US Equities/Options Connectivity Manual

Version 10.4.0

December 19, 2023

Contents

1 Introduction

1.1 Overview

Cboe's primary trading platforms, BZX Equities Exchange, BYX Equities Exchange, EDGA Equities Exchange, EDGX Equities Exchange, BZX Options Exchange, EDGX Options Exchange, C2 Options Exchange ("C2"), and the Cboe Options Exchange ("C1") are housed in the NY5 Equinix data center in Secaucus, New Jersey. The secondary data center is hosted by Cyxtera ("ORD1") in 350 Cermak, Chicago, IL, for all platforms. Customers are strongly encouraged to establish connectivity to both data centers to minimize service disruption in the event of an issue at either data center. Secaucus is the "primary" or "hot" site, with Chicago being "secondary" or "warm". Customers may receive market data from Chicago, and they may connect and heartbeat with order entry systems in Chicago. Orders submitted to Chicago will be rejected until Cboe declares the primary site in Secaucus "down."

Cboe also provides a primary network Point of Presence ("PoP") in the Equinix NY4 data center in Secaucus, NJ. Customers can leverage their NY4/NY5 PoP connectivity to access multicast market data feeds and order entry sessions in the Cboe's primary data center. Customers may access the secondary network via Cyxtera ORD1 or Equinix CH1, both in 350 Cermak, Chicago, IL.

1.2 NY6 PoP

Effective 04/01/24, Cboe will provide a Latency Equalized, primary PoP in the Equinix NY6 data center in Secaucus, NJ. Customers will be able to place NY6 cross connect orders via the Member Portal on **03/01/24**. Access to Certification environments will only be available until **04/01/24**, when all production and certification environments will be available for BZX, BYX, EDGA, EDGX, BZX Options, EDGX Options, and C2 Options. C1 Options and CFE will not be available from the NY6 PoP at this time.

It is the customer's responsibility for selecting their telecommunications provider and arranging for connections to Cboe's data centers and PoPs.

Cboe supports the following network connectivity choices for access to both Equities and Options:

- **IPSec VPN** via the Internet (only for certification or test sessions);
- **Co-location Cross-connect** (i.e., for customers co-located in the same data center as the Cboe trading platforms or a PoP);
- **Extranet** connectivity (See the Cboe Approved Extranet Provider section for a list of approved Extranet Providers); and
- **Private line Ethernet** (circuit extension from a carrier to Cboe, see the Carriers section for a list of Carriers)

1.3 Connectivity Matrix

	NY4/NY5/NY6 Latency Equalized	ORD1	CH1
Data Center Role	**Primary**	**Secondary**	
Data Center Provider	Equinix	Cyxtera	Equinix
Site Location	Secaucus, NJ	Chicago, IL	Chicago, IL
Site Status	Hot/Primary	Warm/Secondary	PoP for Secondary
Accepts Co-location Cross connects?	Yes	Yes	Yes
Accepts Circuit Extension from Telco?	Yes	Telco must be co-located within Telx	Yes
Access to Production Sessions/feeds?	Yes	No	No
Access to Disaster Recovery Sessions/feeds?	No	Yes	Yes
Access to Certification Sessions/Feeds?	Yes	No	No
Colocation of Network Equipment?	No	No	Yes
1G Monthly Recurring Connectivity Fees	See Cboe U.S. Equities Fee Schedules Or Cboe U.S. Options Fee Schedules for details		
10G Monthly Recurring Connectivity Fees			
Supported Media Types	SMF	SMF, MMF, Copper	SMF, MMF, Copper
Round Trip Time to Production FIX gateways	~11µs	N/A	N/A
Connectivity Contact	Greg Nelson (312) 994-3906	Bob Luparello (914) 309-2646	Greg Nelson (312) 994-3906

1.4 Physical Interfaces

The following standard physical interface specifications are supported in the ORD1 and CH1 data centers and PoPs. For other interface specifications contact noc@cboe.com.

10G	SR (multi-mode) , LR (single-mode) & ER (single-mode)
1G	SX (multi-mode), LX (single-mode) & 1000BaseT

The following standard physical interface specifications are supported in the NY4, NY5, and NY6 data center:

10G	ER* (single-mode)
10G	LR (single-mode)
1G	LX (single-mode)

*Contact Cboe NOC for details on ER Optical Transceivers

2 Types of Connectivity

2.1 IPSec VPN

- Customers may connect via an IPSec Virtual Private Network (VPN) over the Internet for access to order entry and unicast market data feeds for certification and test purposes only. LAN-to-LAN IPSec VPN supported.
- IP address of the host presented to Cboe must be registered.
- Customers must contact Cboe NOC for encryption details and to receive their pre-shared key.

Note: Cboe does not offer multicast market data feeds over VPN.

2.2 Co-location Cross-connect

Equities and Options customers may co-locate within the NY5 data center or a data center where a Cboe PoP is located and cross-connect to Cboe.

- Each physical port connection (1Gpbs and 10Gbps) within the Secaucus, and Chicago data centers/PoPs will be subject to a monthly recurring charge. See the Cboe Fee Schedule for more information.
- Co-location cross connect requests must come from a demarcation point on the data center floor or Mezzanine level. Roof-top access requests will not be accepted.
- Cboe reserves the right to charge for one-time setup and monthly recurring fees incurred connecting customers or extranets. See the Cboe Fee Schedule for more information.

With data center co-location, customers can place equipment, terminate communications circuits, and establish a cross-connect to Cboe (or other destinations) in their space. This gives the maximum amount of control to the Member. This option is neutral for the customer and provides the greatest

flexibility for the customer in determining when and to whom to connect. Customers interested in co-location services should contact the data center/PoP Point of Contact (refer to the Connectivity Matrix section for POC information).

2.3 Extranet

Customers may provision connectivity to Cboe via an extranet.

- Extranets have provisioned redundant connections to Cboe for use by multiple customers.
- Contact information for a variety of extranet providers is found below within the Cboe Approved Extranet Providers section below.

This method is an attractive alternative when:

- The customer would otherwise have to provision a long-haul private line;
- Outsourcing of network services and network management is an option; or
- The ease and speed of turn-up are important (when both the customer and Cboe have an existing connection to the extranet).

2.4 Directly Connected via Private Line Ethernet

Customers may connect to Cboe via Private Line Ethernet.

- No co-location space is required. Cross-connect from Telco demarcation point to Cboe network via an Ethernet interface.
- Each physical port connections (1Gpbs and 10Gbps) within the Secaucus and Chicago data centers/PoPs will be subject to a monthly recurring charge. See the Cboe Options Fee Schedule for more information.
- Cboe reserves the right to charge for one-time setup and monthly recurring fees incurred connecting customers or extranets. See the Cboe Options Fee Schedule for more information.
- Contact your carrier of choice to arrange connectivity to Cboe, see the Carriers section below.

2.5 Cboe Global Cloud

- The Cboe Global Cloud service provides three (3) distinct, secure connectivity and access options for customers:
    1. **PrivateLink** – This option is a suitable access method if customer systems and/or processes are running within AWS Cloud (i.e., a current AWS customer).
    2. **Internet Gateway ("IGW")** – This option is a suitable access method for customer systems and/or processes running on-premises in a local data center, or in another infrastructure provider's environment.
    3. **Virtual Private Network ("VPN")** – This option is a suitable access method for customer systems and/or processes running on-premises in a local data center, or in another infrastructure provider's environment, where an encrypted virtual private connection is preferred over internet delivery.

- Cboe Global Cloud enables Cboe Data availability and dissemination in locations around the world. Cboe Data is currently leveraging the Amazon Web services ("AWS") global network in the following three (3) regions:
    1. Virginia ("US-East-1")
    2. London ("EU-West-2")
    3. Hong Kong ("AP-East-1")
- Additional regions will be included in the service through a phased rollout based on client demand. See Cboe Global Cloud Specification and Cboe Global Cloud: Frequently Asked Questions for more information.

3 Ordering a Cross Connect to Cboe

3.1 Submit Request via Cboe Portal

A Cboe Customer Web Portal account is required to request a new cross connect or decommission existing connectivity to Cboe. Please see your firm's account administrator or contact the Cboe Trade Desk for an account:

- Cboe Trade Desk – +1 (913) 815-7001
- Email – tradedesk@cboe.com

3.2 Required Information

- Location (NY5, NY4,… to include cage number if known)
- Number and speed of connections requested (1G or 10G)
- Registered BGP ASN (Cboe NOC can assign a private ASN)
- Networks advertised to Cboe (registered public IP's or Cboe assigned private addresses are accepted
- Network and billing contact information
- Transit IP address (Public or private range assigned by Cboe NOC)

3.3 LOA-CFA

Upon approval of cross connect request, Cboe NOC will provide a Letter of Authorization - Customer Facility Assignment with the "Z-side" cage, cabinet, panel, and port pair assignment. The customer requesting the cross connect is known as the "A-Side."

3.4 Data Center Provider Request

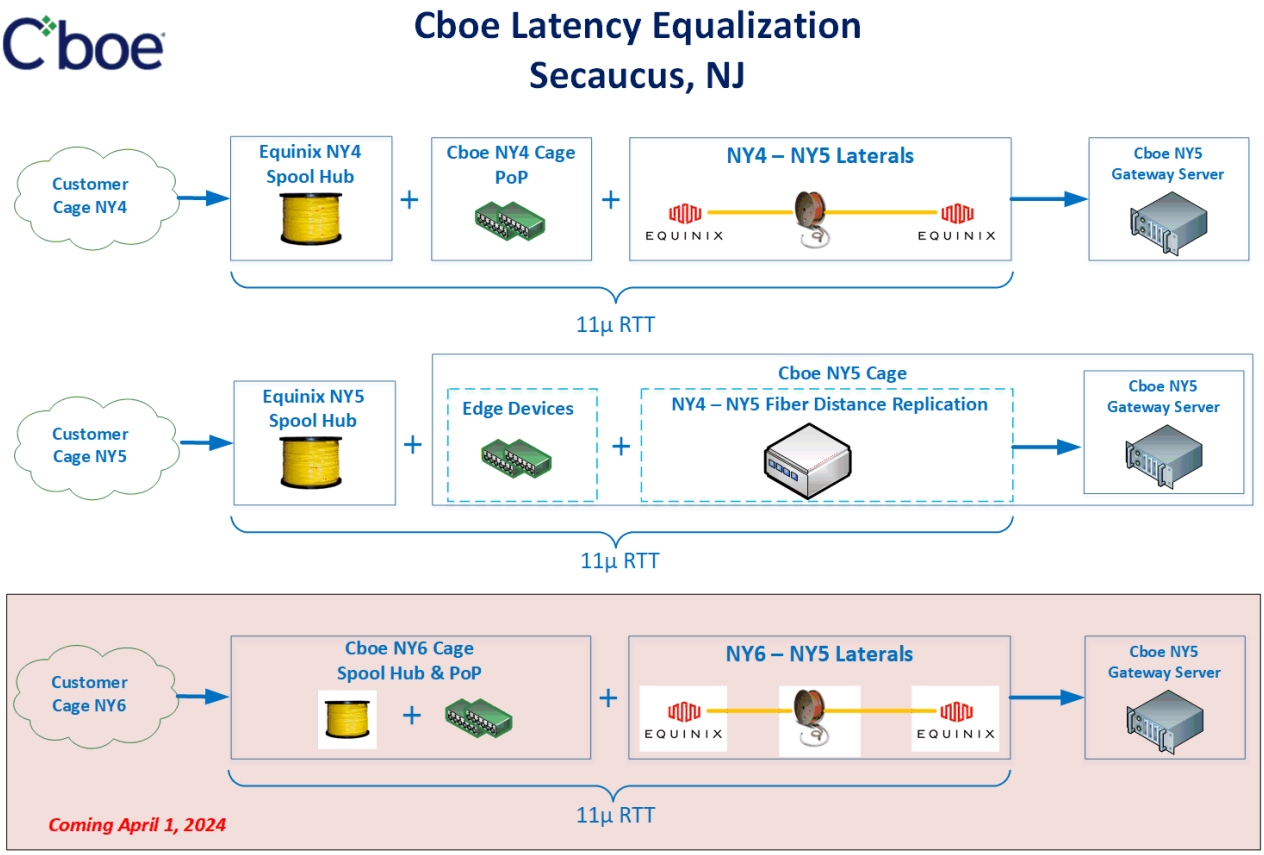
The requesting customer submits a cross connect request with the appropriate data center provider:

- Equinix – NY5, NY4, NY6 and CH1
- Cyxtera – ORD1

The data center provider will need the LOA-CFA and the "A-side" details to complete the connection. The "A-Side" customer is responsible for any data center setup fees and monthly recurring costs associated with the cross connect. As the "A-Side" customer, the customer is also responsible for initiating troubleshooting requests with the data center provider in the event of a down cross connect.

3.5 Latency Equalization

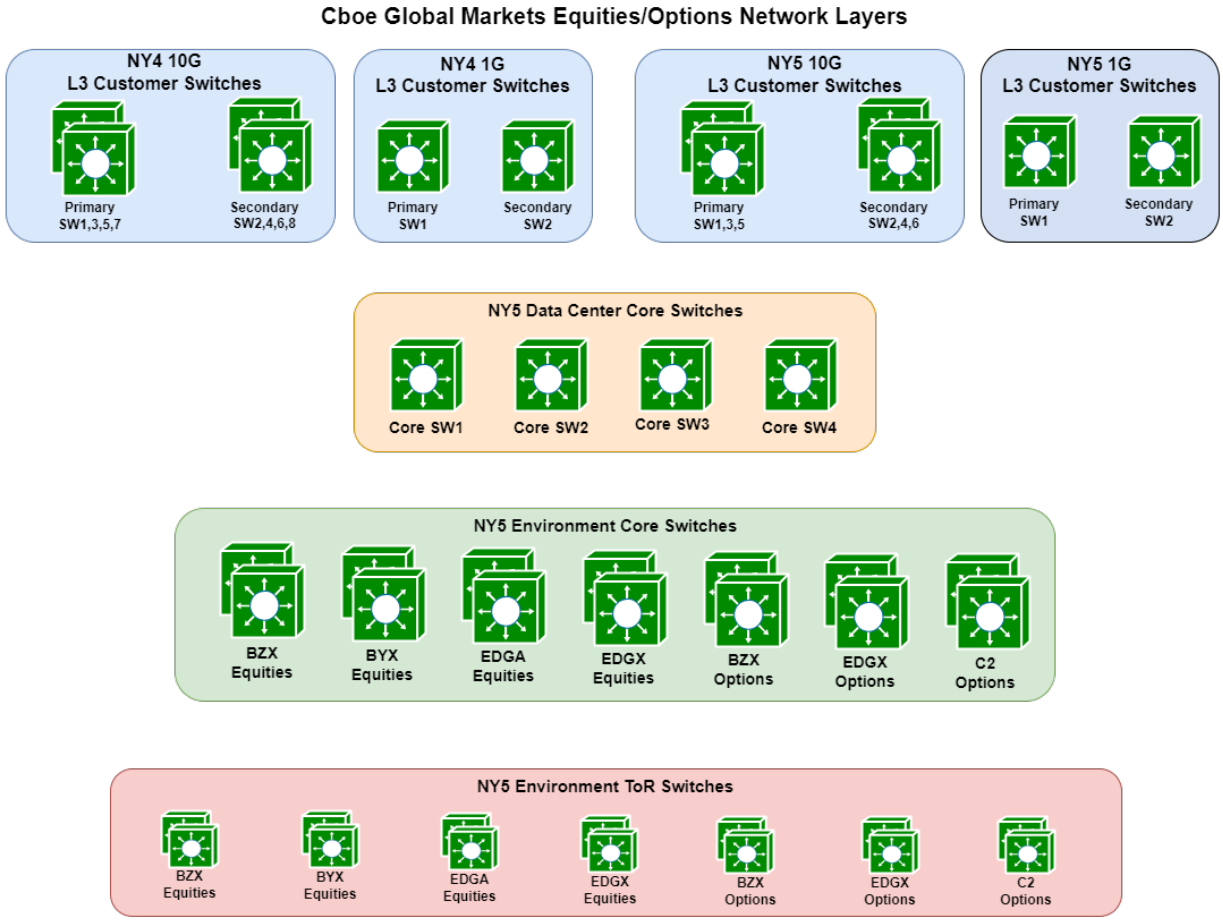
Cross connects originating within either NY4, NY5, or NY6 data centers will be engineered to provide equivalent latency between member demarcation points and the Cboe's order entry gateways in NY5. Equal fiber pathway latency will be determined by OBR testing. WAN circuits originating outside Secaucus, NJ will also be subject to latency equalization. For more details, see Cboe Latency Equalization.



Cboe Latency Equalization
Secaucus, NJ

- Cboe/Equinix Latency Equalization Infrastructure, provides an equal optical length of fiber to customers connecting in the NY4, NY5, or NY6 Secaucus, NJ data centers.
- Fiber cross connects to customer cages are run from Equinix Latency Equalized Hubs using equal lengths of single-mode fiber to each customer cage. The additional slack fiber is stored on the Cboe side of the cross connect. Regardless of the customer's distance from the Equinix Latency Equalized Hub, the fiber spool length is identical. The NY6 Equinix Latency Equalized Hub is housed within the Cboe NY6 cage.
- NY6 – NY5 cross connects use fiber trunks that are engineered to be the same optical distance as NY4 – NY5, even though NY6 is physically closer to NY5.
- Latency Equalized Hubs within NY4/NY5/NY6 are connected via fiber trunks to the gateway servers in the NY5 data center. Since the NY5 Latency Equalized Hub is much closer to the gateway servers, these fiber trunks connect through additional lengths of fiber to replicate the distance between NY4 to NY5. It is imperative that customers order cross connects only in their local data centers. For example, the Letter of Authorization (LOA) for a customer cage located in NY4 will specify a NY4 demarcation. In this scenario, attempting to order a NY4-to-NY5 cross connect would greatly increase your fiber distance and overall latency to the matching engine in NY5 – duplicating the latency equalized engineered distance.
- Customers with cages outside of NY4/NY5/NY6 Secaucus campus or WAN connections should order cross connects to the NY4 Latency Equalized Hub for the lowest latency.
- Every customer fiber path and trunk is tested end-to-end using a proprietary Optical Backscatter Reflectometer (OBR).
- Total roundtrip latency represented is measured from the customer fiber handoff to the Environment ToR switch egress point, prior to the Gateway server NIC.
- Finally, the fiber patch between assigned demarcation point and the Cboe outside network device is adjusted to a custom length, ensuring the total fiber optical length is within acceptable tolerances.

4 Layer 3 Network Overview – Equities/Options



4.1 L3 Customer Access Layer

Equities/Options employs both 1G and 10G dedicated switches that serve as the network access point for customer connections. The number of switches at this layer is largely based on customer demand. Uplinks use the vendor default hashing algorithm.

DC Location	Quantity	Customer Bandwidth	Uplink to DC Core	Make	Model	Switching Mode
NY4	2	1G	8x10G (Core 3&4) 2x40G (Core 1&2)	Cisco	Nexus 56128P	Cut-Through*
NY5	2	1G	8x10G (Core 3&4) 2x40G (Core 1&2)	Cisco	Nexus 56128P	Cut-Through*
NY6**	2	1G	8x10G (Core 3&4) 2x40G (Core 1&2)	Cisco	Nexus 56128P	Cut-Through*
NY4	8	10G	4x100G (Core 1&2) 4x100G (Core 3&4)	Arista	DCS-7050SX3-96YC8	Cut-Through*
NY5	6	10G	4x100G (Core 1&2) 4x100G (Core 3&4)	Arista	DCS-7050SX3-96YC8	Cut-Through*
NY6**	2	10G	4x100G (Core 1&2) 4x100G (Core 3&4)	Arista	DCS-7050SX3-96YC8	Cut-Through*

*Switching mode is effectively store-and-forward one way due to speed change 1G to 10G and from 10G to 100G.
** **Effective 04/01/24**

4.2 L3 Data Center Core Layer

These are chassis-based switches designed to mesh the customer access layer with the Environment core layer. The Data Core layer services seven environments – BZX Equities, BYX Equities, EDGA Equities, EDGX Equities, BZX Options, EDGX Options, and C2 Options. Uplinks use the vendor default hashing algorithm.

DC Location	Quantity	Uplink to Env. Core Switches	Make	Model	Switching Mode
NY5	4*	4x10G Port-Channel	Arista	DCS-7304	Cut-Through

*Each environment is spread across two Data Center Core switches
Cores 1 & 2 - BYX Equities, EDGA Equities, EDGX Equities, and C2 Options
Cores 3 & 4 - BZX Equities, BZX Options, and EDGX Options

4.3 L3 Environment Core Layer

This layer uses dedicated switches for connecting the BZX Equities, BYX Equities, EDGA Equities, EDGX Equities, BZX Options, EDGX Options, and C2 Options environments Top of Rack (ToR) switches with the DC Core layer. Uplinks use the vendor default hashing algorithm.

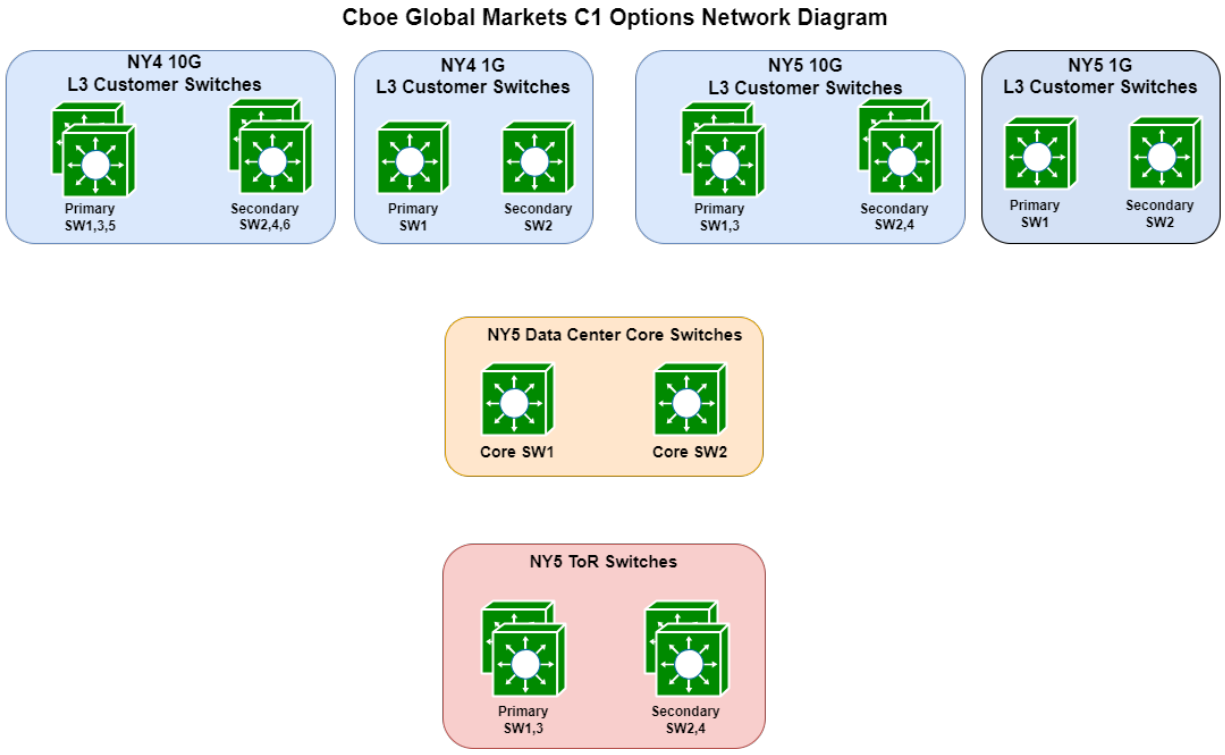
DC Location	Environment	Quantity	Make	Model	Switching Mode
NY5	BZX Equities	2	Arista	DCS-7260CX3-64E-R	Cut-Through
NY5	BYX Equities	2	Arista	DCS-7260CX3-64E-R	Cut-Through
NY5	EDGA Equities	2	Arista	DCS-7260CX3-64E-R	Cut-Through
NY5	EDGX Equities	2	Arista	DCS-7260CX3-64E-R	Cut-Through
NY5	BZX Options	2	Arista	DCS-7260CX3-64E-R	Cut-Through
NY5	EDGX Options	2	Arista	DCS-7260CX3-64E-R	Cut-Through
NY5	C2 Options	2	Arista	DCS-7260CX3-64E-R	Cut-Through

4.4 L3 Top of Rack (ToR) Layer

These switches function to connect order handler servers to the Environment Core switches. Each server NIC is connected to two ToR switches in an active/passive redundancy model.

DC Location	Environment	Quantity	Make	Model	Switching Mode
NY5	BZX Equities	2	Arista	DCS-7050SX3-48YC8	Cut-Through
NY5	BYX Equities	2	Arista	DCS-7050SX3-48YC8	Cut-Through
NY5	EDGA Equities	2	Arista	DCS-7050SX3-48YC8	Cut-Through
NY5	EDGX Equities	2	Arista	DCS-7050SX3-48YC8	Cut-Through
NY5	BZX Options	2	Arista	DCS-7050SX3-48YC8	Cut-Through
NY5	EDGX Options	2	Arista	DCS-7050SX3-48YC8	Cut-Through
NY5	C2 Options	2	Arista	DCS-7050SX3-48YC8	Cut-Through

5 L3 Network Overview – C1 Options



5.1 L3 Customer Access Layer

C1 Options employs both 1G and 10G dedicated switches that serve as the network access point for customer connections. The number of switches is largely based on customer demand. Uplinks use the vendor default hashing algorithm.

DC Location	Quantity	Bandwidth	Uplink Bandwidth	Make	Model	Switching Mode
NY4	2	1G	2x100G	Arista	DCS-7280SR2-48YC6	Cut-Through*
NY5	2	1G	2x100G	Arista	DCS-7280SR2-48YC6	Cut-Through*
NY4	6	10G	4x100G	Arista	DCS-7050SX3-48YC12	Cut-Through*
NY5	4	10G	4x100G	Arista	DCS-7050SX3-48YC12	Cut-Through*

*Switching mode is effectively store-and-forward one way due to speed change 1G to 100G or 10G to 100G.

5.2 L3 Data Center Core Layer

These are chassis-based switches designed to mesh the customer access layer with the Top of Rack layer. Uplinks between layers are all 2x100G port-channel using the vendor default hashing algorithm.

DC Location	Quantity	Uplink Bandwidth	Make	Model	Switching Mode
NY5	2	2x100 port-channel	Arista	DCS-7304	Cut-Through

5.3 L3 Top of Rack (ToR) Layer

These switches function to connect order handler servers to the Data Center Core switches. Each server NIC is connected to two ToR switches in an active/passive redundancy model.

DC Location	Quantity	Uplink Bandwidth	Make	Model	Switching Mode
NY5	4	2x100G port-channel	Arista	DCS-7050CX3-32	Cut-Through

6 Bandwidth

6.1 Market Data Feeds

Cboe offers four different types of market data feeds:

- Multicast PITCH
- TCP PITCH
- TOP
- Last Sale

Cboe requires that customers allocate a ***minimum*** of 10Gb/s per Multicast PITCH 8G or 5G-shaped feed, 1 Gb/s per Gig-Shaped feed and 100 Mb/s per Multicast PITCH WAN-Shaped feed. With respect to TCP PITCH and TOP feeds (not available in options), Cboe understands that firms will have varying levels of sensitivity with respect to latency and as such encourages customers to use the statistics provided below to make a well-informed decision regarding the bandwidth they will require based on their organization's latency sensitivity.

The table below shows the bandwidth statistics for historical highs for Cboe market data feeds. The table shows the bandwidth and Messages Per Second (MPS) peaks for 1, 5, 10, 30, and 60-second intervals. Peaks for 1 and 10 millisecond interval peaks are also included. The TCP statistics include 11 bytes for TCP/IP overhead per packet and do not include the data link layer overhead.

Cboe Market	Interval Seconds	Multicast PITCH		TOP		TCP PITCH	
		MPS	Mb/s	MPS	Mb/s	MPS	Mb/s
BZX Equities Exchange	.001	17,986,000	5,346	2,751,000	669	1,953,000	907
	.010	16,252,300	4,832	1,205,100	318	1,812,300	842
	1	637,269	192	215,627	58	365,278	163
	5	279,463	97	116,664	30	310,585	139
	10	217,556	75	100,800	26	240,165	181
	30	163,754	56	78,557	20	207,030	96
	60	140,200	48	66,133	17	180,113	84
BYX Equities Exchange	.001	18,225,000	5,395	3,900,000	939	1,629,000	750
	.010	11,200,000	3,315	1,256,500	319	1,380,000	540
	1	216,316	69	118,737	31	257,021	119
	5	122,092	41	59,984	16	151,437	69
	10	97,770	33	52,312	14	125,665	57
	30	75,116	25	44,086	11	97,798	45
	60	57,299	19	34,143	9	74,634	34
BZX Options Exchange	.001	28,598,000	8,479	9,645,000	3,337	N/A	N/A
	.010	22,550,800	2,525	8,496,600	2,945	N/A	N/A
	1	10,736,287	3,251	3,514,472	1,274	N/A	N/A
	5	5,551,007	1,827	2,364,405	894	N/A	N/A
	10	4,365,829	1,471	2,023,605	771	N/A	N/A
	30	3,326,019	1,128	1,431,087	492	N/A	N/A
	60	2,718,857	923	1,200,768	413	N/A	N/A
EDGA Equities Exchange	.001	20,416,000	6,043	4,243,000	1,021	1,878,000	1,197
	.010	12,108,700	3,584	1,416,400	419	1,272,500	946
	1	209,444	65	118,348	31	194,984	77
	5	92,745	30	57,352	14	95,557	43
	10	69,549	23	50,475	13	82,011	37
	30	55,258	19	39,572	10	67,367	31
	60	41,676	14	30,638	8	51,206	24
EDGX Equities Exchange	.001	19,272,000	5,704	3,836,000	923	1,800,000	1,415
	.010	17,952,200	5,313	1,283,100	310	1,524,900	1,265
	1	1,180,367	409	151,055	40	382,443	287
	5	236,251	83	94,278	24	209,694	142
	10	150,882	52	83,870	21	161,953	122
	30	113,675	39	66,385	17	121,470	91
	60	93,430	32	54,692	14	99,759	75
EDGX Options Exchange	.001	26,326,000	7,846	15,419,000	5,335	N/A	N/A
	.010	20,742,600	6,185	13,676,400	4,740	N/A	N/A
	1	11,719,226	3,516	4,684,712	1,612	N/A	N/A
	5	5,830,475	1,923	3,019,455	1,058	N/A	N/A
	10	4,609,282	1,561	2,559,651	880	N/A	N/A
	30	3,897,179	1,325	2,302,648	792	N/A	N/A
	60	3,385,583	1,150	2,208,234	760	N/A	N/A
C2 Options Exchange	.001	29,258,000	8,669	14,684,000	5,060	N/A	N/A
	.010	22,463,400	6,669	13,284,100	4,574	N/A	N/A
	1	11,472,020	3,452	4,428,728	1,518	N/A	N/A
	5	4,284,481	1,455	2,431,352	872	N/A	N/A
	10	3,353,716	1,159	1,801,510	620	N/A	N/A
	30	2,669,905	925	1,418,004	488	N/A	N/A
	60	2,406,924	832	1,330,752	458	N/A	N/A
C1 Options Exchange	.001	25,423,000	7,559	13,553,000	4,671	N/A	N/A
	.010	20,111,100	5,974	12,323,700	4,250	N/A	N/A
	1	12,327,181	3,721	4,801,842	2,036	N/A	N/A
	5	6,242,986	2,124	3,116,895	1,274	N/A	N/A
	10	5,068,497	1,706	2,560,687	980	N/A	N/A
	30	4,453,568	1,515	1,993,616	687	N/A	N/A
	60	3,983,947	1,357	1,790,399	617	N/A	N/A

*Statistics as of 12/01/2023. Equities Top feed is TCP. Options TOP feed is multicast.

It should be noted that Cboe data will have microbursts within the one-second interval above, and that these microbursts will exceed the peak rates at the one-second interval. This is demonstrated within the 1 and 10 millisecond interval statistics. The extent to which the network connection to the customer will cope with the microbursts exceeding the available bandwidth without packet loss will depend heavily on the buffers in the end-to-end path.

During spikes in quote updates, customers using less than sufficient bandwidth will experience queuing of their market data. Customers using the same bandwidth to both receive quotes and transmit orders may expect their orders to be slightly delayed if they have less than sufficient bandwidth. Many customers will find these delays unacceptable and should provision their bandwidth to reduce these delays. The following table demonstrates statistics regarding latency incurred as a result of queuing on Gig-Shaped and WAN-Shaped Multicast PITCH feeds.

Cboe Market	Measurement	8G-Shaped Multicast PITCH Serialization Delay (ms)	5G-Shaped Multicast PITCH Serialization Delay (ms)	Gig-Shaped Multicast PITCH Serialization Delay (ms)	WAN-Shaped Multicast PITCH Serialization Delay (ms)
BZX Equities Exchange	**Average**	N/A	N/A	0.0326	1.7550
	Standard Deviation	N/A	N/A	1.4907	27.9921
	Historical High	N/A	N/A	8.2	552
BYX Equities Exchange	**Average**	N/A	N/A	0.0035	0.1895
	Standard Deviation	N/A	N/A	0.2012	4.6123
	Historical High	N/A	N/A	.004	98.3
BZX Options Exchange	**Average**	N/A	0.0004544	187.5566	N/A
	Standard Deviation	N/A	0.2453	182.2266	N/A
	Historical High	N/A	.0084	187.5566	N/A
EDGA Equities Exchange	**Average**	N/A	N/A	0.0080	0.2448
	Standard Deviation	N/A	N/A	0.2843	6.0254
	Historical High	N/A	N/A	.014	1.035
EDGX Equities Exchange	**Average**	N/A	N/A	0.6951	13.1920
	Standard Deviation	N/A	N/A	10.5551	177.4487
	Historical High	N/A	N/A	0.6951	13.1920
EDGX Options Exchange	**Average**	N/A	0.0016	22.5370	N/A
	Standard Deviation	N/A	0.1221	189.9693	N/A
	Historical High	N/A	0.0016	24.004	N/A
Cboe C2 Options Exchange	**Average**	N/A	0.0151	17.6792	N/A
	Standard Deviation	N/A	0.5656	125.8771	N/A
	Historical High	NA/	0.0151	17.6792	N/A
Cboe C1 Options Exchange	**Average**	0.000380	0.0017	N/A	N/A
	Standard Deviation	.6405	2.5091	N/A	N/A
	Historical High	0.000388	0.0017	N/A	N/A

* Statistics as of 12/01/2023.

As the volume on an exchange increases, the market data feed bandwidth required to accommodate peaks will also grow. Customers can obtain the latest published market data bandwidth and serialization statistics within this Connectivity Manual. Additionally, monthly statistical updates are presented through the FIF Market Data Capacity working group.

6.1.1 Multicast PITCH

Key features include:

- Low latency, up to 50% latency reduction vs. TCP PITCH.
- Bandwidth versions:
  - Gig-Shaped, requires minimum gigabit cross-connect.
  - WAN-Shaped (Equities Only) shaped to 100Mb.
  - 5 Gig-Shaped (Options only) requires a dedicated 10G connection
  - 8 Gig-Shaped (C1 Options only) requires a 10G connection
- Gap Response Proxy to recover small data gaps.
- Spin Server to efficiently recover from intra-day disconnects.
- Efficient binary messaging and new modify order message.

Refer to the US Equities/Options Multicast PITCH specification on the Cboe website for complete details.

6.1.2 Multicast PITCH Feed Availability Matrix

Equities:

Cross Connect Data Center & Bandwidth	Equites Full-Depth of Book Multicast Feeds															
	1 Gig-Shaped								WAN-Shaped							
	BZX		BYX		EDGA		EDGX		BZX		BYX		EDGA		EDGX	
	A	B	A	B	A	B	A	B	C	D	C	D	C	D	C	D
Secaucus NY4/NY5 10G	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Secaucus NY4/NY5 1G	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Secaucus NY4/NY5 Options 10G Primary																
Secaucus NY4/NY5 Options 10G Secondary																

Options:

Cross Connect Data Center & Bandwidth	Options Full-Depth of Book Multicast Feeds															
	1 Gig-Shaped						5 Gig-Shaped						5 Gig-Shaped		8 Gig-Shaped	
	BZX		EDGX		C2		BZX		EDGX		Cboe C2		Cboe C1		Cboe C1	
	A	B	A	B	A	B	C	D	C	D	C	D	A	B	C	D
Secaucus NY4/NY5 10G	✓	✓	✓	✓	✓	✓										
Secaucus NY4/NY5 1G	✓	✓	✓	✓	✓	✓										
Secaucus NY4/NY5 Options 10G Primary	✓	✓	✓	✓	✓	✓	✓		✓		✓					
Secaucus NY4/NY5 Options 10G Secondary	✓	✓	✓	✓	✓	✓		✓		✓		✓				
Secaucus NY4/NY5 C1-Only 10G													✓	✓	✓	✓
Secaucus NY4/NY5 C1-Only 1G*																

**C1 1G connections can only subscribe to non-full-depth of book C1 market data products shaped 1G and smaller*

6.1.3 Disaster Recovery

Cross Connect Data Center & Bandwidth	Equities				Options			
	WAN-Shaped				1 Gig-Shaped			5 Gig-Shaped
	BZX	BYX	EDGA	EDGX	BZX	EDGX	C2	C1
Chicago 10G	✓	✓	✓	✓	✓	✓	✓	✓
Chicago 1G	✓	✓	✓	✓	✓	✓	✓	

6.1.4 TCP PITCH

Refer to the TCP PITCH specification on the website for complete details.

6.1.5 TOP

The Cboe TOP feed offers up to 66% reduction in events and 84% reduction in bandwidth compared to the Cboe PITCH market data feed. Refer to the TOP specification on the Cboe website for complete details.

6.1.6 Last Sale

The Last Sale feed is ideal for market data distributors. It is a real-time, intraday TCP feed that disseminates matched trade price, volume, and execution time from the Cboe Exchange order book. Users only need 2Mb of bandwidth to take this extremely efficient feed in real-time. Refer to the Last Sale specification on the Cboe website for complete details.

6.2 FIX Order Entry

Bandwidth recommended for submitting orders via FIX depends on expected customer order volume. If a customer intends to submit orders to Cboe and will not receive market data, then it is possible that the customer can connect with less than a T1 equivalent connection. The following table shows the maximum number of inbound orders (and/or cancels) per second that can be handled, with no buffering or delay, with different capacity connections.

Example Connection Rates

Order Protocol	256Kb	512Kb	1.5Mb
FIX	75/sec.	150/sec.	450/sec.

7 Telecommunications Providers

Some telecommunications providers available within the Secaucus and Chicago data centers/PoPs are listed below. This list is a summary and is not indicative of Cboe's preference or recommendation. For telecommunications providers not included on the list, please contact the Cboe NOC to discuss.

7.1 Extranet Providers

Cboe partners with several extranet providers to aggregate customer connectivity and provide low cost, value-added B2B services such as multicast market data feeds. Extranet providers are required to sign Telecommunications Service Provider Agreement after meeting the requirements outlined in the Extranet Provider Manual.

7.1.1 Cboe Approved Extranet Providers

Company	Contact	Phone	Multicast Feeds *	Data Center(s)
BT Radianz www.btradianz.com	Gregory Knopp Gregory.Knopp@bt.com	US: (212) 205-1849		Secaucus Chicago
CenturyLink www.centurylink.com/technology	Danielle Durkin gems@centurylink.com	US: (973) 650-1107	Z, Y, O, A, X, C	Chicago
IPC Systems, Inc. www.ipc.com	John Tarantino john.tarantino@ipc.com	US: (212) 709-1099	Z, Y, A, X	Secaucus Chicago
ICE Data Services – Connectivity www.iceglobalnetwork.com	Connectivity Sales iceglobalnetwork-info@theice.com	US: (770) 661-0010 EU: +44 207 429 4610 APAC: +613 9249 2093	Z, Y, O, A, X, C	Secaucus Chicago
Pico www.pico.net	Sales sales@pico.net	US: (646) 701-6120	Z, Y, A, X, C, O	Secaucus Chicago
TNSi www.tnsi.com	Melissa Trulock, Sr. Project Manager mtrulock@tnsi.com	US: (312) 859-2633	Z, Y, O, C	Secaucus Chicago

*** Z = BZX Equities, Y = BYX Equities, A = EDGA Equities, X = EDGX Equities, C = C1 Options, O = BZX Options, EDGX Options, or C2 Options**

7.1.2 Carriers

Telecom carriers provide a dedicated circuit between customers in different data centers to a demarcation point in the Secaucus or Chicago data centers/PoPs. The circuit is extended from the demarc to a Cboe's network device.

It is recommended that customers use redundant connectivity via multiple telecommunications providers to each of the Cboe data centers.

Contact the Cboe NOC for information about circuit ordering details (e.g. NPA-NXX, LOA/CFA requirements, demarcation information, etc.).

Company	Contact	Phone	Data Center
Anova Technologies www.anova-tech.com	Heather Cannon hcannon@anova-tech.com	(312) 540-9594 x1113	Chicago
AT&T www.business.att.com	Dale Rife wr7024@att.com	(816) 275-2335	Secaucus
Hibernia Atlantic www.hiberniaatlantic.com	Hibernia Sales sales@hibernianetworks.com	(908) 516-4200 (888) 774-8080	Chicago
Hudson Fiber www.hudsonfiber.com	Thomas Kennedy tkennedy@hudsonfiber.com	(201) 820-8206	Secaucus
Level(3) Communications www.level3.com	William Simmons william.simmons@level3.com	(913) 909-9009	Secaucus Chicago
Lightower Fiber Networks www.lightower.com	Christopher J. Schook cschook@lightower.com Jeffrey Mollica jmollica@lightower.com	(631) 974-4307 (516) 375-6808	Secaucus
NexGen Networks www.nexgen-net.com	Jeffrey Barth jeffrey.barth@nexgen-net.com	(800) 310-2501	Chicago
Optimum LightPath www.optimumlightpath.com	Colleen M. Capen ccapen@optimumlightpath.com	(201) 644-9610	Secaucus
Perseus www.perseus.co	Tony Gerace agerace@perseus.co	(347) 325-9416	Secaucus Chicago
Sidera Networks www.sidera.net	Stephen Papa stephen.papa@sidera.net	(212) 324-5033	Chicago
Spread Networks, LLC www.spreadnetworks.com	Spread Network Sales sales@spreadnetworks.com	(646) 837-0330	Chicago
Verizon Financial Network www.verizonbusiness.com/solutions/finance/institutional/servicesnetwork.xml	Verizon Financial Network Sales vfnsales@verizon.com	(800) 825-9196	Secaucus Chicago
XO Communications www.xo.com	Robert Bye robert.g.bye@xo.com	(630) 544-8512	Secaucus Chicago
Zayo Fiber Solutions/AboveNet www.abovenet.com	Travis Brown tbrown@above.net	(212) 803-5597	Secaucus Chicago

8 Support

Please direct questions or comments regarding this manual to noc@cboe.com. Cboe NOC is a one-call shop supporting U.S. customer and telecommunications providers during initial setup and continuing support of all connectivity issues.

8.1 Support Hours

- Phone: +1 (913) 815-7005
- Email: noc@cboe.com
- Core phone support hours are 7:00 a.m. – 11:00 p.m. ET Monday – Friday
- Outside of core support hours, to report a network issue that must be addressed prior to market open – leave a voice mail with the firm name, contact number, and the nature of the issue.
- For non-critical issues or for information, please email or NOC and your request will be responded to on the next business day.

Revision History

Document Version	Date	Description
7.0.0	04/04/14	Initial version of Manual supporting Cboe/Direct Edge integration changes.
8.0.0	02/21/15	Post-Direct Edge migration changes.
8.1.0	03/16/15	Added bandwidth statistics for EDGA/EDGX.
8.2.0	04/16/15	BZX Options move from NJ2 to NY5. Updated extranet contacts.
8.2.1	04/21/15	Update name change for Cboe Options Exchange to BZX Options Exchange.
8.3.0	05/04/15	Migration of BZX/BYX Exchanges to Secaucus, NJ.
8.3.1	05/07/15	Added to Approved Extranets table.
8.3.2	06/10/15	Updated Statistics Tables.
8.3.3	09/01/15	Updated Statistics Tables.
8.3.4	10/22/15	Updated Carrier Table.
8.3.5	12/03/15	Updated Statistics Tables.
8.4.0	12/07/15	Added section Feed Availability Matrix section 4.1.2.
8.5.0	02/19/16	Cboe branding/logo changes.
8.5.1	03/02/16	Updated Statistics Tables.
8.5.2	06/22/16	Updated Statistics Tables.
8.5.3	08/23/16	Updated Carrier Table.
8.5.4	09/01/16	Updated Statistics Tables.
8.5.5	09/23/16	Updated Carrier Table.
8.5.6	12/01/16	Updated Statistics Tables.
8.5.7	03/01/17	Updated Statistics Tables.
8.5.8	04/24/17	Updated Extranet Table.
8.5.9	06/01/17	Updated Statistics Tables.
8.5.10	08/01/17	Update Statistics Tables.
9.0.0	09/01/17	Added Cboe C2 connectivity information.
9.0.1	10/17/17	Cboe branding/logo changes.
9.0.2	01/02/18	Update Statistics Tables.
9.0.3	03/02/18	Update Statistics Tables.
9.0.4	07/02/18	Updated Statistics Tables.

Document Version	Date	Description
9.0.5	07/30/18	Updated contact information for extranet providers.
9.0.6	08/06/18	Updated Statistics Tables.
9.0.7	08/15/18	Updated Statistics Tables.
9.0.8	10/05/18	Updated contact information for data center providers.
9.1.0	11/08/18	Updated Cyxtera data center identifiers. Added Latency Equalization diagram and link.
9.1.1	12/03/18	Updated Statistics Tables.
9.1.2	01/16/19	Updated Statistics Tables.
9.1.3	04/18/19	Updated Statistics Tables.
9.1.4	07/15/19	Updated contact information for extranet providers.
9.1.5	08/09/19	Updated link to Cboe Fee Schedule.
9.1.6	08/13/19	Updated Statistics Tables.
10.0.0	10/07/19	Updated for launch of C1 Options on Bats Tech platform.
10.0.1	01/02/20	Updated Statistics Tables, added C1 statistics.
10.1.0	02/03/20	Added provision for ER Optical Transceivers in NY4/NY5.
10.1.1	03/02/20	Amended Feed Availability Matrix for 1G Shaped Feeds.
10.1.2	04/02/20	Updated Statistics Tables.
10.1.3	07/07/20	Updated Statistics Tables. Added Pico to Extranet Provider Table.
10.1.4	09/01/20	Updated C2 DR location to 350 Cermak.
10.1.5	12/09/20	Updated Statistics Tables.
10.1.6	04/05/21	Updated Statistics Tables.
10.1.7	09/27/21	Updated Statistics Tables. Removed Weehawken ERW2 as a PoP offering.
10.2.0	12/16/21	Updated hyperlink to Fee Schedule. Updated Statistics Tables. Added Cboe Global Cloud section.
10.2.1	09/14/22	Updated Statistics Tables.
10.2.2	01/31/23	Updated Statistics Tables. Fixed links to fee schedules and updated TNSi contact.
10.3.0	06/30/23	Added network diagrams and L3 details. Updated Statistics Tables.
10.3.1	08/14/23	Notice for Customer Access switch replacement.
10.3.2	11/20/23	Added DCS-7050SX3-96YC8 customer access switches.

Document Version	Date	Description
10.3.3	12/08/23	Updates statistics tables.
10.4.0	12/19/23	Announcement of NY6 PoP **(effective 04/01/24)**.