Chapter 2. Planning a Network Using Permanently Installed Cable

Now that you have learned the essentials of the IBM Token-Ring Network, you are ready to begin planning a network to meet the needs of your establishment. Although planning a network is a straightforward process, you should follow these instructions carefully to ensure that the network you design will be functional, and that the plans will describe the installation completely.

This chapter describes how to plan for single rings that will use type 1 or 2 IBM Cabling System cable from work areas to wiring closets and type 1, 2, or 62.5/125-micron optical fiber cable (see Appendix D for this cable's specification) from wiring closet to wiring closet. IBM Cabling System type 5 optical fiber cable is also supported for wiring closet-to-wiring closet cable runs. If you are planning to use type 8 or 9 cable for all cabling in your ring, the planning process described in this chapter applies. However, the tables indicating the allowable drive distances for type 9 cabling are found in Appendix A.

This chapter also will help you to plan rings using combinations of copper cable types. For example, in some instances you may want to use type 9 cable for lobe wiring and type 1 cable for the main ring path.

This chapter describes planning for rings operating at either 4 or 16 Mbps using IBM 8228 Multistation Access Units, 8220 Optical Fiber Converters, and 8230 Controlled Access Units. Planning for rings that that employ IBM 8218 Copper Repeaters or 8219 Optical Fiber Repeaters is described in Appendix A.

Warning: All attaching devices on a ring must operate at the same data rate. Connecting an adapter to a ring operating at a data rate different from the adapter data rate is never permitted and can adversely affect system operation.

What You Will Need

If your building has been wired with the IBM Cabling System, or if the installation of the IBM Cabling System has been planned, the following completed IBM Cabling System worksheets will help you to begin planning your network:

- Cable Schedules
- Rack Inventory Charts.

If you have your cabling system installed and are already using it for connecting systems other than the Token-Ring Network, you should also have:

- System Configuration Worksheets.

If you will be replacing point-to-point or loop systems with token-ring components, read and follow the procedures on system migration in Chapter 6 of this manual and then return to this chapter to begin the planning process.

In addition to the above materials, you should also have:

- Blank labels (ordered from the *IBM Cabling System Catalog*, G570-2040).
- Floor plans for each part of your establishment where you will place attaching devices and components. The floor plans should indicate the location of wiring closets, cable troughs (if any), and work areas.

If you have not installed the IBM Cabling System or planned for its installation, you can still begin planning your IBM Token-Ring Network. However, before you can fill out any of the network planning charts as described in Chapter 3, you must complete the planning procedure described in the *IBM Cabling System Planning and Installation Guide*.

As you read this chapter for the first time, you should refer to the charts in the pocket on the back cover to help you trace the planning process.

General Guidelines for Planning Your Network

Before you begin detailed planning of your 4 or 16 Mbps IBM Token-Ring Network, you should consider the following guidelines:

- All of the tables and configuration rules in this chapter assume that cable drops between work areas and wiring closets are type 1 or 2 IBM cable, and that cables between wiring closets are type 1 or 2 copper cable installed as specified in the *IBM Cabling System Planning and Installation Guide*.[1] Where optical fiber cable is used between wiring closets, you should consult Appendix D for the specification of the 62.5/125-micron optical fiber that is assumed in this planning process. Other multimode optical fiber cables may be accommodated. Refer to the *IBM Token-Ring Network Optical Fiber Cable Options* manual for instructions on qualifying optical fiber cable segments for use with IBM Token-Ring Network products.
- All patch cables are either ordered assembled from IBM or made up of IBM Cabling System data connectors and type 6 IBM cable to the lengths specified in this manual.[1]
- You may install up to 260 attaching devices on a single ring. For each 8218 or 8219 installed on a ring, you must reduce the total number of allowable attaching devices by one. For each 8220 installed on a ring, you must reduce the total number of allowable attaching devices by two. For each 8230 installed on a ring, you must reduce the total number of allowable attaching devices by three.

  Note: If your ring contains any non-IBM token-ring adapters, then you should restrict the maximum number of attaching devices on a single ring to 250, as specified in the IEEE 802.5-1989 standard and in the ISO/DP 8802/5 standard.
- You may install up to 33 IBM 8228s on a single ring. Since each of the IBM 8230s regenerates the signal, you may install as many 8230s and associated LAMs (a maximum of four per base unit) as your system demands provided that the total number of attaching devices does not exceed 260, including the deduction of three stations for each 8230.
- All drops between the distribution panel in a wiring closet and the faceplate in a work area (in other words, the drop for every *lobe*) should be limited to no more than 100 m (330 ft). Although there are some exceptions to the 100-m rule presented in this manual, you should be cautious in adopting wiring configurations with drops in excess of 100 m because such drops may jeopardize future system growth.[1]

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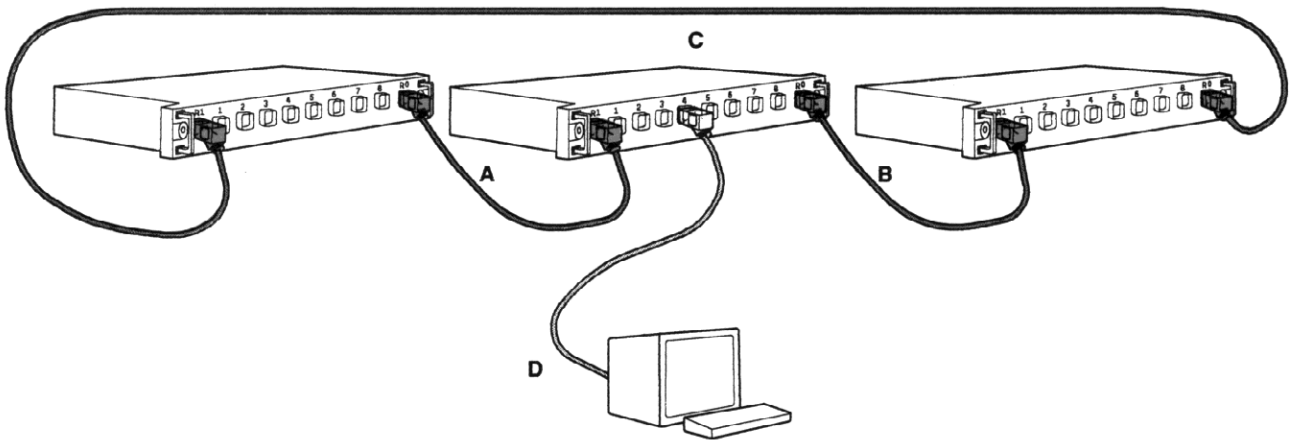
[1] Some IBM Cabling System installations not following these guidelines may be accommodated. See Appendix A for further information.



A + B + C = Main Ring Length D = Lobe Length

Figure 2-1. Distinguishing between Main Ring Length and Lobe Length

- For networks that pass through two or more wiring closets and do not use 8218s, 8219s, 8220s, or 8230s, the allowable lobe length varies inversely with the length of cable in the main ring path (the main ring path consists of the 8228s and the cables between them). That is, the shorter the lobe length, the longer the main ring path may be.

Placing Attaching Devices on Your Building Plans

Now you are ready to mark the locations of attaching devices on your building floor plans. If your establishment is planning for more than one ring, you should plan each ring separately to avoid any possibility of confusion. However, at this stage of the planning process, mark the location of all attaching devices on your floor plan. You will need to determine the following information about each ring in your proposed network:

1. The number of attaching devices you want on each ring. The maximum number of attaching devices on a single ring is 260. However, as you draw your preliminary sketch, you may want to try several different configurations depending upon your physical layout, affinity groupings, performance requirements, and use of bridges to connect smaller rings together into a network.
2. The number of wiring closets each ring will pass through. (Treat work areas where 8228s, 8218s, 8219s, 8220s, or 8230s have been placed as wiring closets.)
3. The number of racks that each ring will pass through. The IBM Cabling System recommends a maximum of 96 cables from work areas to each rack in a wiring closet. Each rack can contain up to twelve 8228s or two 8230 base units with up to six LAMs. If RJ-45 LAMs are used with telephone twisted-pair wiring, a rack can hold two 8230 base units and eight RJ-45 LAMs. To determine what combinations of 8228s and 8230s can fit in a single rack, use the Rack Inventory Chart as described in Chapter 3.
4. The length and type (for example, type 1 [copper wire] or 62.5/125-micron optical fiber cable) of each cable between wiring closets in each ring, including the cable from the RO receptacle of the last 8228 or 8230 to the RI receptacle of

the first 8228 or 8230 in your ring (from the Cable Schedules or measured on your building floor plan).

Note: When determining the length of wiring closet-to-wiring closet cable runs, you should count only the actual length of cable installed. Patch cables, if they do not exceed 2.4 m (8 ft) when the connection is in a single rack or 9 m (30 ft) when the connection is from one rack to another when used to connect the installed cable to devices in the main ring path, are automatically taken into consideration.

5. The length of the *longest* lobe in each ring (the length of cable from the attaching device to the 8228 or 8230).

   Note: When determining the length of the longest lobe, you do not have to include the adapter cable from the attaching device to the faceplate or the patch cables from the distribution panel connector to the 8228 or 8230 lobe receptacle, provided that the lengths of those cables fall within the guidelines on pages 2-11 and 2-16.

   If you follow these guidelines, the lengths of all cables may be determined by consulting the drop lengths recorded on the IBM Cabling System Cable Schedules.

To help you visualize each of your proposed rings, you should prepare a simple rough sketch similar to the one in Figure 2-2 for each ring. The sketch in this figure is the initial drawing for the ring that appears on the chart called "Multiple-Building IBM Token-Ring Networks " that was packaged with this manual. Your drawing should show:

- The location of each wiring closet
- The number of 8228s and 8230s in each wiring closet
- The type and length of each cable between wiring closets
- The locations of surge suppressors, if any.

The information on this rough drawing will help you determine whether or not you will need 8218s, 8219s, 8220s, or 8230s used as repeaters or converters in your rings.

The IBM Token-Ring Network allows great flexibility in the physical layout of a ring. However, you should take such issues as ease of problem determination and physical management into consideration as you determine how many rings you need to serve your establishment. Generally, rings that connect a group of users together should be restricted to single floor of a building and, where possible, to a single wiring closet to enhance ease of planning, reconfiguration, moves and changes, and problem determination. Such rings do not usually require the use of 8218s, 8219s, or 8220s. Backbone rings, which connect several local rings together using bridges, may pass through several wiring closets and employ repeaters and converters to regenerate the signal and serve a larger geographic area. Rings that connect buildings should use optical fiber cable between buildings to eliminate ground potential difference problems, increase data security, and avoid susceptibility to lightning strikes.

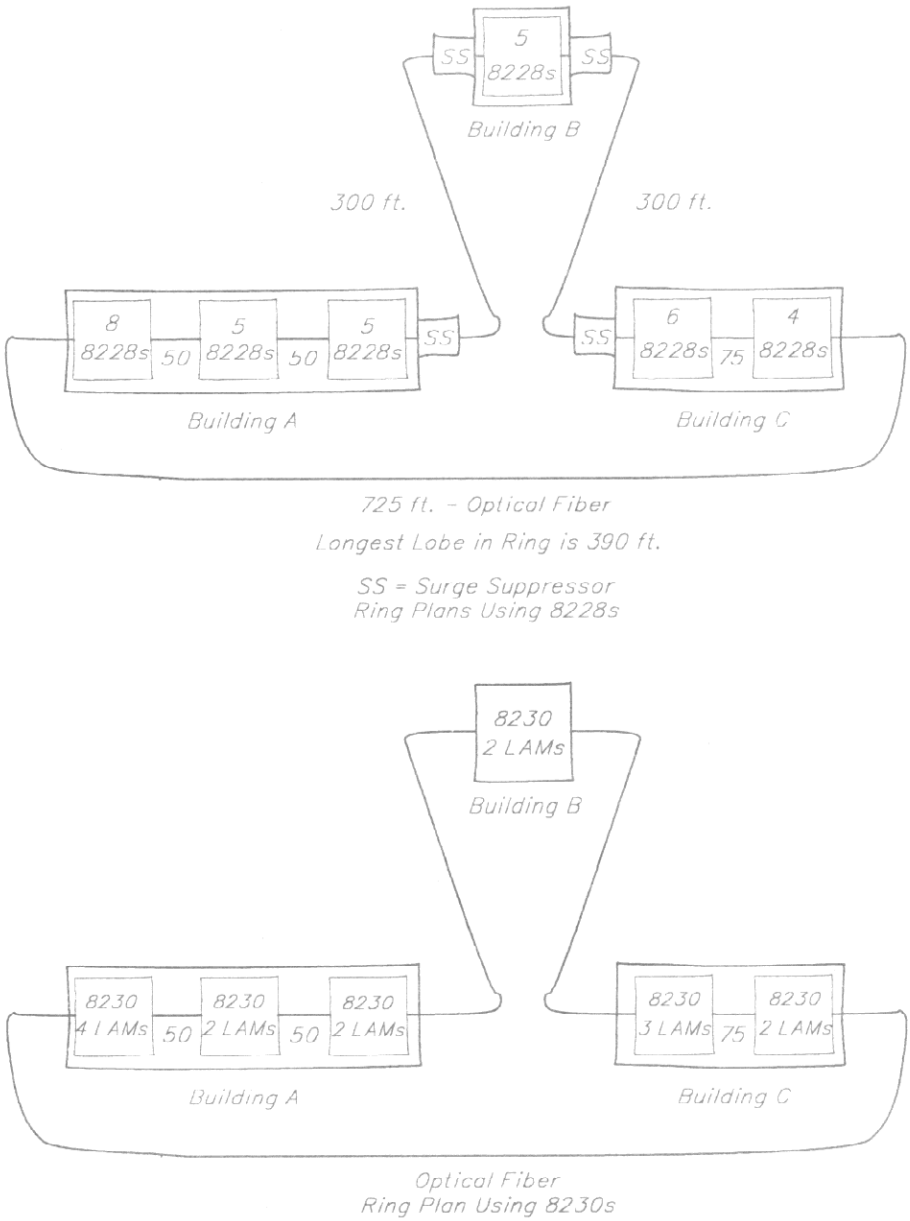


Figure 2-2. Rough Sketch of 2 Proposed Rings

Estimating Ring Performance

As suggested earlier in the section of Chapter 1 called "Performance Considerations," the performance of the network is linked to its utilization. You should estimate the utilization of each ring you plan to install to ensure that each ring will perform satisfactorily. To allow for expansion and increased workloads, you should probably not exceed 30% estimated utilization. Since transfer times increase sharply only as utilization exceeds 80%, you should have an adequate allowance for increased traffic on each ring.

A precise method of estimating ring performance during the planning process would be extremely complex and time-consuming. In most cases, an approximation based upon representative station workloads will provide an adequate estimate for planning purposes. The typical workloads listed below provide a convenient way of estimating a ring's utilization. For each workstation on your ring, select a workstation type that most closely approximates the typical workloads generated by attaching devices on your planned ring. If you feel that your workloads are not adequately reflected in these four types, you may substitute your own figures.

Since Token-Ring Networks can operate at either 4 or 16 Mbps, you should perform the ring utilization calculation described below using the ring data rate at which you are planning to operate your ring. If the calculation indicates that the ring may be overutilized, there are two possible solutions. If the potentially overutilized ring was planned for operation at 4 Mbps, recalculate the utilization at 16 Mbps or divide the ring into two or more rings to be connected with bridges (see Chapter 4). Be sure to check the ring utilization of each of the new rings. If the potentially overutilized ring was planned for operation at 16 Mbps, divide the ring into two or more rings to be connected with bridges and check the utilization of each of the new rings.

WORKSTATION DESCRIPTION	DIALOG RATE	MESSAGE MIX	TRAFFIC/ WORKSTATION
Mainframe Interactive (MFI-nominal)	3/min	3 at 32 bits: 1 at 104 bits: 1 at 240 bits: 1 at 11 200 bits:	0.58 Kbps
Mainframe Interactive (MFI-high)	6/min	3 at 32 bits: 1 at 104 bits: 1 at 240 bits: 1 at 11 200 bits:	1.16 Kbps
Mainframe Interactive (MFI-graphics)	3/min	6 at 32 bits: 1 at 104 bits: 1 at 240 bits: 4 at 11 200 bits:	3.22 Kbps
Personal Computer Workstation	per hour	239 at 32 bits: 8 at 4000 bits: 231 at 16 000 bits:	1.03 Kbps

Activity (file size)	Times/Hour	Frames/Hour
Load program (512 Kb)	6	192
Load spreadsheet data (16 Kb)	3	3
Save spreadsheet data (16 Kb)	2	2
Load text data (96 Kb)	3	18
Save text data (96 Kb)	2	12
Send message (4 Kb)	4	4
Receive message (4 Kb)	4	4
Quality print pages (32 Kb)	2	4

To estimate ring utilization, perform the following steps:

1. Multiply the number of each of the four types of workstation by the traffic generated per workstation.
2. Add together the products obtained in step 1. This figure represents the estimated traffic per second on the ring.
3. Divide the estimated traffic per second obtained in Step 2 by 4 or 16 Mbps (the ring data rate).

The following example shows a calculation of utilization for a ring with 200 attaching devices operating at a data rate of either 4 or 16 Mbps:

WORKSTATION TYPE	TRAFFIC	NUMBER	TRAFFIC BY TYPE
MFI-nominal	0.58 Kbps	50	29 Kbps
MFI-high	1.16 Kbps	25	29 Kbps
MFI-graphics	3.22 Kbps	25	70.5 Kbps
PC workstation	1.03 Kbps	100	103 Kbps
		Total Estimated Traffic	231.5 Kbps

$$\frac{\text{Total Estimated Traffic}}{\text{4 Mbps}} = \frac{231\,500 \text{ bps}}{4\,000\,000 \text{ bps}} = 5.79\% \text{ utilization}$$

$$\frac{\text{Total Estimated Traffic}}{\text{16 Mbps}} = \frac{231\,500 \text{ bps}}{16\,000\,000 \text{ bps}} = 1.44\% \text{ utilization}$$

If your network is to consist of two or more rings connected by bridges, you should see Chapter 4 for guidance in planning it.

Determining Ring Size

This section tells you how to determine how many attaching devices you can serve on a single 4 or 16 Mbps ring without using 8218s, 8219s, or 8220s. You should check all proposed rings that will use IBM Cabling System types 1, 2, 6, 8, or 9 that have been installed as described in the *IBM Cabling System Planning and Installation Guide*. If your work in this section indicates that the proposed ring violates the allowable drive distances, you should consider the following options:

- Large rings can frequently be divided into two or more smaller rings, which can then be joined together by bridges. See Chapter 4 of this manual for a discussion of planning multiple ring networks using bridges.
- For 4 Mbps rings
  - You can use 8218s in the main ring path to increase the allowable drive distance of a single ring. See Appendix A for a full discussion of planning rings using copper repeaters.
  - You can install 8219s or 8220s with optical fiber cables between two or more wiring closets in your ring. See Appendix A for a full discussion of using optical fiber cabling with 8219s in 4 Mbps rings.
  - You can install 8230s instead of 8228s. The 8230 regenerates the signal at both its RI and RO circuitry and supports both copper and optical fiber cabling in the main ring path.
- For 16 Mbps rings
  - If your ring is too large to operate without converters, you may use optical fiber cable between some or all wiring closets (depending upon the ring configuration) and install an 8220 at each end of the optical fiber cable. The 8230 may also be used with optical fiber media in the main ring path, when equipped with the Optical Fiber Converter Module.
  - If installing optical fiber cable is impractical, you should consider replacing 8228s with 8230s. The signal regeneration capability of the 8230 on copper media is frequently sufficient for operation within a single building.
  - For 16 Mbps rings whose main ring path travels from building to building, optical fiber cable must always be used. Use of copper cables with surge suppressors is not supported at 16 Mbps. However, using optical fiber cable between buildings eliminates ground potential difference problems, protects from lightning, and increases the security of the network, so it should be considered for all interbuilding cable runs.

Rings Using a Single Wiring Closet without Separate Repeaters or Converters

Rings have been placed into two basic categories to help determine maximum ring size allowable without repeaters:

- Rings using a single wiring closet
- Rings using two or more wiring closets.

Limitations on the size of rings using 8228s but without 8218s, 8230s, or optical fiber media are a function of the ring data rate, the length of the main ring path, the length of the *longest* lobe on the ring, and the number of 8228s in the ring. Generally speaking, the longer the main ring path, the shorter the longest allowable lobe length will be. As the number of 8228s increases, the longest allowable lobe length and/or the length of the main ring path will decrease.

Planning Assumptions for Single-Wiring-Closet Rings

In a single-wiring-closet ring using only 8230s, you may attach up to 260 devices, less the allowance that must be made for each 8230 base unit in the ring. Each base unit can support up to 4 LAMs, each of which can provide attachment for up to 20 attaching devices. For example, a ring containing five 8230s and up to 13 LAMs could serve a maximum of 245 attaching devices.

To determine the number of 8228s you will need, divide the number of attaching devices assigned to the ring by eight and round up to the nearest whole number. You may wish to divide the number of attaching devices by a lower number to allow for future system growth without having to add 8228s. Remember that no single ring operating with or without repeaters at either data rate will support more than 33 IBM 8228s. If you have 33 IBM 8228s in a single ring, you may attach no more than 260 devices to the ring.

If you wish to intermix 8230s and 8228s in a single-wiring-closet ring, you must calculate the allowable lobe lengths for devices attached to the 8228s as though they were a ring segment bounded by 8230s. This process is described later in this chapter.

Refer to your IBM Cabling System Cable Schedules or measure each cable on your floor plan to determine the *longest* lobe on your proposed ring. The number of attaching devices and the maximum lobe length stated above are based upon the following cabling assumptions. Figure 2-4 on page 2-13 illustrates these assumptions. If you must deviate from these assumptions or use drop lengths greater than 100 m (330 ft) of type 1 or 2 cable, the information in Appendix A will help you plan your ring if you are using 8228s.

- Use one 2.4-m (8-ft) cable between the attaching device and the faceplate in the work area (if the attaching device is an IBM Personal Computer, this cable will be the IBM Token-Ring Network PC Adapter Cable).
- Use 2.4-m (8-ft) patch cables between the distribution panel and the 8228 or 8230.[2]
- Use 2.4-m (8-ft) patch cables between 8228s or 8230s in the same rack.[2]
- Use 9-m (30-ft) patch cables between 8228s or 8230s in different racks in a wiring closet.[2]
- All cables between work areas and wiring closets must be IBM Cabling System type 1, type 2, type 8, or type 9 cable. To convert lengths of type 9 cable to their type 1 equivalents, multiply the type 9 length by 3/2. See Appendix A if you are substituting other types of IBM Cabling System cable for type 1 or type 2.
- If you wish to use telephone twisted-pair media for lobe wiring in a 4 Mbps ring, see the *IBM Token-Ring Network Telephone Twisted-Pair Media Guide*.

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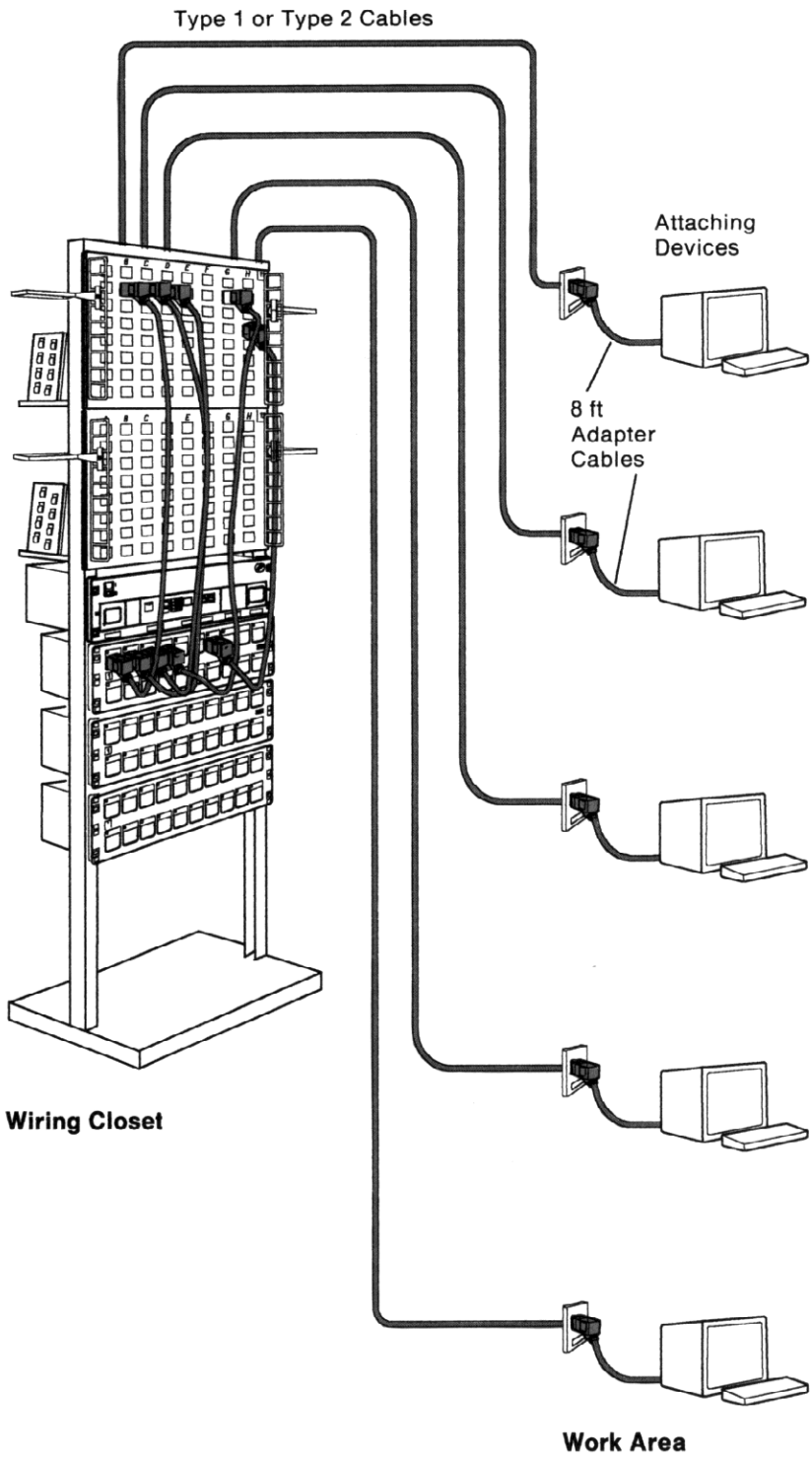
[2] Shorter lengths may be used.



This figure shows only how the cables are connected, not how they should be routed.

Figure 2-3. Single-Wiring-Closet Installation Assumptions for Rings Using 8230s

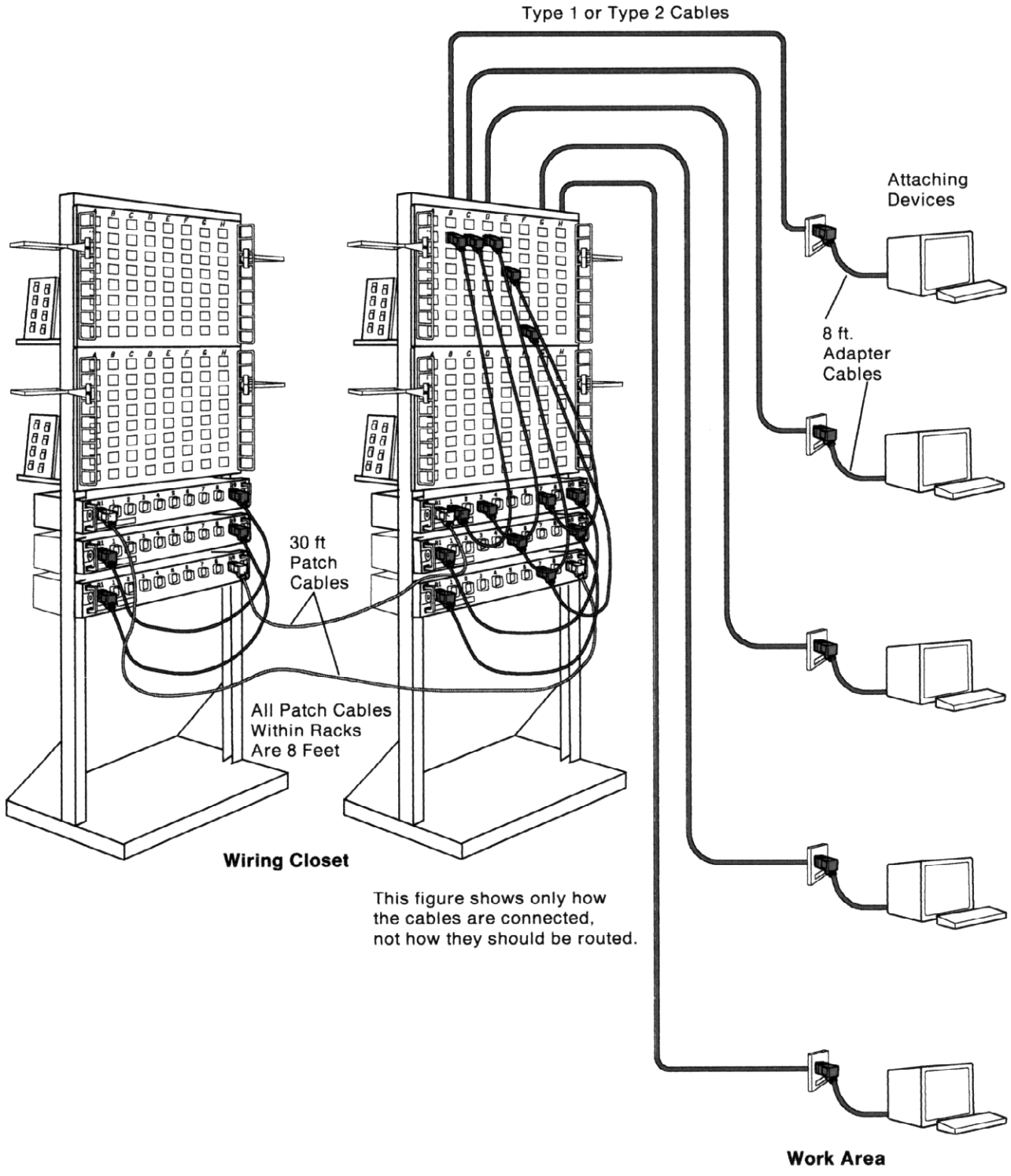


Figure 2-4. Single-Wiring-Closet Installation Assumptions for Rings Using 8228s

Operating at 4 Mbps with 8230s or 8228s

A single wiring closet ring made up of all 8230s may have up to 13 LAMs and 5 base units in up to 5 different racks. Such a ring will support up to 245 attaching devices. The maximum lobe length for an all-8230 ring operating at 4 Mbps is 375 m (1180 ft). However, 100 m (330 ft) is still the maximum recommended lobe length to allow for future requirements.

If all of your lobe cables terminate in a single wiring closet with up to 10 distribution racks, you may connect up to 33 IBM 8228s. These may serve up to 260 attaching devices, each of which may have a drop length of up to 100 m (330 ft) of type 1 or 2 cable. Drop lengths of up to 66 m (220 ft) of type 9 cable are also permitted. The drop length is the length of cable from the faceplate in a work area to the distribution panel in the wiring closet.

If your single-wiring-closet ring has lobe lengths greater than those recommended above, see Appendix A to determine maximum allowable lobe lengths.

Operating at 16 Mbps without Separate Converters

A single wiring closet ring made up of all 8230s may have up to 13 LAMs and 5 base units in up to 5 different racks. Such a ring will support up to 245 attaching devices. The maximum lobe length for an all-8230 ring operating at 16 Mbps is 145 m (478 ft). However, 100 m (330 ft) is still the maximum recommended lobe length to allow for future requirements.

If all of your lobe cables terminate in a single wiring closet with up to 2 distribution racks, you may connect up to 17 IBM 8228s. These may serve up to 136 attaching devices, each of which may have a drop length of up to 100 m (330 ft) of type 1 cable. Drop lengths of up to 66 m (220 ft) of type 9 cable are also permitted. The drop length is the length of cable from the faceplate in a work area to the distribution panel in the wiring closet.

If your single-wiring-closet ring requires more than 17 IBM 8228s or does not meet any one of the other criteria stated above, see Appendix A to determine the maximum allowable lobe lengths.

If you have determined that the ring you are planning meets the guidelines in the preceding section, you should go to Chapter 3 to continue the planning process. Otherwise, continue on in this chapter until you have prepared a configuration that meets the guidelines for multiple-wiring-closet rings.

Multiple-Wiring-Closet Rings with 8230s and 8228s

This section describes how to plan for rings passing through multiple wiring closets that contain either all 8230s or all 8228s without the use of 8218s or 8219s. This section also describes how to plan for rings that contain 8220s and 8230s in rings with 8228s. For rings containing all 8228s that do not fit within the planning guidelines that follow, see Appendix A.

Rings Using Only 8230s

Since the 8230 has a built-in copper repeating function and an optional Optical Fiber Converter Module, planning for multiple-wiring-closet rings using 8230s is straightforward. Remember that each 8230 base unit decreases the allowable number of attaching devices on the ring by three. Therefore, in a 13-wiring-closet ring with an 8230 in each, the total number of attaching devices permitted would be 260 less 39, or 221. Both 4 and 16 Mbps rings must not exceed 260 attaching devices. If you are planning rings where the number of lobe receptacles available

exceeds the permitted number of attaching devices, as in the example above, you must be prepared to exercise careful control over physical attachment to the ring. An excessive number of attaching devices may lead to an excessive soft error condition on the ring and affect ring performance and availability.

For 4 Mbps rings, wiring closets connected by runs of type 1 copper cable may be up to 400 m (1320 ft) apart if the temperature of the installed cable will not exceed 60°C (140°F). For environments with temperatures between 60°C and 80°C (140° and 176°F), the maximum distance between wiring closets should not exceed 385 m (1213 ft). Wiring closets connected by runs of 62.5/125-micron optical fiber cable meeting the specification in Appendix D may be up to 2000 m (6560 ft) apart. Lobe lengths may be up to 375 m (1180 ft). Generally, lobes should not exceed 100 m (330 ft).

For 16 Mbps rings, wiring closets connected by runs of type 1 copper cable may be up to 200 m (660 ft) apart if the temperature does not exceed 60°C (140°F). For environments with temperatures between 60°C and 80°C (140°F and 176°F), the maximum distance between wiring closets should not exceed 180 m (600 ft). Wiring closets connected by runs of 62.5/125-micron optical fiber cable meeting the specification in Appendix D may be up to 2000 m (6560 ft) apart. Lobe lengths may be up to 145 m (478 ft). Generally, lobes should not exceed 100 m (330 ft).

For both 4 and 16 Mbps rings, you should use 2.4-m (8-ft) patch cables between the distribution panel and the lobe or RI and RO receptacles on the 8230.[2] Use 9-m (30-ft) patch cables between 8230 base units installed in different racks in the same wiring closet.

Use one 2.4-m (8-ft) cable between the faceplate in a work area and the attaching device.

All of these cables have been taken into consideration in the rules for planning rings, so you need not add these lengths to your calculation of either lobe lengths or inter-wiring-closet cable lengths.

Now that you have determined the distances between wiring closets and the length of the longest lobe on the ring, using the sketch of the ring you prepared earlier you are ready to fill out the planning charts as described in Chapter 3. You should skip the rest of this chapter and begin work on the planning charts if your rings contain no 8228s, 8218s, 8219s, or 8220s.

Planning Assumptions for Rings Using 8228s

If your ring will have 8228s installed in two or more wiring closets, you will use the chart in Figure 2-9 on page 2-23 (for 4 Mbps rings) or in Figure 2-10 on page 2-24 (for 16 Mbps rings) to determine the allowable drive distance (Adjusted Ring Length + longest lobe length) for your ring. A work area with one or more 8228s installed should be treated as though it were a separate wiring closet. IBM 8228s installed in a work area should be connected to each other and to the faceplates in the work area with 2.4-m (8-ft) patch cables. All 8228s not installed in racks should be installed in component housings.

If your ring will have surge suppressors attached to cables between wiring closets and will operate at 4 Mbps, use the information in Appendix A to determine the allowable size of your network. Surge suppressors are not permitted in 16 Mbps rings. Optical fiber cable must be used for cabling between buildings in such instances.

The numbers in the chart in Figure 2-9 on page 2-23 and Figure 2-10 on page 2-24 are based upon the following cabling assumptions. If you cannot stay within these assumptions, the information in Appendix A will help you calculate adjustments to cable length so that you may use the chart accurately. Figure 2-6 on page 2-18 illustrates the multiple-wiring-closet cabling assumptions.

- Use one 2.4-m (8-ft) cable between the attaching device and the faceplate in the work area (if the attaching device is an IBM Personal Computer, this will be the IBM Token-Ring Network PC Adapter Cable).[3]
- Use 2.4-m (8-ft) patch cables between the distribution panel and the 8228.[3]
- Use 2.4-m (8-ft) patch cables between 8228s.[3]
- All drops must be IBM Cabling System type 1 or 2 cable. See Appendix A if you are substituting other types of IBM Cabling System Cable for type 1 or 2.
- The chart in Figure 2-9 on page 2-23 assumes that up to 12 IBM 8228 Multistation Access Units are installed in each rack. If a ring can be configured with no more than twelve 8228s per wiring closet, then the chart assumes a single rack is used. If not, the minimum number of additional racks and 9-m (30-ft) patch cables is assumed.
- All wiring closet-to-wiring closet connections must use IBM Cabling System type 1, 2, 8, or 9 cable.
  - For information on using telephone twisted-pair media at a data rate of 4 Mbps, see the *IBM Token-Ring Network Telephone Twisted-Pair Media Guide*.

[3] Shorter lengths may be used.

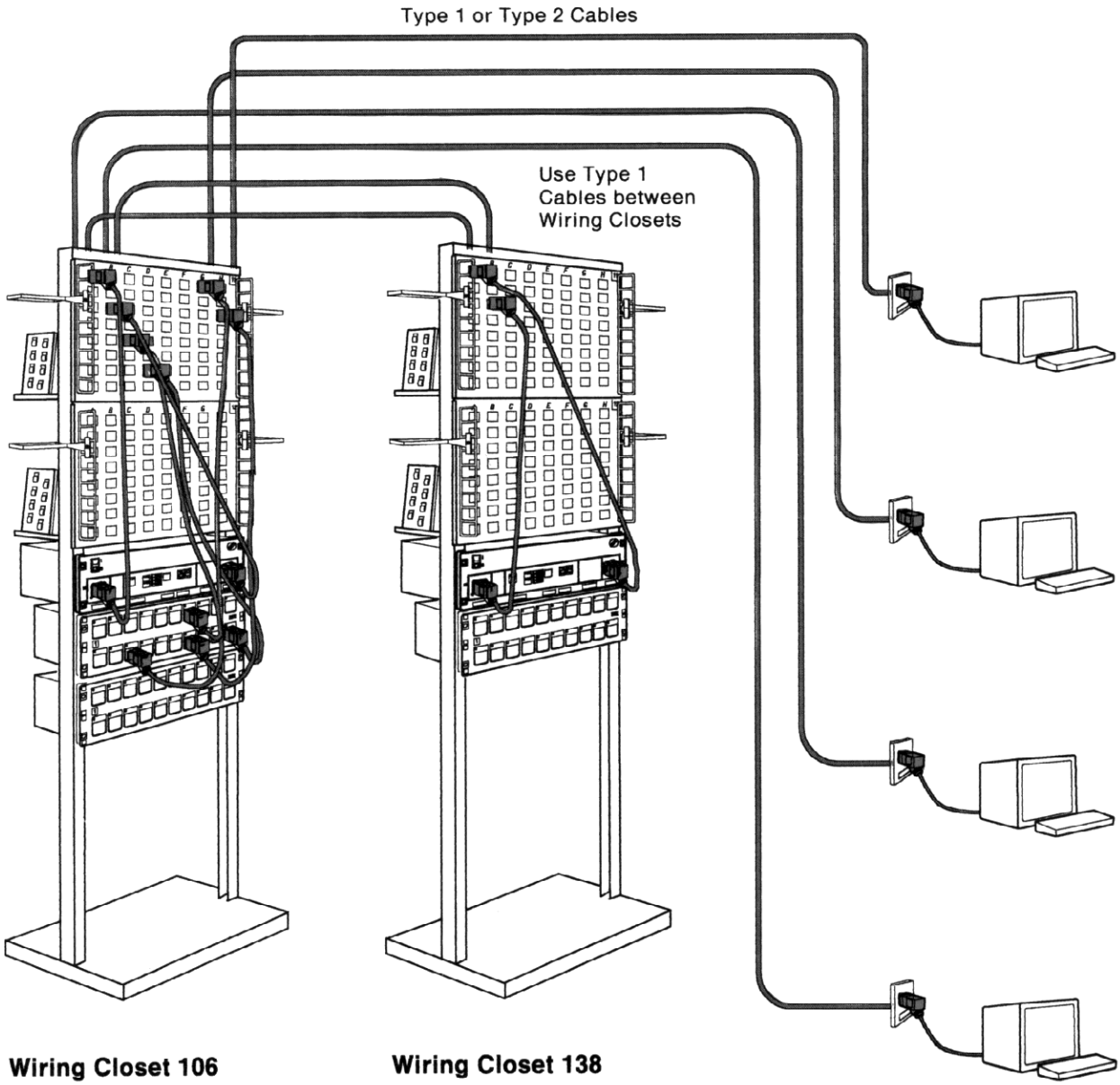


Figure 2-5. Multiple-Wiring-Closet Installation Assumptions for Rings Using 8230s

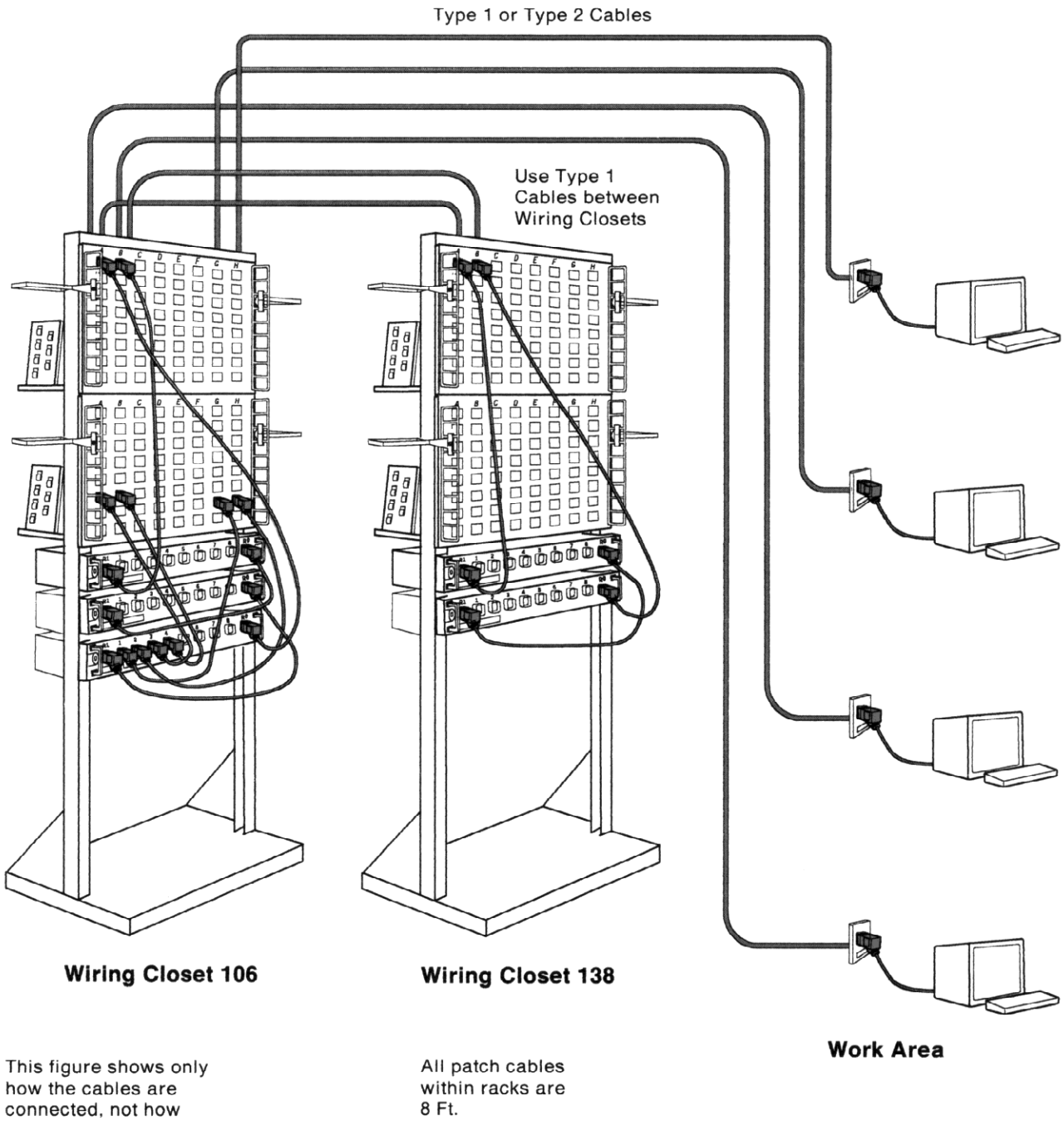


Figure 2-6. Multiple-Wiring-Closet Installation Assumptions for Rings Using 8228s

- To convert type 9 cable lengths to their type 1 equivalents, multiply the length of type 9 cable by 3/2.
- For conversion factors for rings wired with IBM Cabling System types 6 and 8, see Appendix A.
- For information on using optical fiber cable, see "Using IBM 8220 Optical Fiber Converters" later in this chapter.

Rings Using Multiple Wiring Closets Containing 8228s

The charts in Figure 2-9 on page 2-23 (for 4 Mbps rings) and Figure 2-10 on page 2-24 (for 16 Mbps rings) allow you to use the information you already know about your requirements to determine the size of your ring. The charts contain three kinds of information:

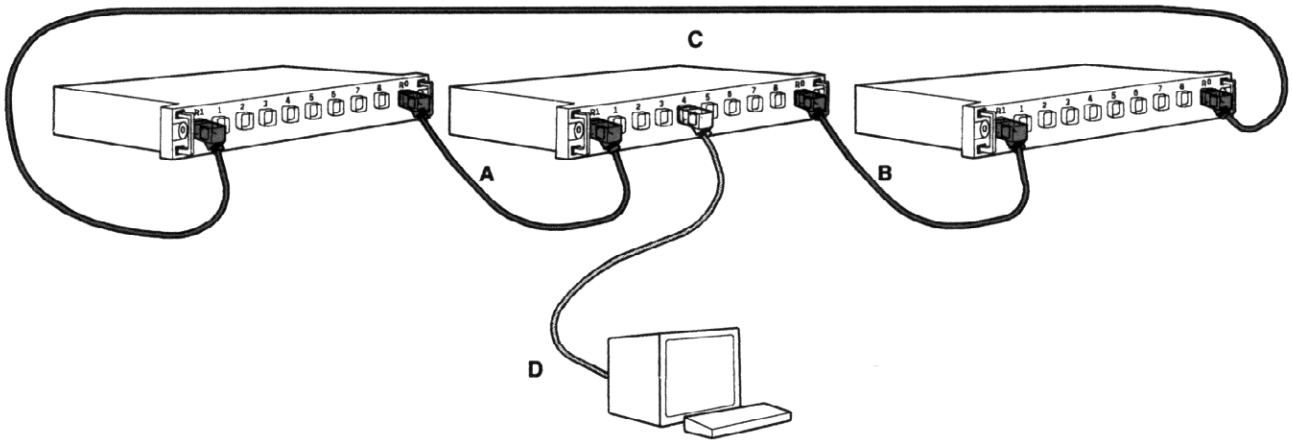
- The number of wiring closets on the ring (count a work area with one or more 8228s as a wiring closet)
- The number of 8228s on the ring
- The sum of the longest lobe and the Adjusted Ring Length (the sum of the length of all wiring closet-to-wiring closet cables less the length of the shortest of those cables).

If any two of these items are known, the chart can be used to determine the maximum limit for the third value. If you have marked the locations of attaching devices on your building floor plans and have determined which wiring closet each device's cable will terminate in, you can measure the length of the cable drop on the floor plan. If installation of the IBM Cabling System has been planned, check the length of each drop on the Cable Schedule. You need only determine the *longest* distance between a wiring closet and an attaching device.

Figure 2-7 on page 2-20 shows the significance of the longest lobe. If the device on that lobe is the only one active on the network, the total distance that frames and tokens have to travel (to return to the sending device) is the main ring path plus two times the longest lobe length.

You should also count the number of wiring closets your ring will pass through and determine the length of the cables that connect them, either by measuring the distance on the floor plan, or by consulting the Cable Schedules. Remember that when network components are placed in work areas, the work area should be treated as a wiring closet for planning purposes.

If your system follows the cabling guidelines described for multiple-wiring-closet networks, you should not add the lengths of any patch cables or adapter cables to either drop cable lengths or wiring closet-to-wiring closet cable lengths when performing the calculations described below. If you will use more or longer patch cables than previously described, see Appendix A for the correct adjustments to lobe and Adjusted Ring Length (ARL) calculations.



A = 150 Feet B = 200 Feet C = 250 Feet

Drive Distance with only longest Lobe Active = A + B + C + (2 x D)
= 150 + 200 + 250 + (2 x 300)
= 1200

Figure 2-7. Significance of the Longest Lobe Length

Determining the Number of 8228s in a Ring

To determine the number of 8228s you will need, divide the number of attaching devices assigned to each wiring closet by eight and round up to the nearest whole number. Then, add the number of 8228s needed for each wiring closet together to determine the total number required for the ring. You may wish to divide the number of attaching devices in each wiring closet by a lower number to allow for future system growth without having to add 8228s. Remember that a single ring will not support more than 33 IBM 8228s. If you have 33 IBM 8228s in a single ring, you may attach no more than 260 devices to the ring.

Determining the Adjusted Ring Length (ARL)

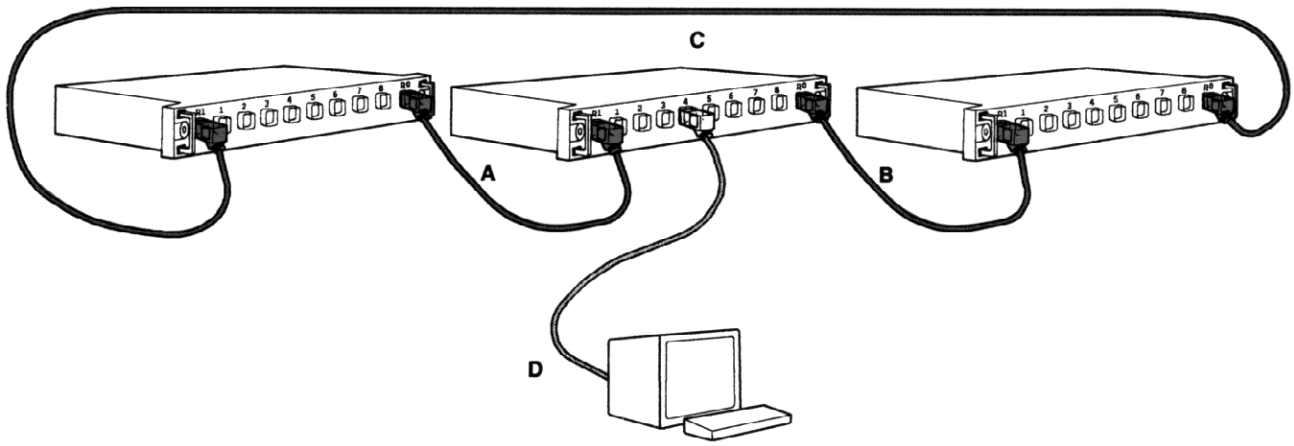
The main ring path in multiple-wiring-closet installations requires at least one cable leading from one wiring closet to the next one on the ring. Because a cable must be provided to connect the RO of the last 8228 in the ring to the RI of the first 8228, a two-wiring-closet ring will have two cables between wiring closets.

Once you have determined the length of each wiring closet-to-wiring closet cable, you can determine the ARL.

The ARL is a concept made necessary by problem determination. Some problem determination procedures require portions of the ring to be removed. When this happens, frames and tokens have to "wrap around" the ends of the main ring to complete their path around the ring. This increases the drive distance. The smallest portion of the main ring that may be removed (thus leaving the largest remaining path) is the shortest cable.

For an illustration, see Figure 2-8. With segment A removed, messages wrap around the ends of the ring to return to the sending device. Since segment A is the shortest cable, the distance messages have to travel is maximized.

To calculate the ARL, find the sum of all of the cables between wiring closets, then subtract the length of the shortest cable. For example, in Figure 2-8, the sum of all of the cable lengths is 600 ft; the length of the shortest cable is 150 ft. So the ARL is 450 ft.



ARL = (the sum of all wiring closet-to-wiring closet cable length) -
(the length of the shortest wiring closet-to-wiring closet cable)

A = 150 Feet
B = 200 Feet
C = 250 Feet
D = Lobe (Not part of ARL calculation)

ARL = (A + B + C) - A
ARL = (150 + 200 + 250) - 150
ARL = 450 Feet

Figure 2-8. The Adjusted Ring Length

Determining Allowable Lobe Length

On the chart in Figure 2-9 on page 2-23 (for 4 Mbps rings) or the chart in Figure 2-10 on page 2-24 (for 16 Mbps rings), look in the column that matches the number of wiring closets you will use and the row that matches the number of 8228s you will need. The number at the intersection of the row and column is the sum (in ft) of the length of the longest lobe in the network and the ARL. To find the length of the longest allowable lobe, subtract the ARL from the number on the table.

For example, for a ring whose data rate is 4 Mbps, if you are using 10 IBM 8228s and your ring passes through 6 wiring closets, the sum of the allowable lobe length and ARL is 903 ft. If the ARL is calculated as 450 ft, lobe lengths of up to 453 ft are allowed; however, even if the chart indicates that your ring can have lobe lengths greater than 330 ft, you should be cautious about installing lobes of more than 330 ft because doing so may limit future expansion of the network.

Check the allowable lobe length against the longest lobe on your network.

If you find that your ring exceeds the limitations in the chart, there are several ways that you may be able to adjust your plans so that your ring will meet your needs.

- Reducing the number of 8228s on the ring will allow longer ARLs and/or lobe lengths. If you have allowed for growth by specifying spare 8228s, you may want to eliminate them. A ring that has been planned geographically can often be replanned as several affinity rings without any significant loss of flexibility (see Chapter 1).
  - Using bridges, affinity rings can be joined together to form a single network of two or more rings (see Chapter 4).
- In buildings that have not yet been wired, decreasing the number of wiring closets can significantly increase the allowable lobe length.
- For rings with a data rate of 4 Mbps, you can use 8218s, 8219s, 8220s, or 8230s to extend the geographic coverage of a single ring. IBM 8219s and 8220s require optical fiber cable in the main ring path. IBM 8218s can be used with IBM Cabling System types 1, 6, 8, and 9. See Appendix A for converting lengths of types 6, 8, and 9 to their type 1 equivalents. IBM 8230s can use either copper or optical fiber cable. See Appendix A for information on using 8218s, 8219s, 8220s, or 8230s in rings containing 8228s.
- For rings with a data rate of 16 Mbps, you can use 8220s or 8230s to extend the geographical coverage of a single ring. IBM 8220s require optical fiber cables in the main ring path. IBM 8230s can use either copper or optical fiber cable.

NUMBER OF 8228s	NUMBER OF WIRING CLOSETS										
	2	3	4	5	6	7	8	9	10	11	12
2	1192										
3	1163	1148									
4	1135	1120	1104								
5	1106	1091	1076	1061							
6	1078	1062	1047	1032	1017						
7	1049	1034	1019	1004	989	974					
8	1021	1005	990	975	960	945	930				
9	992	977	962	947	932	916	901	886			
10	963	948	933	918	903	888	873	858	843		
11	935	920	905	890	874	859	844	829	814	799	
12	906	891	876	861	846	831	816	801	786	770	755
13	878	863	848	833	817	802	787	772	757	742	727
14	849	834	819	804	789	774	759	744	729	713	698
15	821	806	791	775	760	745	730	715	700	685	670
16	792	777	762	747	732	717	702	687	671	656	641
17	764	749	733	718	703	688	673	658	643	628	613
18	735	720	705	690	675	660	645	629	614	599	584
19	707	691	676	661	646	631	616	601	586	571	556
20	678	663	648	633	618	603	587	572	557	542	527
21	649	634	619	604	589	574	559	544	529	514	499
22	621	606	591	576	561	545	530	515	500	485	470
23	592	577	562	547	532	517	502	487	472	457	441
24	564	549	534	519	503	488	473	458	443	428	413
25	502	520	505	490	475	460	445	430	415	399	384
26	474	492	477	461	446	431	416	401	386	371	356
27	445	463	448	433	418	403	388	373	357	342	327

Figure 2-9. Multiple-Wiring-Closet Distances (Adjusted Ring Length + Longest Lobe Length) in Feet for 4 Mbps Rings

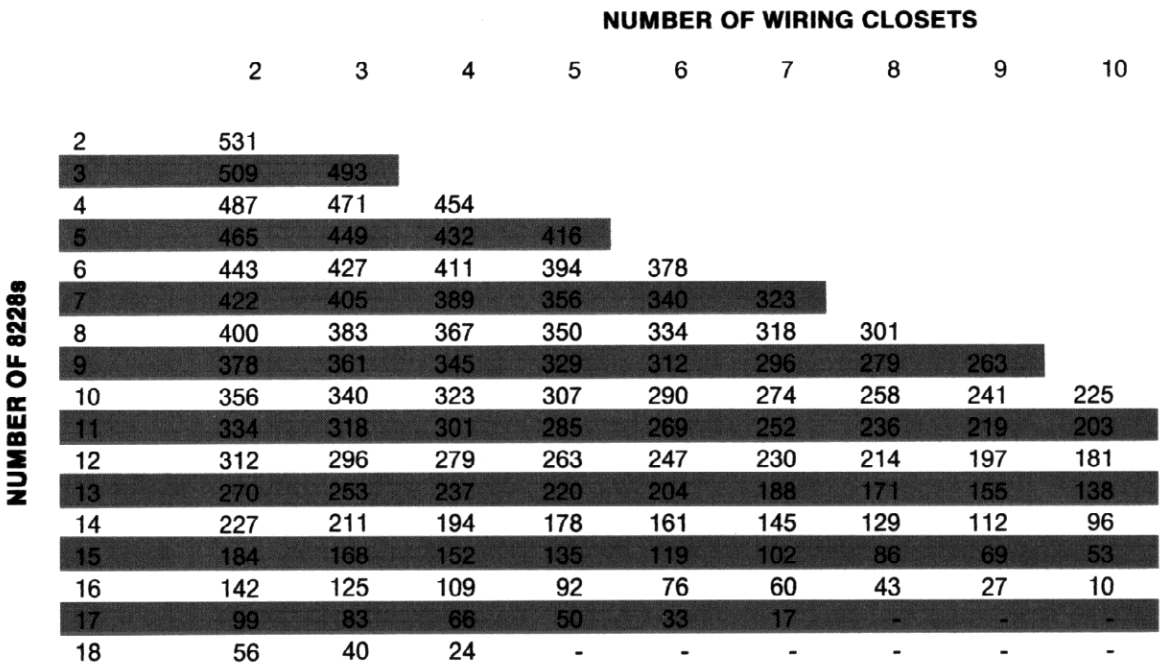


Figure 2-10. Multiple-Wiring-Closet Distances (Adjusted Ring Length + Longest Lobe Length) in Feet for 16 Mbps Rings

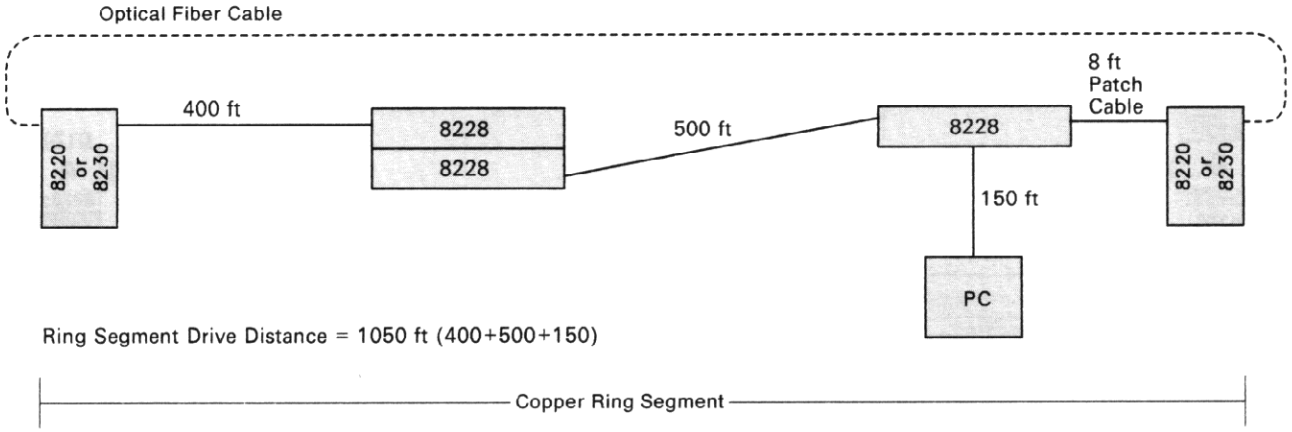
4 Mbps Rings Using 8220s or 8230s

Because of the self-wrapping capability of 8220s and 8230s, which increases the availability of the ring, determining the drive distance of the copper ring segment or segments between 8220s or 8230s is exactly the same. When planning rings that contain both 8220s and 8230s in the same main ring path, remember that under no circumstances should you attempt to use an 8220 at one end of an optical fiber segment and an 8230 on the other.

IBM 8230 base units may be used as copper repeaters or optical fiber converters in rings containing 8228s. If 8230s are used together with their lobe attachment modules, remember that the total number of attaching devices on a single ring cannot exceed 260, including the allowance of 3 for each base unit and 2 for each 8220 in the main ring path.

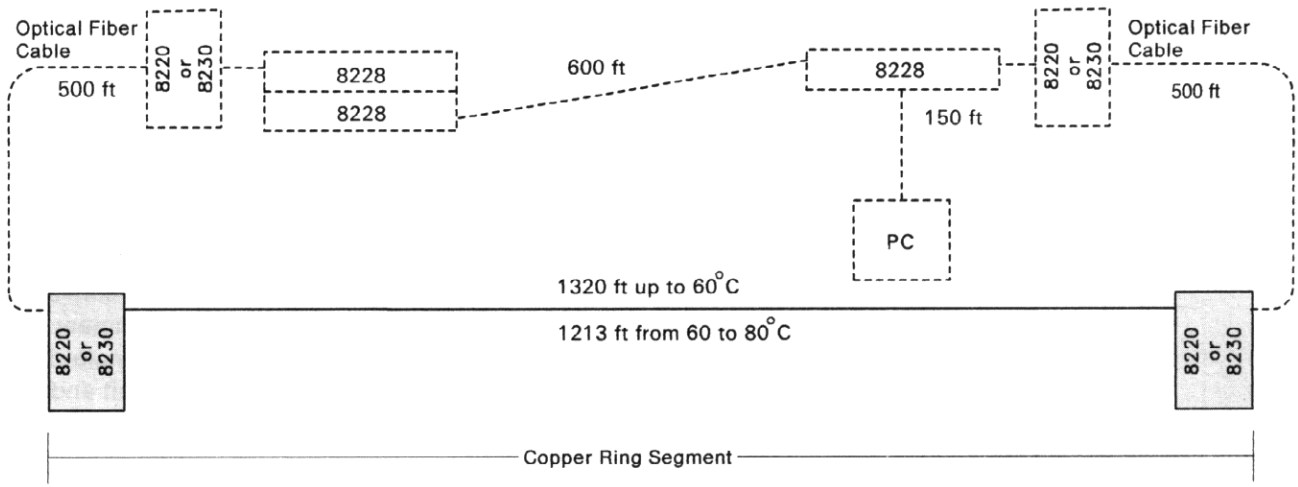
- Situation 1: For all copper ring segments that contain 8228s and are bounded by 8230s.

  The ring segment drive distance is the sum of all of the lengths of cable in the main ring path plus the length of the longest lobe in the ring segment.



- Situation 2: There are no 8228s in the copper ring segment.

  The allowable drive distance is 400 m (1320 ft) between the 8220s or 8230s bounding the copper ring segment if the temperature of the wire is less than 60°C (140°F). If the temperature is between 60°C and 80°C (140°F and 176°F), the maximum drive distance is 385 m (1213 ft). If there are surge suppressors in the copper ring segment between the 8220s or 8230s, reduce the allowable drive distance by 60 m (100 ft) for each surge suppressor.



If the ring segment exceeds the drive distance in the chart in Figure 2-13 on page 2-29, you must do one of the following:

- Replace additional segments of copper cabling with optical fiber cable and use additional 8220s or 8230s.
- Place 8218s in the ring segment as described in Appendix A.

Figure 2-11 on page 2-26 shows a ring with intermixed cable in its main ring path. The sum of the lengths of the type 1 cable is indicated, and the longest lobe on the ring that is applicable to the drive distance calculation is identified.

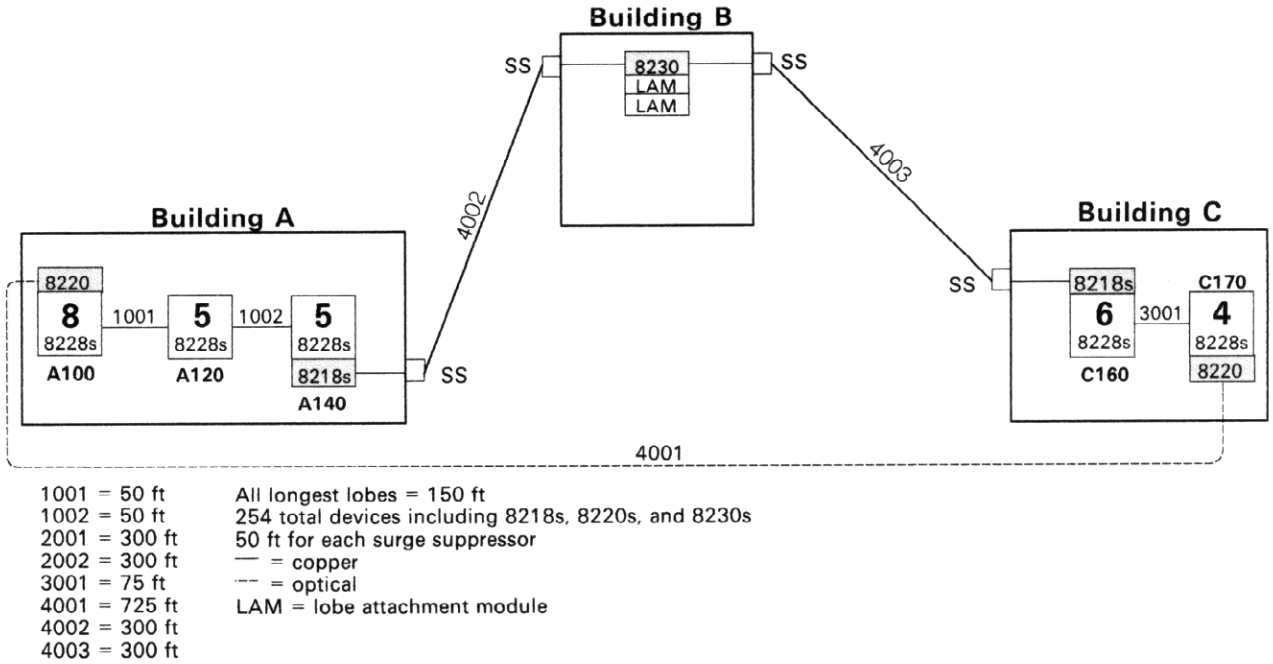


Figure 2-11. A 4 Mbps Ring with Intermixed Main Ring Path Cabling Using 8220s or 8230s

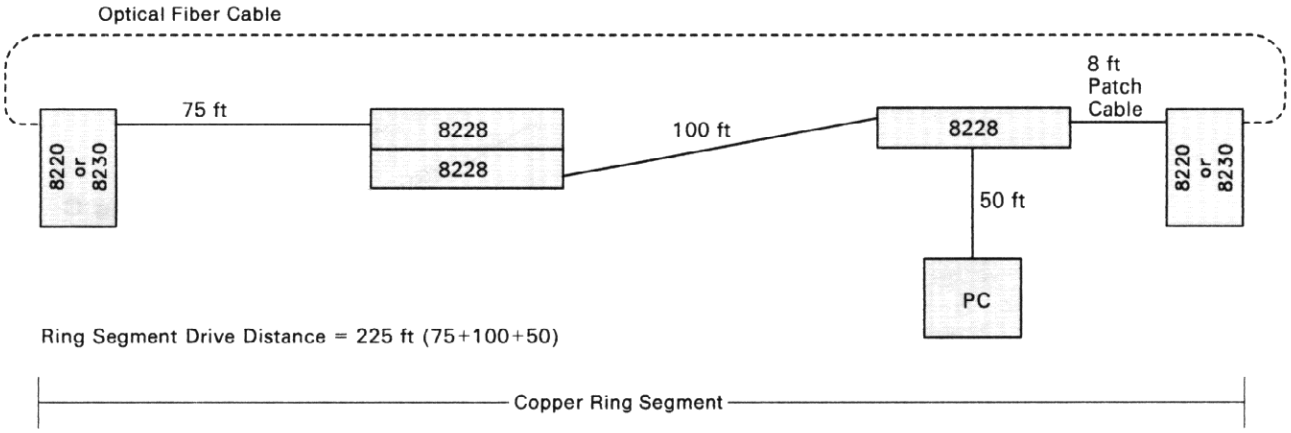
16 Mbps Rings Using 8220s or 8230s

Because of the self-wrapping capability of 8220s and 8230s, which increases the availability of the ring, determining the drive distance of the copper ring segment or segments between 8220s or 8230s is exactly the same. When planning rings that contain both 8220s and 8230s in the same main ring path, remember that under no circumstances should you attempt to use an 8220 at one end of an optical fiber segment and an 8230 on the other.

IBM 8230 base units may be used as copper repeaters or optical fiber converters in rings containing 8228s. If they are used together with their lobe attachment modules, remember that the total number of attaching devices on a single ring cannot exceed 260, including the allowance of 3 for each 8230 base unit and 2 for each 8220 in the main ring path.

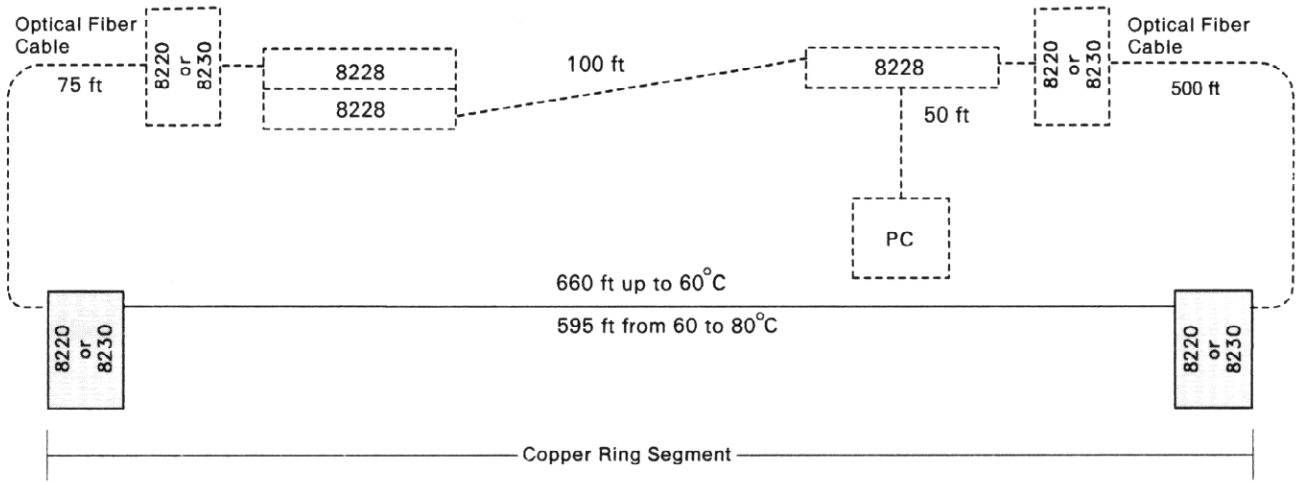
- Situation 1: For all copper ring segments that contain 8228s.

  The ring segment drive distance is the sum of all of the lengths of cable in the main ring path plus the length of the longest lobe in the ring segment.



- Situation 2: There are no 8228s in the copper ring segment.

  The allowable drive distance is 200 m (660 ft) between the 8220s or 8230s bounding the copper ring segment, if the temperature of the cable is 60°C (140°F) or less. If the temperature of the cable is from 60°C to 80°C (140°F to 176°F), the maximum drive distance is 180 m (595 ft). Remember that surge suppressors in the copper ring segment are not supported for 16 Mbps operation.



If the ring segment exceeds the allowable drive distance in the chart in Figure 2-14 on page 2-30, you must do one of the following:

- Replace additional segments of copper cabling with optical fiber cable and use additional 8220s or 8230s.
- Use additional 8230s as copper repeaters.

Figure 2-12 shows a 16 Mbps ring with intermixed cable in its main ring path. The sum of the lengths of the type 1 cable is indicated, and the longest lobe on the ring that is applicable to the drive distance calculation is identified.

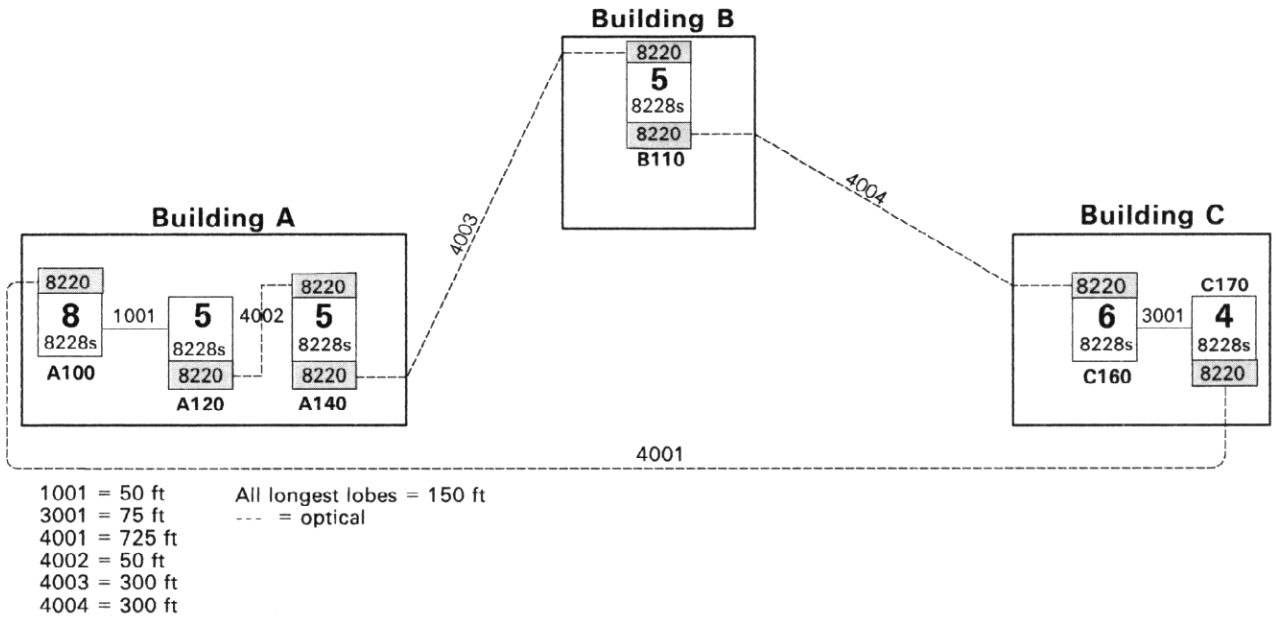


Figure 2-12. A 16 Mbps Ring with Intermixed Main Ring Path Cabling Using 8220s

NUMBER OF 8228s	NUMBER OF WIRING CLOSETS											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1235											
2	1207	1192										
3	1178	1163	1148									
4	1150	1135	1120	1104								
5	1121	1106	1091	1076	1061							
6	1093	1078	1062	1047	1032	1017						
7	1064	1049	1034	1019	1004	989	974					
8	1036	1020	1005	990	975	960	945	930				
9	1007	992	977	962	947	932	916	901	886			
10	979	963	948	933	918	903	888	873	858	843		
11	950	935	920	905	890	874	859	844	829	814	799	
12	921	906	891	876	861	846	831	816	801	786	770	755
13	860	878	863	848	833	817	802	787	772	757	742	727
14	832	849	834	819	804	789	774	759	744	729	713	698
15	803	821	806	791	775	760	745	730	715	700	685	670
16	774	792	777	762	747	732	717	702	687	671	656	641
17	746	764	749	733	718	703	688	673	658	643	628	613
18	717	735	720	705	690	675	660	645	629	614	599	584
19	689	707	691	676	661	646	631	616	601	586	571	556
20	660	678	663	648	633	618	603	587	572	557	542	527
21	632	649	634	619	604	589	574	559	544	529	514	499
22	603	621	606	591	576	561	545	530	515	500	485	470
23	575	592	577	562	547	532	517	502	487	472	457	441
24	546	564	549	534	519	503	488	473	458	443	428	413
25	485	502	520	505	490	475	460	445	430	415	399	384
26	456	474	492	477	461	446	431	416	401	386	371	356
27	428	445	463	448	433	418	403	388	373	357	342	327

Figure 2-13. 4 Mbps Allowable Drive Distances in Feet with Repeaters or Converters

NUMBER OF 8228s	NUMBER OF WIRING CLOSETS									
	0	1	2	3	4	5	6	7	8	9	10
1		569									
2		547	531								
3		525	509	493							
4		503	487	471	454						
5		482	465	449	432	426					
6		460	443	427	411	394	378				
7		438	422	405	389	372	356	340			
8		416	400	383	367	350	334	318	301		
9		394	378	361	345	329	312	296	279	263	
10		372	356	340	323	307	290	274	258	241	225
11		351	334	318	301	285	269	252	236	219	203
12		329	312	296	279	263	247	230	214	197	181
13		253	270	253	237	220	204	188	171	155	138
14		211	227	211	194	178	161	145	129	112	96
15		168	184	168	152	135	119	102	86	69	53
16		125	142	125	109	92	76	60	43	27	10
17		83	99	83	66	50	33	17	-	-	-
18		40	56	40	24	-	-	-	-	-	-

Figure 2-14. 16 Mbps Allowable Drive Distances in Feet with Converters