance iSeries Model <u>840</u> worksheet on page 15, while using the "**Max**" values from tables 2 and 3 for the desired CUoD Feature. Then place the value from line 10 of that worksheet into line 1 of this worksheet.	1)	1) 99
2. Following the normal instructions, complete the DASD Arms Required for Performance iSeries Model <u>840</u> worksheet on page 15, while using the "**Min**" values from tables 2 and 3 for the desired CUoD Feature. Then place the value from line 10 of that worksheet into line 1 of this worksheet.	2)	2) 79
3. Subtract the value in line 2 from the value in line 1, and place in line 3.	3)	3) 20
4. In Table A1 on this page, for the selected CUoD Processor Feature, find the Processor Delta value. Then place that value in line 4	4)	4) 6
5. Divide the value from line 3 by the value from line 4. Place that result into line 5.	5)	5) 3.33
6. In Table A1 on this page, for the selected CUoD Processor Feature, find the Minimum Number of Processors value. Then place that value in line 6	6)	6) 18
7. Set line 7 equal to the desired number of processors. Note: This value must be a number between the Minimum and Maximum Number of Processors for the desired Processor Feature.	7)	7) 22
8. Subtract line 6 from line 7. Enter the result on line 8.	8)	8) 4
9. Multiply value in line 8 by line 5 value. Place result in line 9.	9)	9) 13.32
10. Add the value in line 2 to the value in line 9. Round the result up to the nearest whole number and enter on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 93

Table A1 - Model 840 CUoD Feature Processors

Processor Feature	Processor Delta	Minimum Number of Processors	Maximum Number of Processors
2354	6	18	24
2353	6	12	18
2352	4	8	12
2419	6	18	24
2417	6	12	18
2416	4	8	12

.

Appendix B: Enterprise Storage Server (ESS or "Shark") Attachment

IBM Enterprise Storage Servers (code named 'Shark') can be attached to iSeries CPUs via #2766 PCI Fibre Channel (FC) Disk Controllers. The following worksheet method estimates:
- the number of physical Shark disks (DDMs) needed (line 1),
- how they should be configured :
  - how many RAID Ranks (line 2) - A RAID Rank is a set of 7 active disk drives plus 1 spare.
  - how many LUNs (line 4) - A LUN or Logical UNit represents the capacity of a physical disk drive as defined by an iSeries. Each Shark iSeries LUN is spread across multiple DDMs.
- and how many iSeries FC controllers are needed to attach them (line 6).

Worksheet for Shark **DASD Arms required for performance**		Example: Model 840-2420/1540 , Light server workload, 2766 IOA, 2105 DASD w/18GB DDMs
1. Following the normal instructions for your processor model and using the 2766 IOP/IOA and 2105-Fx0 Drive Model Adjustment Factor, complete the appropriate worksheet from "DASD Arms Required for Performance Worksheets" section starting on page 14. Then for all models that support Shark, except Domino Models 270 and 820 and the CPU Intensive Model 820, place the value from line 10 of that worksheet into line 1 of this worksheet. For the other 3 models , place the value from line 5 of their respective worksheet into line 1 of this worksheet. **This value is the minimum number of physical arms required in Shark to support the CPU**.	1)	1) **99**
2. Place line 1 value, divided by 7, rounded UP to next whole number, in line 2. **This value is the number of Shark RAID Ranks to configure.**	2)	2) **15**
3. In Table B1, for the desired DDM capacity, find the Recommended LUNs per RAID Rank value. Then place that value in line 3.	3)	3) 12
4. Calculate line 4 to be the value in line 2 multiplied by the value in line 3. **This value is the number of LUNs used to address the Shark RAID Ranks**.	4)	4) **180**
5. In Table B1, for the desired DDM capacity, find the Recommended LUNs per IOA value. Then place that value in line 5.	5)	5) 32
6. Divide the number of LUNs from line 4 by the value from line 5. Place that number, rounded UP to the next whole number, into line 4. **This value is the minimum number of iSeries Fibre Channel IOAs required to address the Shark LUNs.**	6)	6) **6**

Note: This method assumes that the Shark disks are being configured to use RAID-5 protection.

Table B1 - Shark Configuration Parameters

Shark DDM Capacity	**Recommended LUNs per RAID Rank**	**Recommended LUNs per IOA**
9GB	6	16
18GB	12	32
36GB	16	32

Note: Besides iSeries rules, these calculations do not take into account all ESS configuration rules.

Refer to the discussion in Chapter 14 (DASD Performance) of the "iSeries Performance Capabilities Reference V5R1" (available at http://publib.boulder.ibm.com/pubs/html/as400/online/chgfrm.htm in the AS/400 online library) for more information on Shark performance characteristics.

Appendix C: System Memory vs. Disk Arms

There are cases where the disk arms estimated using the worksheets in this document can be too high. The tables of Arm Factors in the document are derived from experience with systems with very large databases and random accesses of the records in those databases. If the database on a large system is relatively small, or the access to the records in that database are not random, or the database is large but only a small fraction of the database is actively used, it is possible, even likely, that a significant fraction of the database will be cached in memory. When a significant fraction of the database is cached in memory, the number of reads to the disks are reduced. This in turn reduces the number of disk arms needed to support the application.

While we recognize the existence of this phenomena, we do not have data that you can use to modify the calculations in this document to account for this. However, if you have a system with the databases in question installed and operational, there is a way of telling, after the fact, whether this is happening on a given system or not.

Using the performance monitor, you can determine the mix of reads and writes to the disks produced by the system. A normal mix of reads and writes to the disks on a transaction processing system is between 55% and 70% reads and between 45% and 30% writes. For small databases, more of the database becomes cached in system memory and the number of reads to the disks goes down while the number of writes remains nearly constant. This shifts the balance of reads and writes to favor the writes. That is you might see a 30% to 40% read and a 70% to 60% write. System's with this pattern across all shifts can safely reduce the number of disk arms required. The net of all of this is that the reduction in disk reads will reduce the disk utilization, creating the opportunity for the use of fewer, higher capacity disks.