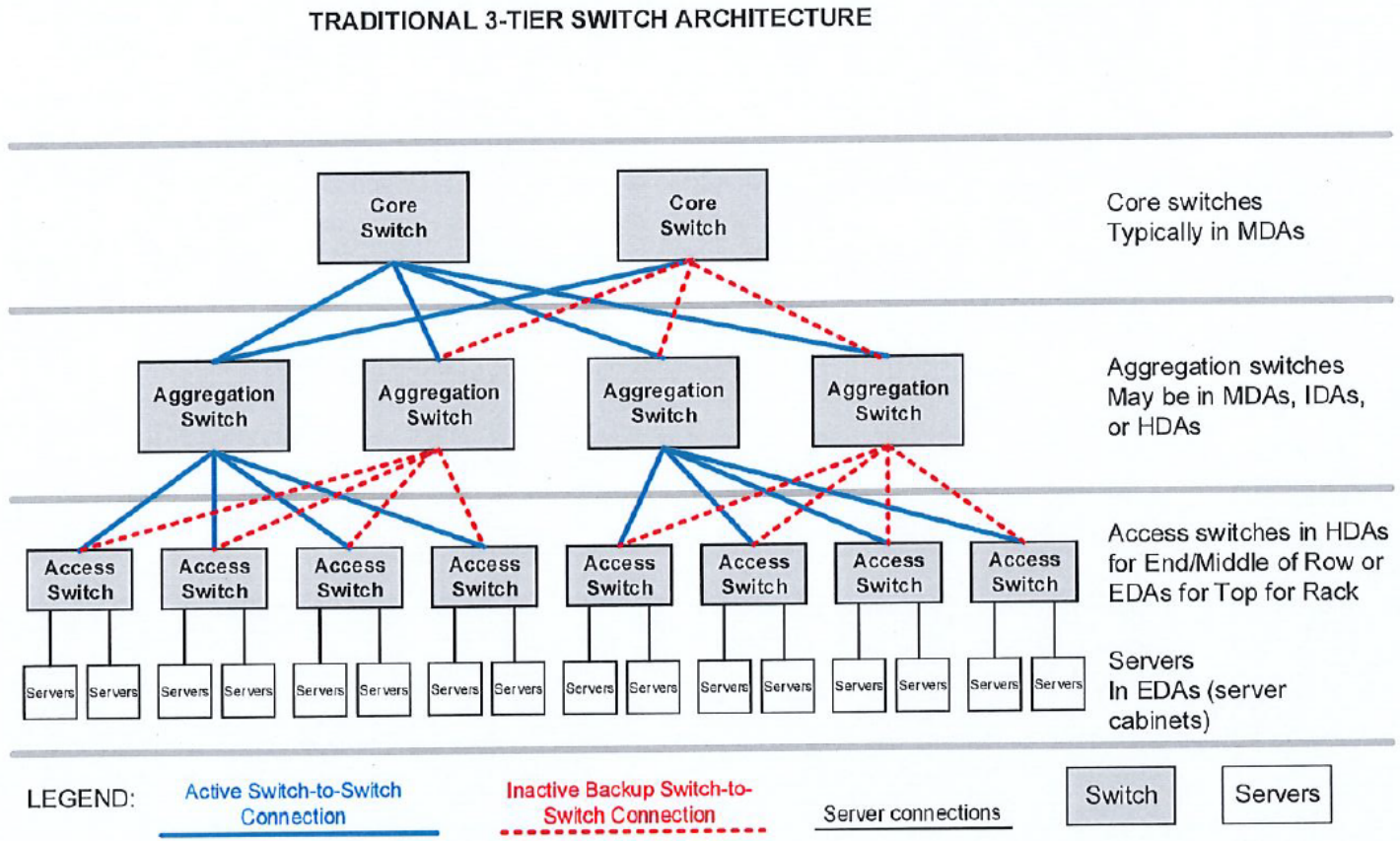
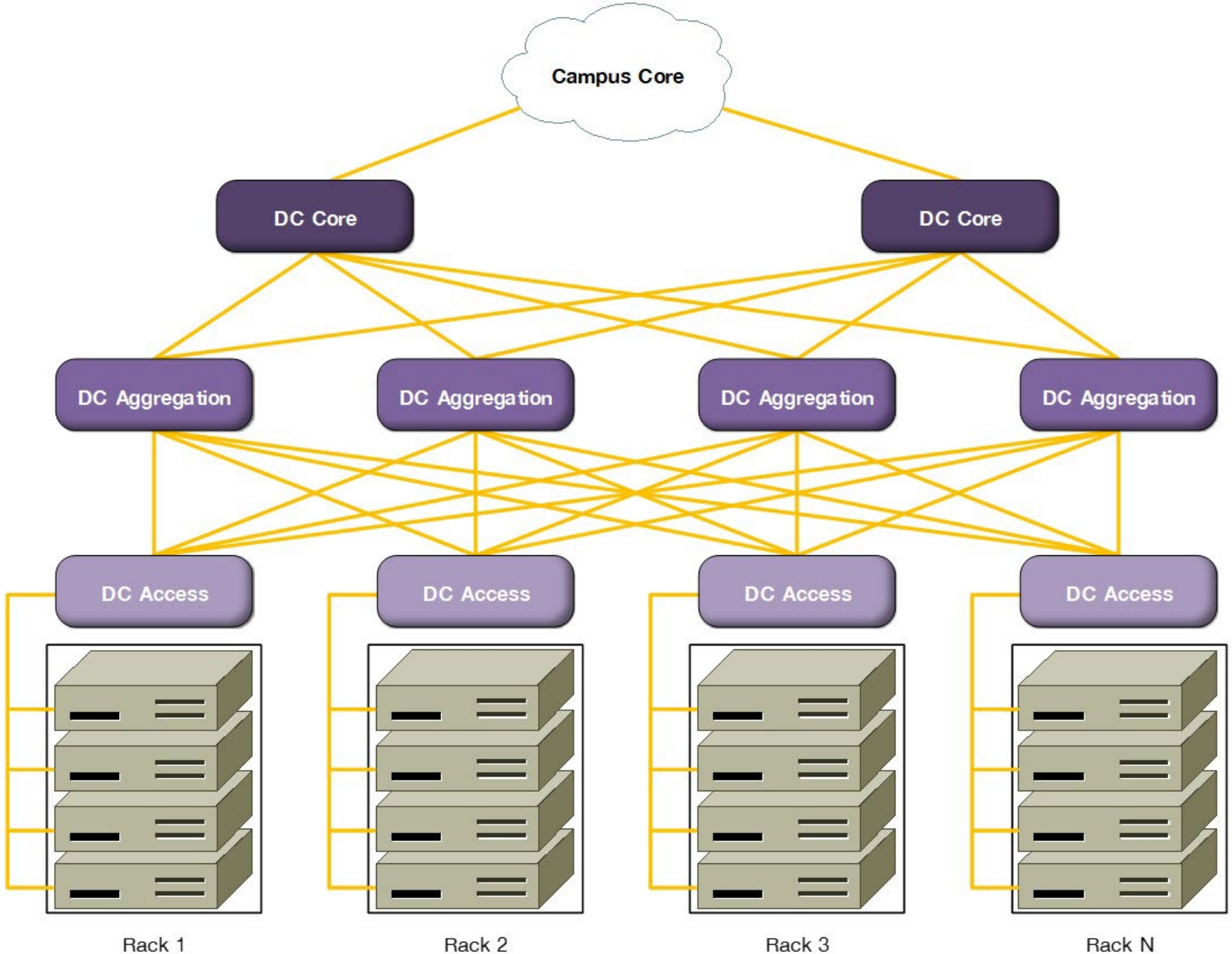
J.1 Traditional switch architecture

Figure 22 provides an example of the traditional three-tier data center switch architecture.



- Backup connections are inactive due to spanning tree protocols
- Connections to access aggregation and core switches are typically over-subscribed
- Traffic between two access switches may need to traverse three intermediate switches
- Servers may be connected to multiple switches for redundancy
- All cabling follows hierarchical structure specified in ANSI/TIA-942-A


Campus Core
DC Core
DC Core
DC Aggregation
DC Aggregation
DC Aggregation
DC Aggregation
DC Access
DC Access
DC Access
DC Access
Rack 1
Rack 2
Rack 3
Rack N

J.3.1 Data center fabric fat-tree

Figure 25 is an example of the fat-tree switch fabric architecture (also called the leaf and spine switch architecture). This architecture has no more than one switch between any two access switches and can be non-blocking by providing sufficient bandwidth from each access switch to the interconnection switches.

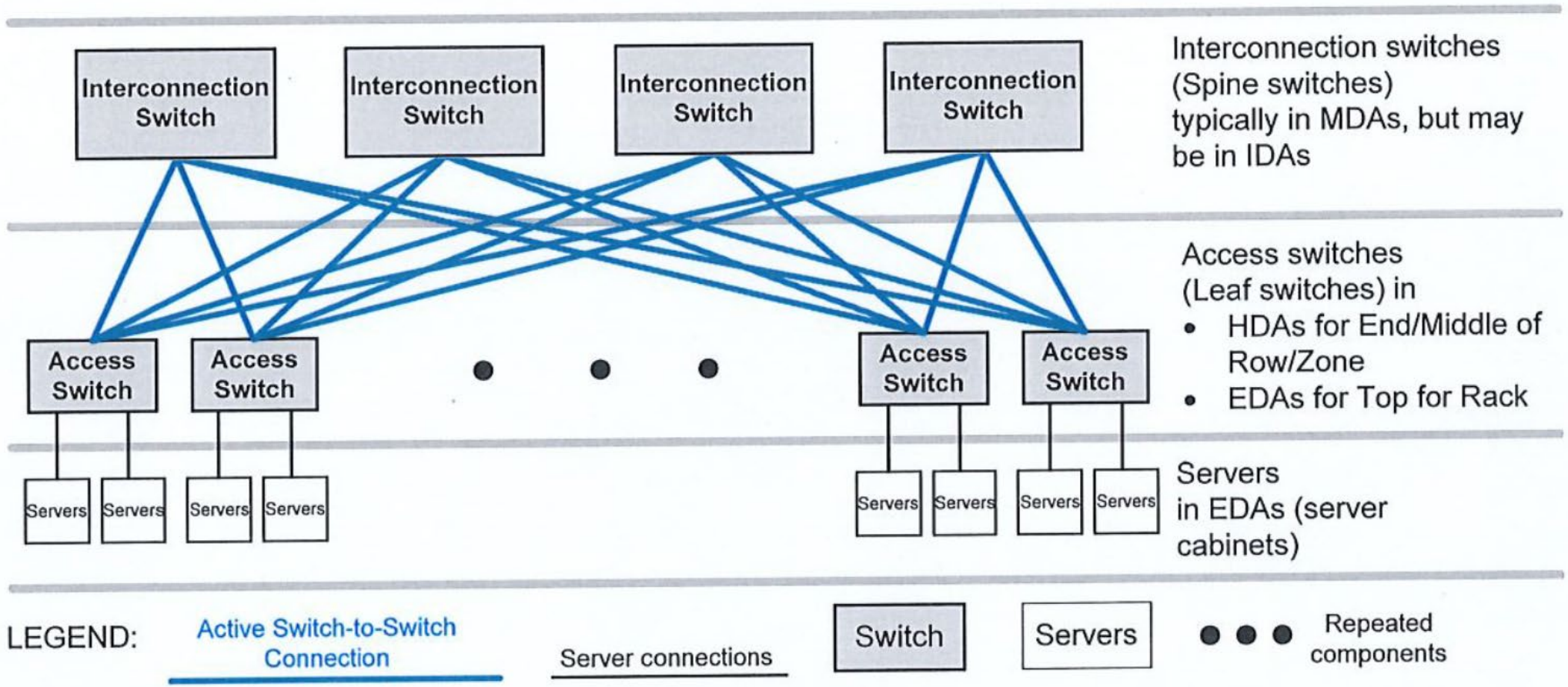
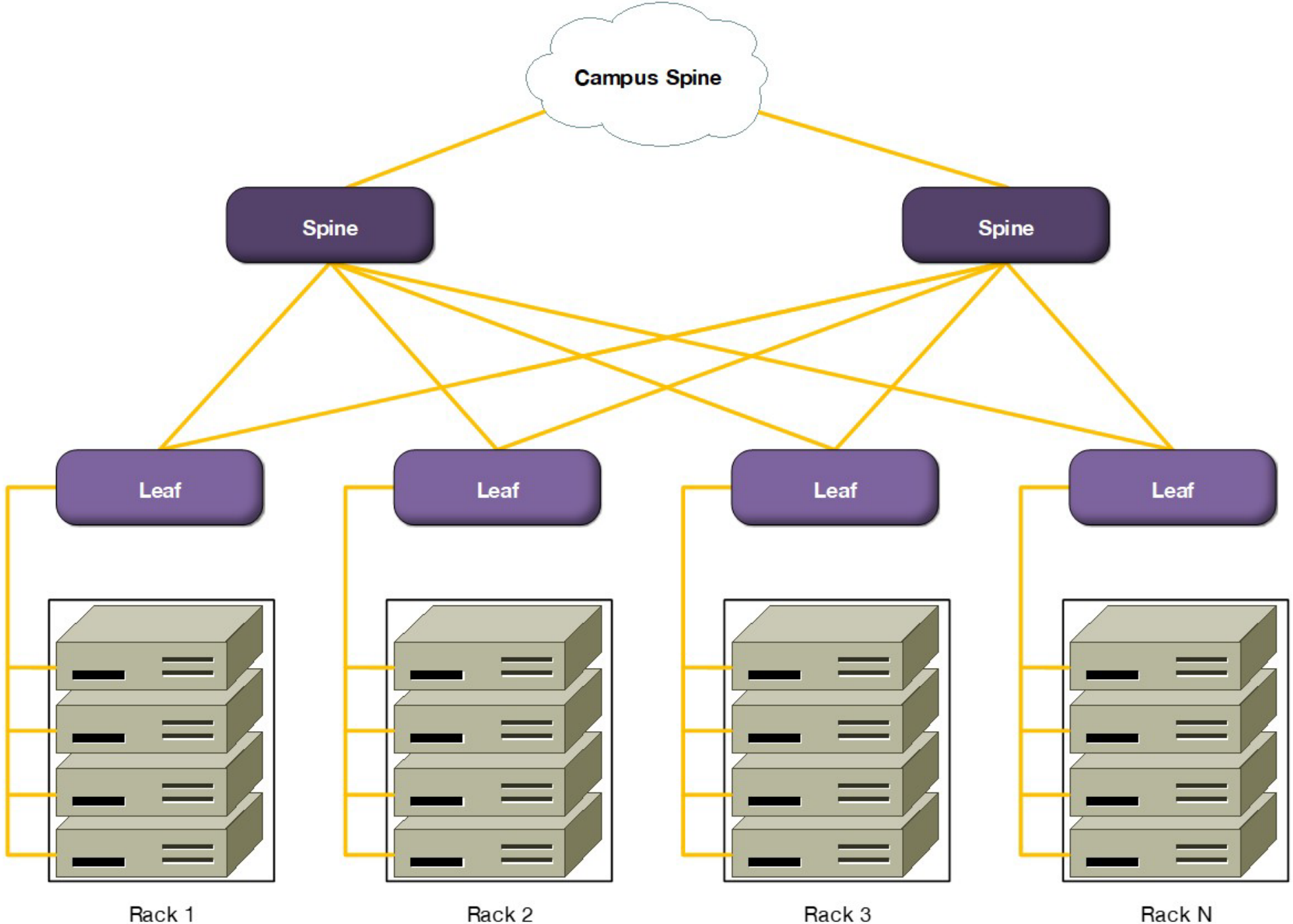
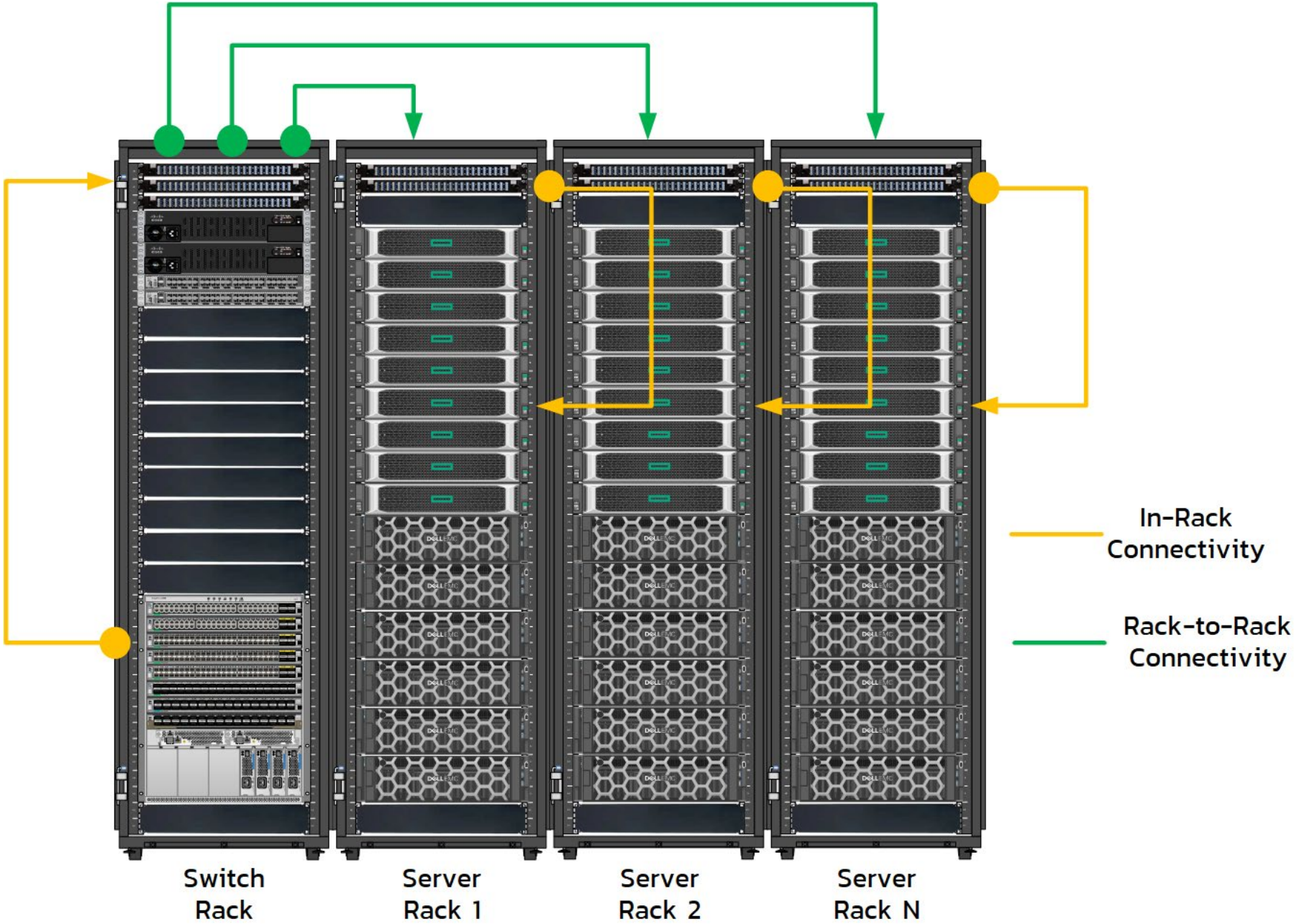


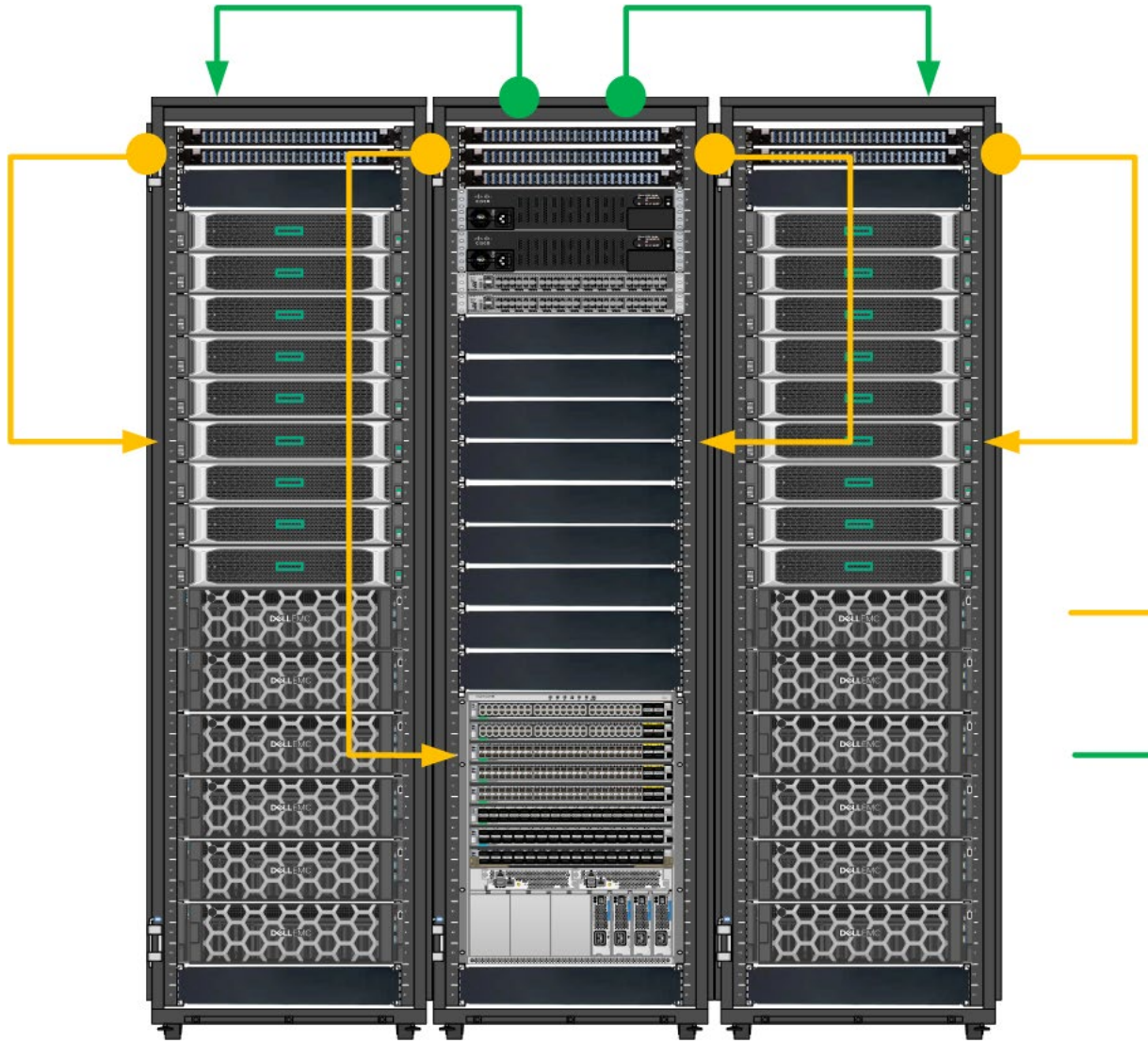
Figure 25: Fat-tree example


Campus Spine
Spine
Spine
Leaf
Leaf
Leaf
Leaf
Rack 1
Rack 2
Rack 3
Rack N

Top-of-Rack (ToR)



End-of-Row (EoR)



Middle-of-Row (MoR)

6.2.2 Basic data center topology

The basic data center includes a single entrance room or entrance space, possibly one or more telecommunications rooms, one MDA, and several HDAs. Figure 6 illustrates the basic data center topology.

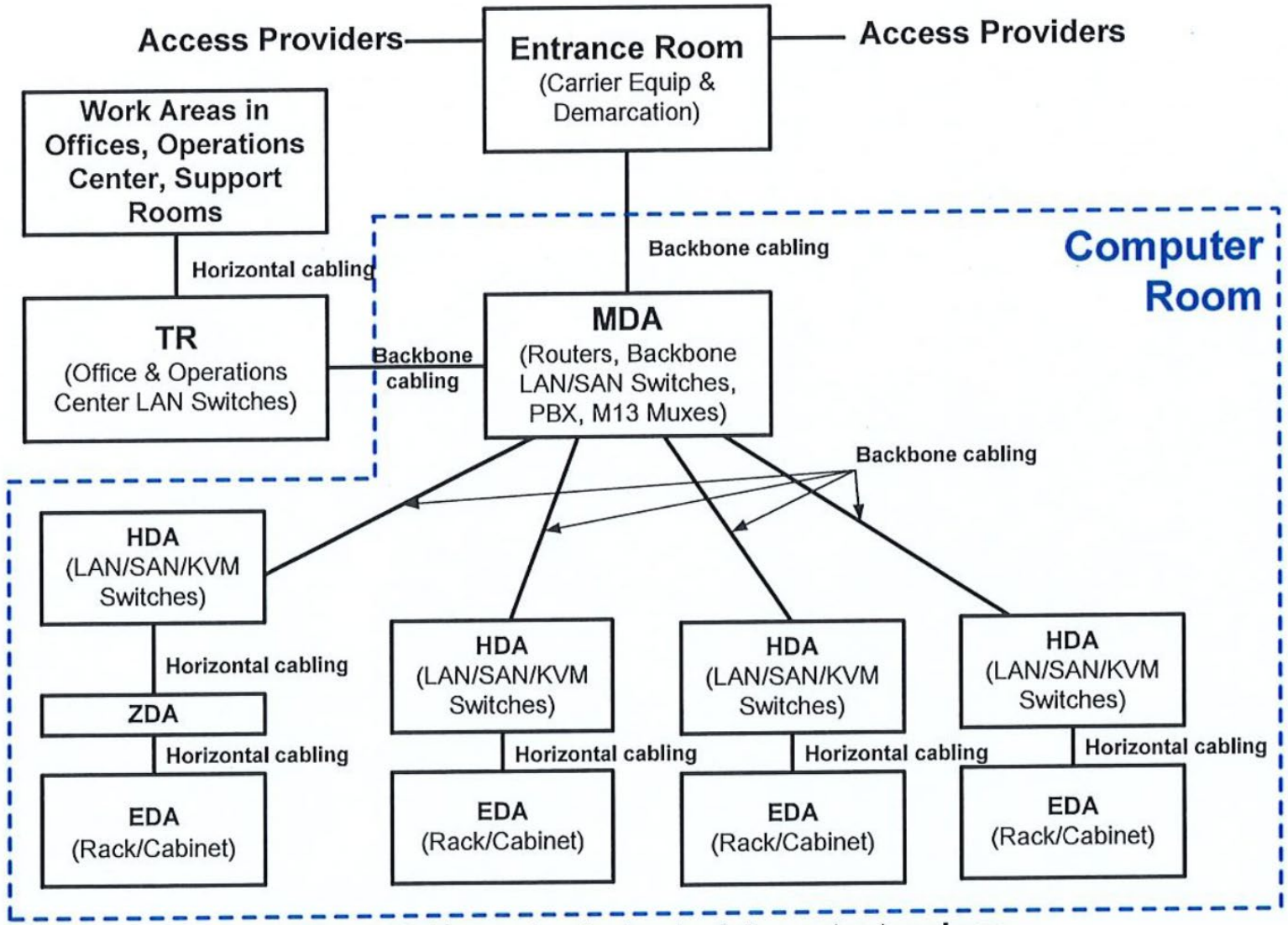


Figure 6: Example of a basic data center topology

MDA : Main Distribution Area

IDA : Intermediate Distribution Area

HDA : Horizontal Distribution Area

ZDA : Zone Distribution Area

EDA : Equipment Distribution Area

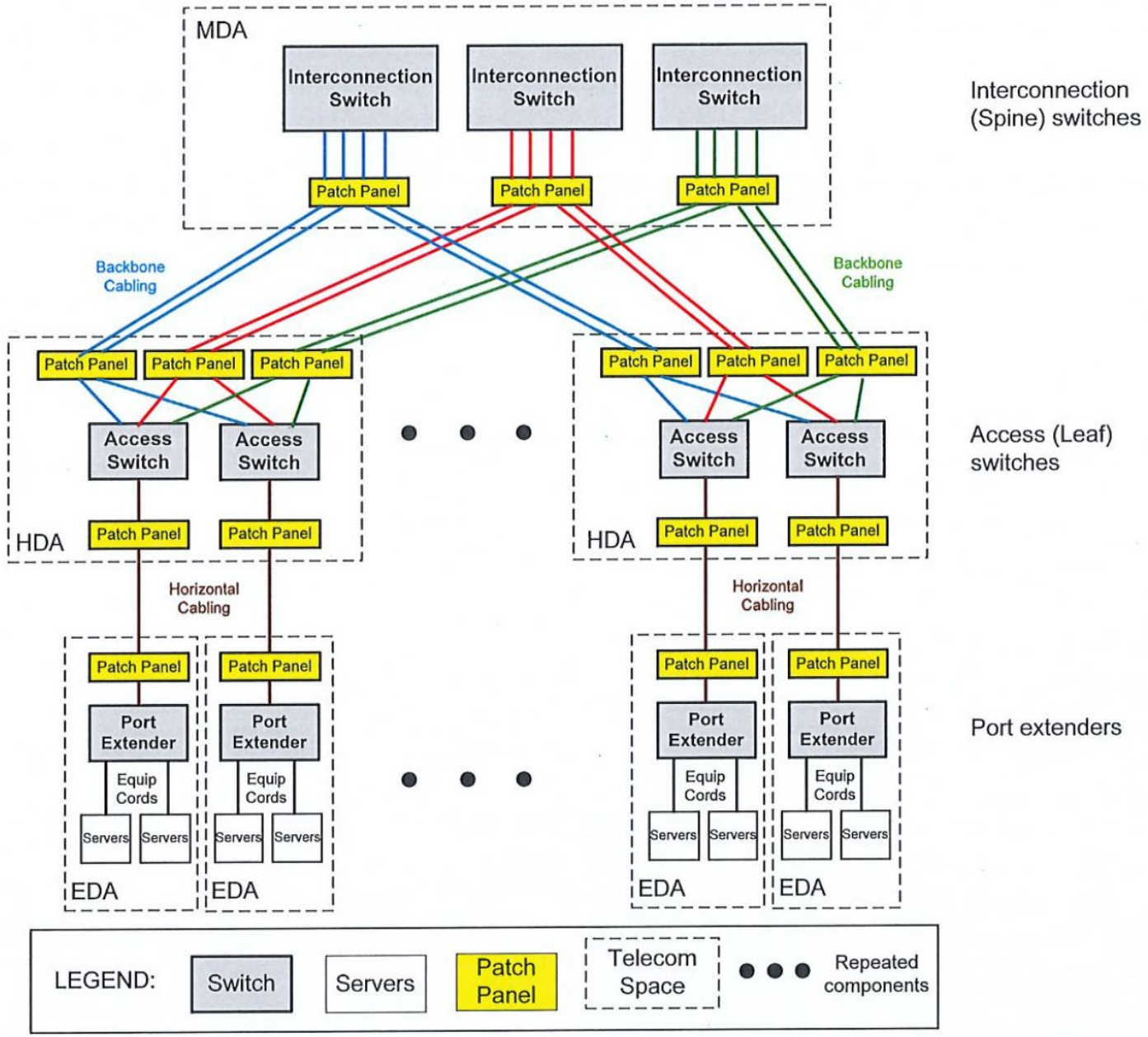


Figure 27: Example of use of structured cabling for fat-tree switch architecture

6.2.3 Reduced data center topologies

Data center designers can consolidate the main cross-connect, and horizontal cross-connect in a single MDA, possibly as small as a single cabinet or rack. The telecommunications room for cabling to the support areas and the entrance room/space may also be consolidated into the MDA in a reduced data center topology. The reduced data center topology is illustrated in figure 7.

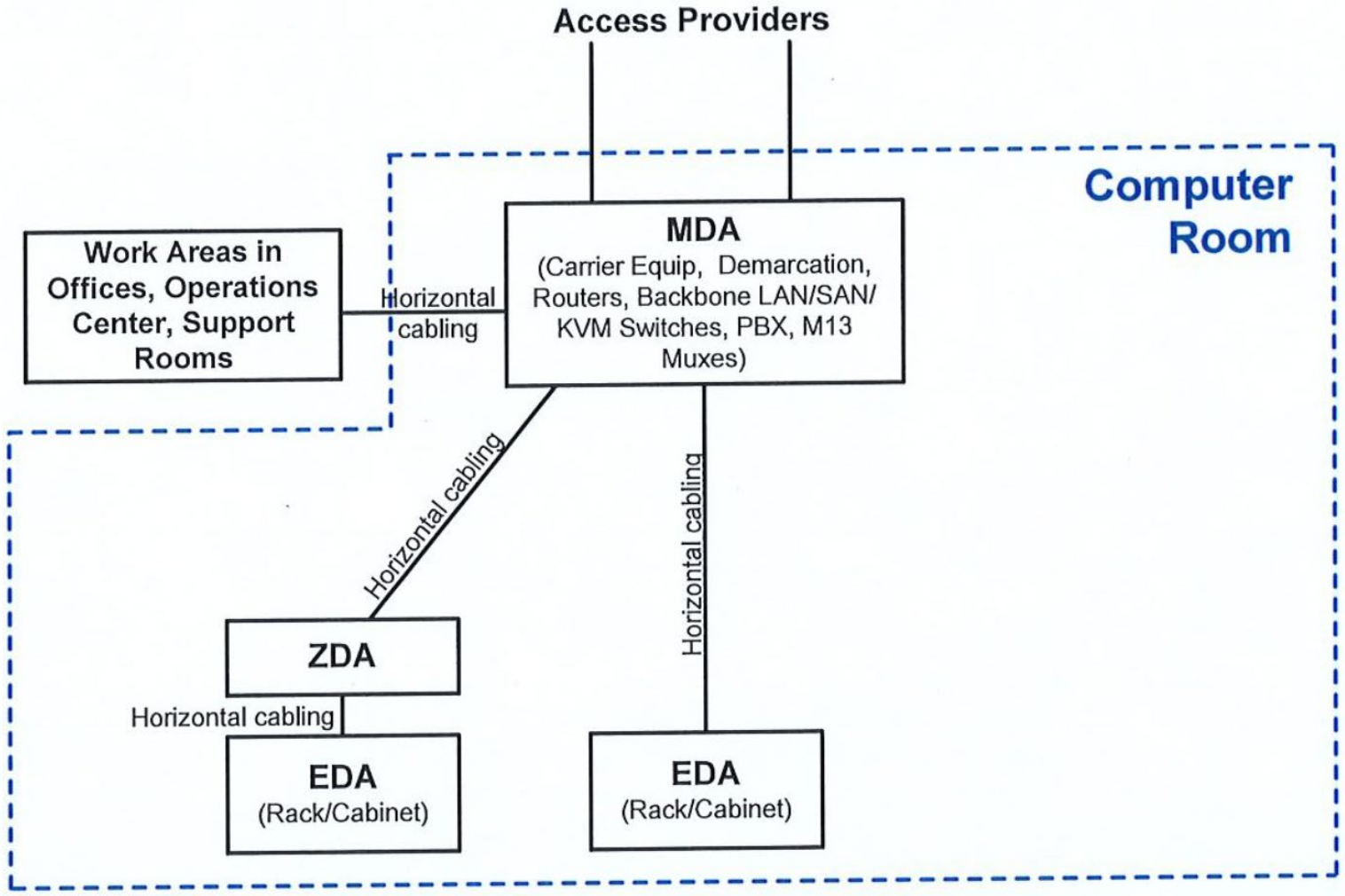


Figure 7: Example of a reduced data center topology

MDA : Main Distribution Area

IDA : Intermediate Distribution Area

HDA : Horizontal Distribution Area

ZDA : Zone Distribution Area

EDA : Equipment Distribution Area

6.2.4 Distributed data center topologies

Large data centers, such as data centers located on multiple floors or in multiple rooms, may require intermediate cross-connects located in IDAs. Each room or floor may have one or more IDAs.

Multiple telecommunications rooms may be required for data centers with large or widely separated office and support areas.

In very large data centers, circuit length restrictions may require multiple entrance rooms or spaces. The data center topology with multiple entrance rooms/spaces and IDAs is shown in figure 8. Although cabling from entrance rooms/spaces directly to the IDAs and HDAs is not common practice or encouraged, it is allowed to meet certain circuit length limitations and redundancy needs.

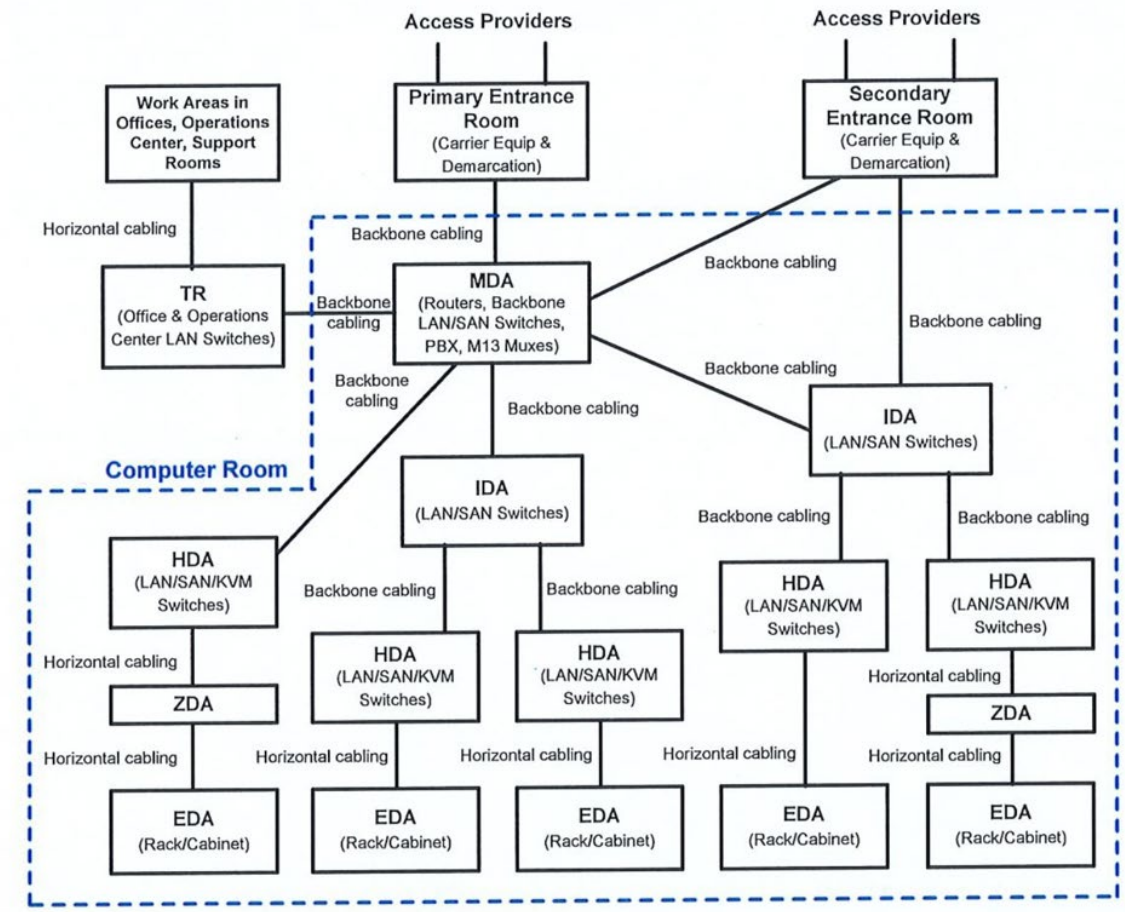


Figure 8: Example of a distributed data center topology with multiple entrance rooms

MDA : Main Distribution Area

IDA : Intermediate Distribution Area

HDA : Horizontal Distribution Area

ZDA : Zone Distribution Area

EDA : Equipment Distribution Area

Rated-1 Data Center: Basic

A Basic data center is susceptible to disruptions from both planned and unplanned activity on the distribution path and/or equipment (e.g., building power shutdown, maintenance/failure of equipment and/or distribution path). Operation errors or spontaneous failures of site infrastructure components may cause a data center disruption.

Rated-1 data centers have a single path for distribution of power, cooling and telecommunications. There is no requirement for component or equipment redundancy.

Rated-1 data centers have little to no requirements for compartmentalization for critical facilities.The standby power system shall be sized for UPS & mechanical systems without redundancy.Rated-1 data centers will typically have limited physical security controls.

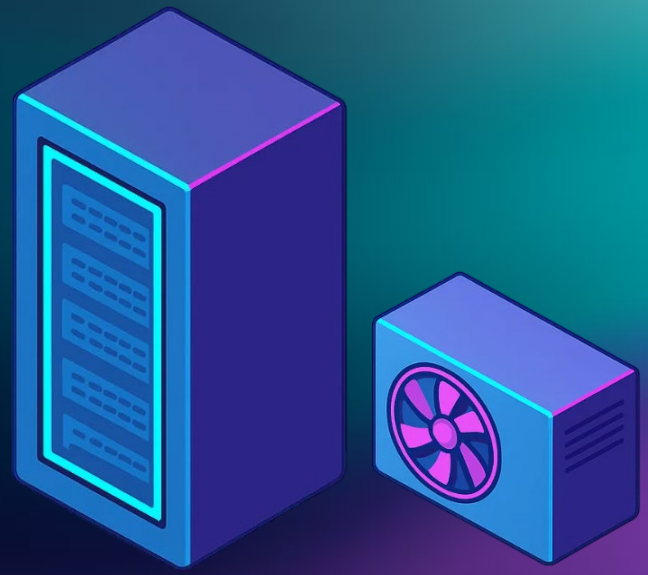
ANSI/TIA-942-C

TIER 1
Basic Capacity

Single Path of power, cooling and telecommunication.

No Redundancy.

Max. Downtime 28.8 hours/year.



99.671%

Uptime

Rated-2 Data Center: Redundant Component

A Redundant Component data center is susceptible to disruptions from both planned and unplanned activity on the distribution path (e.g., building power shutdown, maintenance or failure of a distribution path). Redundant components may enable planned maintenance for individual components without interruption to the ICT load. A standby power system is required and sized for UPS & mechanical systems without redundancy.

Rated-2 data centers have a single path for distribution of power, cooling and telecommunications. There is a requirement for component/equipment redundancy.

Rated-2 data centers have little to no requirements for compartmentalization for critical facilities.

Rated-2 data centers will typically have basic physical security controls.

Preventative maintenance should be performed as specified by manufacturers and may require a shut down.

ANSI/TIA-942-C

TIER 2
Redundant Capacity Components

- Single Path of power, cooling and telecommunication.
- Partial Redundancy.
- Max. Downtime 22.7 hours/year.

99.741%

Uptime

Rated-3 Data Center: Concurrently Maintainable

A Concurrently Maintainable data center is able to handle planned maintenance on any part of the distribution path or any single piece of equipment or component without causing interruption to the data center operations.

Rated-3 data centers have, at a minimum, one active (N) and one standby (+1) path for distribution of power, cooling and telecommunications. There is no requirement for component/equipment redundancy within each distribution path.

Rated-3 data centers do not require, but should be compartmentalized for electrical, mechanical and telecommunication critical facilities.

Rated-3 data centers have improved physical security controls.

ANSI/TIA-942-C

TIER 3
Concurrently Maintainable

- Multiple paths of power, cooling and telecommunication.
- Fully Redundancy : one Active (N) and one standby (+1)
- Max. Downtime 1.6 hours/year.

99.982%

Uptime

Rated-4 Data Center: Fault Tolerant

A Fault Tolerant data center is able to withstand one single fault at a time on any part of the distribution path or any single piece of equipment or component without causing interruption to the data center operations.

Rated-4 data centers have, at a minimum, dual active (2N / N+N) path for distribution of power, cooling and telecommunications. There is no requirement for component/equipment redundancy within each distribution path.

Rated-4 data centers require compartmentalization for electrical, mechanical and telecommunication critical facilities.

Rated-4 data centers have strong physical security controls.

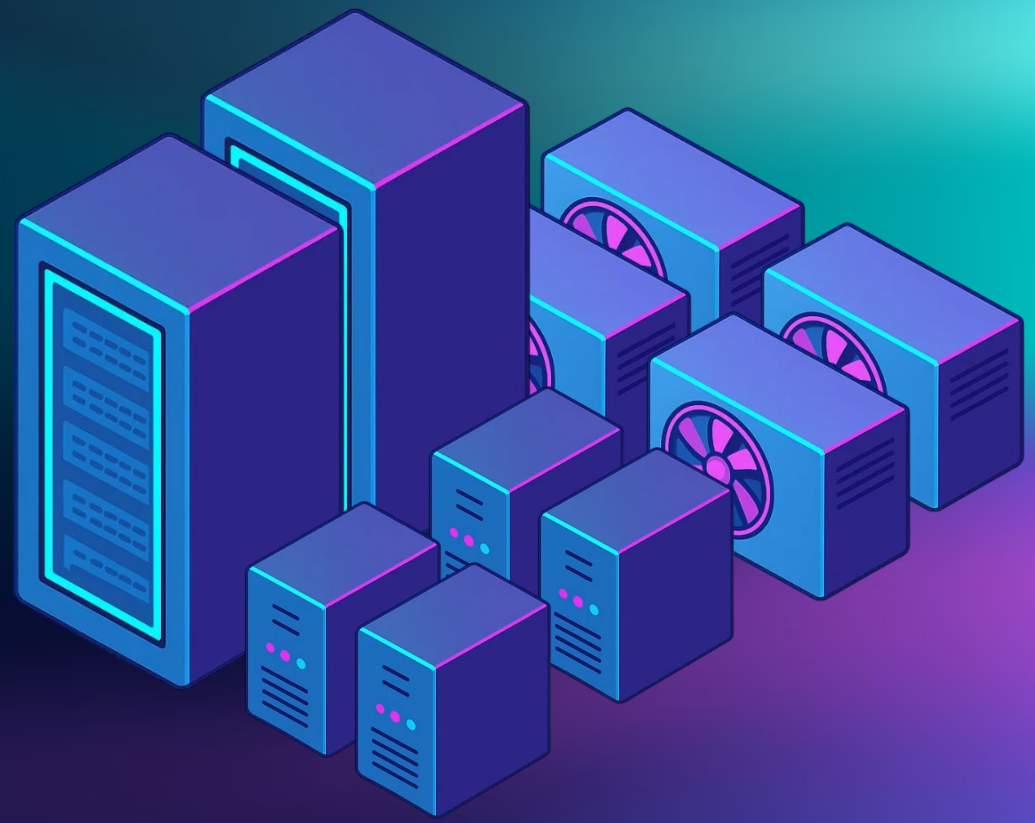
ANSI/TIA-942-C

TIER 4
Fault Tolerant

Fully independent and isolated of power, cooling and telecommunication (different ISPs) paths.

Fully Independent Redundancy : Dual Active (2N)

Max. Downtime 26 mins/year.



99.995%

Uptime

Ethernet Speed	Applications	IEEE Reference	Wavelength (nm)	Interface	Transceiver Module	Max. Distance (meter)		
						OM3	OM4	OM5
10G	10GBase-SR	802.3ae-2002	850	SC / LC	SFP+/XENPAK/X2/XPAK/XFP	300	550	550
25G	25GBase-SR	802.3by-2016	850	LC	SFP28	70	100	100
40G	40GBase-SR4	802.3ba-2010	850	MPO-12	CFP/QSFP+	100	150	150
40G	40GBase-eSR4	non IEEE	850	MPO-12	QSFP+	300	400	400
40G	40GBase-SR2-BiDi	non IEEE	850/900	LC	QSFP+			200
40G	40GBase-SWDM4	non IEEE	850-940*	LC	QSFP+			440
50G	50GBase-SR	802.3cd-2018	850	LC	SFP56	70	100	100
100G	100GBase-SR10	802.3ba-2010	850	MPO-24	CXP/CFP/CFP2/CFP4/CPAK	100	150	150
100G	100GBase-SR4	802.3bm-2015	850	MPO-12	QSFP28/CFP2/CFP4/CPAK	70	100	100
100G	100GBase-SWDM4	non IEEE	850-940*	LC	QSFP28			150
100G	100GBase-SR2	802.3cd-2018	850	MPO-12	QSFP28	70	100	100
200G	200GBase-SR4	802.3cd-2018	850	MPO-12	QSFP56	70	100	100
200G	2x100GBase-SR4	Prop.	850	MPO-24	QSFP-DD	70	100	100
400G	400GBase-SR16	802.3bs-2017	850	MPO-32	CFP8	70	100	100
400G	400GBase-SR8	802.3cm-2020	850	MPO-16	OSFP/QSFP-DD	70	100	100
400G	400GBase-SR4.2 BiDi	802.3cm-2020	850/910	MPO-12	OSFP/QSFP-DD			150
400G	400GBase-VR4	802.3db-2022	850	MPO-12	QSFP-DD	30	50	50
400G	400GBase-SR4	802.3db-2022	850	MPO-12	QSFP-DD	60	100	100
800G	800GBase-VR8	802.3df	850	MPO-16	OSFP/QSFP-DD	30	50	50
800G	800GBase-SR8	802.3df	850	MPO-16	OSFP/QSFP-DD	60	100	100

*850-940 wavelength : 850, 880, 910 and 940 nm

Ethernet Speed	Applications	IEEE Reference	Wavelength (nm)	Interface	Transceiver Module	Max. Distance (meter) OS2
10G	10GBase-LR	802.3ae-2002	1310	SC / LC	SFP+/XENPAK/X2/XPAK/XFP	10 km
10G	10GBase-ER	802.3ae-2002	1550	SC / LC	SFP+/XENPAK/X2/XFP	40 km
25G	25GBase-LR	802.3cc-2017	1310	LC	SFP28	10 km
25G	25GBase-ER	802.3cc-2017	1550	LC	SFP28	40 km
40G	40GBase-LR4	802.3ba-2010	1271-1331*	LC	CFP/QSFP+	10 km
40G	40GBase-ER4	802.3bm-2015	1271-1331*	LC	QSFP+	40 km
40G	40GBase-PLR4	non IEEE	1310	MPO-12	QSFP+	10 km
40G	40GBase-FR	802.3bg-2011	1550	LC	CFP	2 km
50G	50GBase-LR	802.3cd-2018	1304.5-1317.5	LC	SFP56	10 km
50G	50GBase-FR	802.3cd-2018	1304.5-1317.5	LC	SFP56	2 km
50G	50GBase-ER	802.3cn-2019	1304.5-1317.5	LC	SFP56	40 km
100G	100GBase-LR4	802.3ba-2010	1296-1309*	LC	QSFP28/CFP/CFP2/CFP4/CPAK	10 km
100G	100GBase-ER4	802.3ba-2010	1296-1309*	LC	QSFP28/CFP/CFP2	40 km
100G	100GBase-DR	802.3cd-2018	1311	LC	QSFP28	500 m
100G	100GBase-FR1	802.3cu-2021	1311	LC	QSFP28	2 km
100G	100GBase-LR1	802.3cu-2021	1311	LC	QSFP28	10 km
100G	100GBase-ZR	802.3ct-2021	1546.119	LC	CFP	80 km
200G	200GBase-DR4	802.3bs-2017	1310	MPO-12	QSFP56	500 m
200G	200GBase-FR4	802.3bs-2017	1271-1331*	LC	QSFP56	2 km
200G	200GBase-LR4	802.3bs-2017	1296-1309*	LC	QSFP56	10 km
200G	200GBase-ER4	802.3cn-2019	1296-1309*	LC	QSFP56	40 km
400G	400GBase-DR4	802.3bs-2017	1310	MPO-12	CFP8/OSFP/QSFP-DD	500 m
400G	400GBase-XDR4	Prop.	1310	MPO-12	CFP8/OSFP/QSFP-DD	500 m
400G	400GBase-FR8	802.3bs-2017	1273-1309*	LC	OSFP/QSFP-DD	2 km
400G	400GBase-LR8	802.3bs-2017	1273-1309*	LC	OSFP/QSFP-DD	10 km
400G	400GBase-FR4	802.3cu-2021	1271-1331*	LC	OSFP/QSFP-DD	2 km
400G	400GBase-LR4	802.3cu-2021	1271-1331*	LC	OSFP/QSFP-DD	10 km
800G	800GBase-DR8	802.3df	1310	MPO-16	OSFP/QSFP-DD	500 m
800G	800GBase-DR8-2	802.3df	1310	MPO-16	OSFP/QSFP-DD	2 km