

LSEG Real-Time APIs

CONCEPTS GUIDE

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LSEG DATA &
ANALYTICS

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1 Guide Introduction

1.1 About this Manual

This document is authored by LSEG Real-Time API architects and programmers who encountered and resolved many of the issues the reader might face. Several of its authors have designed, developed, and maintained LSEG Real-Time API products and other LSEG products which leverage them.

This guide documents the functionality and capabilities of the LSEG Real-Time APIs. In addition to connecting to itself, an LSEG Real-Time API can also connect to and leverage many different LSEG and customer components. If you want an LSEG Real-Time API to interact with other components, consult that specific component's documentation to determine the best way to configure for optimal interaction.

1.2 Audience

This manual provides information and examples that aid programmers using a LSEG Real-Time API. The level of material covered assumes that the reader is a user or a member of the programming staff involved in the design, coding, and test phases for applications which will use a LSEG Real-Time API. It is assumed that the reader is familiar with the data types, classes, operational characteristics, and user requirements of real-time data delivery networks, and has experience developing products using the relevant programming language in a networked environment.

While technically the LSEG Robust Foundation API is not a LSEG Real-Time API, the content presented herein also accurately describes the structure and concepts of the LSEG Robust Foundation API. For simplicity, whenever the manual refers to the LSEG Real-Time APIs, LSEG Robust Foundation API is also included in its scope. Additionally, while UPA is technically a part of the LSEG Real-Time APIs, it has been rebranded as the Enterprise Transport API.

1.3 Programming Languages

This guide discusses concepts and architecture specific to the LSEG Real-Time API suite. Any code examples in this document are either language-neutral or labeled according to the language used in the example. Example applications provided with a specific API product are written in the relevant product's language (i.e., C++, C#, Java, etc.).

1.4 Acronyms and Abbreviations

ACRONYM / TERM	MEANING
ADH	LSEG Real-Time Advanced Distribution Hub is the horizontally scalable service component within the LSEG Real-Time Distribution System providing high availability for publication and contribution messaging, subscription management with optional persistence, conflation and delay capabilities.
ADS	LSEG Real-Time Advanced Distribution Server is the horizontally scalable distribution component within the LSEG Real-Time Distribution System providing highly available services for tailored streaming and snapshot data, publication and contribution messaging with optional persistence, conflation and delay capabilities.
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
DMM	Domain Message Model

Table 1: Acronyms and Abbreviations

ACRONYM / TERM	MEANING
Enterprise Message API	The Enterprise Message API (EMA) is an ease of use, open source, Open Message Model API. EMA is designed to provide clients rapid development of applications, minimizing lines of code and providing a broad range of flexibility. It provides flexible configuration with default values to simplify use and deployment. EMA is written on top of the Enterprise Transport API (ETA) utilizing the Value Added Reactor and Watchlist features of ETA.
Enterprise Transport API (ETA)	Enterprise Transport API is a high performance, low latency, foundation of the LSEG Real-Time SDK. It consists of transport, buffer management, compression, fragmentation and packing over each transport and encoders and decoders that implement the Open Message Model. Applications written to this layer achieve the highest throughput, lowest latency, low memory utilization, and low CPU utilization using a binary Wire Format when publishing or consuming content to/from LSEG Real-Time Distribution Systems.
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol (Secure)
JWK	JSON Web Key. Defined by RFC 7517, a JWK is a JSON formatted public or private key.
JWKS	JSON Web Key Set, This is a set of JWK, placed in a JSON array.
JWT	JSON Web Token. Defined by RFC 7519, JWT allows users to create a signed claim token that can be used to validate a user.
OMM	Open Message Model
QoS	Quality of Service
RDM	Domain Model
DP	Delivery Platform: this platform is used for REST interactions. In the context of Real-Time APIs, an API gets authentication tokens and/or queries Service Discovery to get a list of Real-Time - Optimized endpoints using DP.
LSEG Real-Time Distribution System	LSEG Real-Time Distribution System is LSEG's financial market data distribution platform. It consists of the LSEG Real-Time Advanced Distribution Server and LSEG Real-Time Advanced Distribution Hub. Applications written to the LSEG Real-Time SDK can connect to this distribution system.
Reactor	The Reactor is a low-level, open-source, easy-to-use layer above the Enterprise Transport API. It offers heartbeat management, connection and item recovery, and many other features to help simplify application code for users.
RFA	Robust Foundation API
RMTEs	A multi-lingual text encoding standard
RSSL	Source Sink Library
RTT	Round Trip Time, this definition is used for round trip latency monitoring feature.
RWF	Wire Format, an LSEG proprietary binary format for data representation.
SOA	Service Oriented Architecture
SSL	Sink Source Library
LDF-D	Data Feed Direct
UML	Unified Modeling Language
UTF-8	8-bit Unicode Transformation Format

Table 1: Acronyms and Abbreviations

1.5 References

- LSEG Real-Time API-Specific *LSEG Domain Model Usage Guides*
- LSEG Real-Time API-Specific *ANSI Library Reference Manuals*
- LSEG Real-Time API-Specific *DACS LOCK Library Reference Manuals*
- LSEG Real-Time API-Specific *Value Added Components Developers Guide*
- LSEG Real-Time API-Specific *Developers Guide*
- The [LSEG Developer Community](#)

1.6 Documentation Feedback

While we make every effort to ensure the documentation is accurate and up-to-date, if you notice any errors, or would like to see more details on a particular topic, you have the following options:

- Send us your comments via email at ProductDocumentation@lseg.com.
- Add your comments to the PDF using Adobe's **Comment** feature. After adding your comments, submit the entire PDF to LSEG by clicking **Send File** in the **File** menu. Use the ProductDocumentation@lseg.com address.

1.7 Document Conventions

This document uses the following types of conventions:

- Typographic
- Diagrams

1.7.1 Typographic

This document uses the following types of conventions:

- Structures, methods, in-line code snippets, and types are shown in **Courier New** font.
- Parameters, filenames, tools, utilities, and directories are shown in **Bold** font.
- Document titles and variable values are shown in *italics*.
- When initially introduced, concepts are shown in ***Bold, Italics***.
- Longer code examples are shown in Courier New font against a gray background.

1.7.2 Diagrams

Diagrams that depict the interaction between components on a network use the following notation:


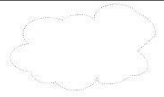
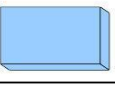

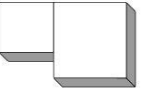


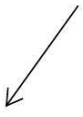


	Feed Handler, Real-Time server, or other application		Network of multiple servers
	Real-Time API application		Point-to-point connection showing direction of primary data flow
	Application with local daemon		Point-to-point connection showing direction of client connecting to server
	Multicast network		Data from external source (e.g. consolidated network or exchange)
	Connection to Multicast network, no primary data flow direction		Connection to Multicast network showing direction of primary data flow

Figure 1. Network Diagram Notation




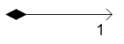
	Object
	Inheritance: object on left is like object on right
	Composition: object on left is made up of some number of objects on right
	Composition: object on left is made up of one object on right

Figure 2. UML Diagram Notation

2 Product Description

2.1 What is an LSEG Real-Time API?

The LSEG Real-Time API consists of any API that can retrieve real-time content from LSEG Real-Time Distribution Systems using the Open Message Model. Several API suites fall into this category: the LSEG Real-Time SDK (consisting of several layers of API libraries optimized for highest performance or ease-of-use), the Robust Foundation API, and the Websocket API (protocol specification only, with examples written to widely available frameworks). Applications written to LSEG Real-Time APIs can be written in any supported language (i.e., C, C++, C#, or Java), platform (i.e., Linux or Windows), or compiler to connect to the LSEG Real-Time Distribution System products or to the Real-Time -- Optimized service offered via the Delivery Platform. Whether you need to achieve the highest throughput possible, realize the lowest latency, or rapidly build applications that allow easy access to content, LSEG Real-Time APIs offer you the broadest range of capabilities to make it possible.

The LSEG Real-Time APIs are currently used by products such as the LSEG Real-Time Advanced Distribution Server, LSEG Real-Time Advanced Distribution Hub, Data Feed Direct, and certain Delivery Platform APIs where Enterprise Transport API serves as a foundation. Other Real-Time APIs such as the Websocket and Robust Foundation APIs serve as the foundation for Workspace, Eikon, and certain other Delivery Platform APIs.

LSEG Real-Time APIs support all constructs available as part of the Open Message Model. The Real-Time SDK (RTSDK) consists of the Enterprise Transport and Message APIs packaged together. Users of this API suite can write consumer and provider (interactive or non-interactive) applications to the Enterprise Transport API (directly to the RSSL library or Value-Add Reactor library, either using value-add features or watchlist features) or to the Enterprise Message API. With RTSDK, customers can choose between an easy-to-use session-level API (Enterprise Message API) and a high-performance transport-level API (Enterprise Transport API).

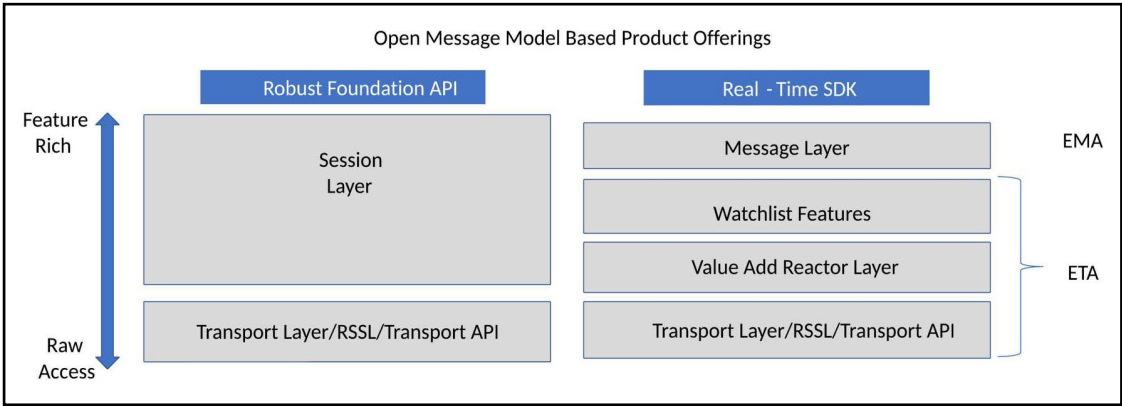


Figure 3. Open Message Model-Based Product Offerings

The LSEG Real-Time APIs provide application developers with the most flexible development environment and are the foundation on which all LSEG Open Message Model-based components are built.

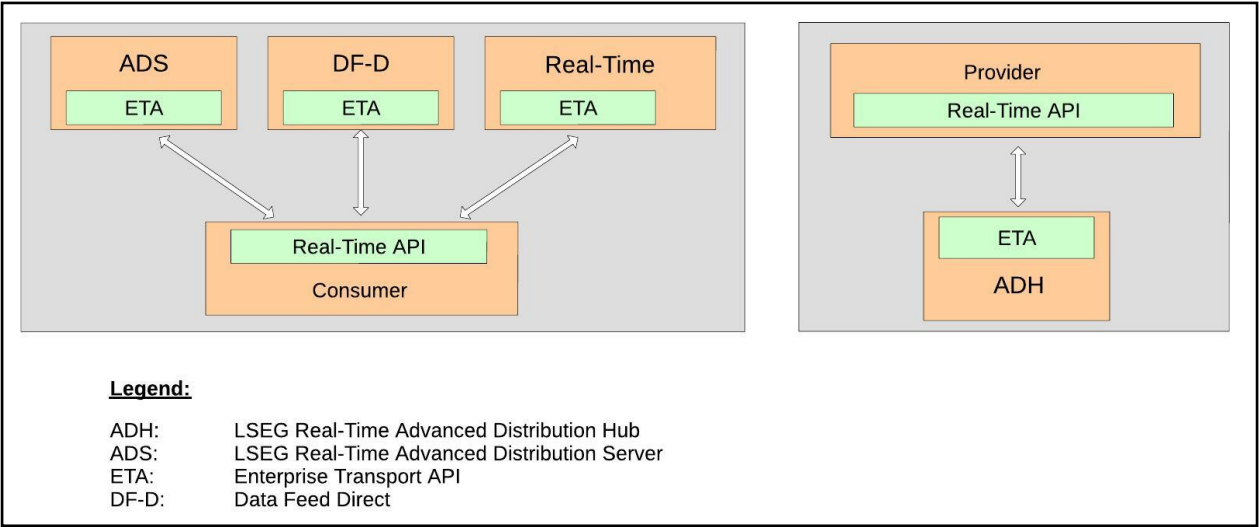


Figure 4. LSEG Real-Time API: Core Diagram

2.2 API Features

The LSEG Real-Time APIs are:

- Depending on the particular API, available in C++ / C and Java.
- 64-bit.
- Thread-safe and thread-aware.
- Capable of handling:
 - Any and all Open Message Model primitives and containers.
 - All Domain Models, including those defined by LSEG as well as other user-defined models.
- A reliable, transport-level API which includes Open Message Model encoders/decoders.

2.2.1 General Capabilities

LSEG Real-Time APIs provide general capabilities independent of the type of application. The LSEG Real-Time APIs:

- Supports fully connected or unified network topologies as well as segmented topologies.
- Supports multiple network session types, including TCP, HTTP, and multicast-based networks.
- Can internally fragment and reassemble large messages.
- Can pack multiple, small messages into the same network buffer.
- Can perform data compression and decompression internally.

2.2.2 Consumer Applications

You can use the LSEG Real-Time APIs to create consumer-based applications that can:

- Make streaming and snapshot-based subscription requests to the LSEG Real-Time Advanced Distribution Server.
- Send batch, views, and symbol list requests to the LSEG Real-Time Advanced Distribution Server.
- Support pause and resume on active data streams with the LSEG Real-Time Advanced Distribution Server.
- Send post messages to the LSEG Real-Time Advanced Distribution Server (for consumer-based publishing and contributions).
- Send and receive generic messages with LSEG Real-Time Advanced Distribution Server.
- Establish private streams and tunnel streams.
- Transparently use HTTP to communicate with an LSEG Real-Time Advanced Distribution Server by tunneling through the Internet.

2.2.3 Provider Applications: Interactive

You can use the LSEG Real-Time APIs to create interactive providers that can:

- Receive requests and respond to streaming and snapshot-based requests from an LSEG Real-Time Advanced Distribution Hub.
- Receive and respond to batch, views, and symbol list requests from an LSEG Real-Time Advanced Distribution Hub.
- Receive and respond to requests for a private streams and tunnel streams from an LSEG Real-Time Advanced Distribution Hub.
- Receive requests for pause and resume on active data streams.
- Receive and acknowledge post messages (used receiving consumer- based Publishing and Contributions) from an LSEG Real-Time Advanced Distribution Hub.
- Send and receive Generic Messages with an LSEG Real-Time Advanced Distribution Hub.

Additionally, you can use the LSEG Real-Time APIs to create server-based applications that can accept multiple connections from an LSEG Real-Time Advanced Data Hub, or allows multiple LSEG Real-Time Advanced Distribution Hubs to connect to a provider.

2.2.4 Provider Applications: Non-Interactive

Using the LSEG Real-Time APIs, you can write non-interactive applications that start up and begin publishing data to an LSEG Real-Time Advanced Distribution Hub. This includes both TCP and UDP multicast-based non-interactive provider applications.

2.3 Performance and Feature Comparison

As illustrated in Figure 4, core infrastructure components (as well as their performance test tools, such as `testclient` and `sink_driven_src`) are all written to the Enterprise Transport API. An LSEG Real-Time API-based application's maximum achievable performance (latency, throughput, etc) is determined by the infrastructure component to which it connects. Thus, to know performance metrics, you should look at the performance numbers for the associated infrastructure component. For example:

- If a LSEG Real-Time API consumer application talks to the LSEG Real-Time Advanced Distribution Server and you want to know the maximum throughput and latency of the consumer, look at the performance numbers for the LSEG Real-Time Advanced Distribution Server configuration you use.
- If a LSEG Real-Time API provider application talks to an LSEG Real-Time Advanced Distribution Hub and you want to know the maximum throughput and latency of the LSEG Real-Time API provider, look at the performance numbers for the LSEG Real-Time Advanced Distribution Hub Configuration you use.



TIP: The LSEG Real-Time API ships with API performance tools and additional documentation to which you can refer which you can use to arrive at more-specific results for your environment.

The following table compares existing API products and their performance. Key factors are latency, throughput, memory, and thread safety. Results may vary depending on whether you use watch lists and memory queues and according to your hardware and operating system. Typically, when measuring performance on the same hardware and operating system, these comparisons remain consistent.

API	THREAD SAFETY	THROUGHPUT	LATENCY	MEMORY FOOTPRINT
Enterprise Transport API	Safe and Aware	Very High	Lowest	Lowest
ETA Reactor ^a	Safe and Aware	Very High	Low	Medium (watch list optional)
Enterprise Message API	Safe and Aware	High	Low	Medium (watch list ^b)
Websocket API ^c	Depends on application	Medium	Medium	Depends on application
Robust Foundation API	Safe and Aware	High	Low	Medium (watch list, allows optional queues)
System Foundation Classes C++	None	Medium	High	Medium – High (watch list, cache)

Table 2: API Performance Comparison

a. The Reactor is an ease-of-use layer provided with the Enterprise Transport API.

b. The Enterprise Message API leverages the reactor watchlist.

c. The Websocket API is a protocol specification to implement a simpler version of the Open Message Model using a JSON payload over the wire over a websocket. There are examples to show how to access content using this specification [on GitHub](#).

2.4 Functionality: Which API to Choose?

To make an informed decision on which API to use, you should balance consider both performance and functionality. For performance comparisons, refer to Section 2.3.

The Robust Foundation API uses information provided from the Enterprise Transport API and creates specific implementations of capabilities. Though some of these capabilities are not implemented in the Enterprise Transport API, Enterprise Transport API-based applications can use the information provided by the Transport API to implement the same functionality (i.e., as provided by the Robust Foundation API). Additionally, Enterprise Transport API Value Added Components offer fully-supported reference implementations for much of this functionality.

The Enterprise Transport API Reactor is an open source component that functions within the Enterprise Transport API.

The following table lists API capabilities using the following legend:

- X: Supported in current version, natively implemented
- X*: Supported only in the C / C++ version of the software
- X**: Supported in current version, leverages lower-level capability
- Any X that is in blue: Supported only in C/C++ and Java version of the software.
- X+: Only supports V2 authentication in C# Edition.
- Future: Planned for a future release
- Legacy: A legacy functionality

CAPABILITY TYPE	CAPABILITY	ENTERPRISE TRANSPORT API 3.X	ENTERPRISE TRANSPORT REACTOR	ENTERPRISE MESSAGE API 3.X	THE ROBUST FOUNDATION API 8.X
Transport	Compression via Open Message Model	X	X**	X**	X
	HTTP Tunneling (Wire Format)	X	X**	X**	X
	TCP/IP: Wire Format	X	X**	X**	X
	Reliable Multicast: Wire Format	X	X**	X**	X
	Sequenced Multicast	X			
	Websocket	X	X	X**	
	Unidirectional Shared Memory	X			
Application Type	Consumer	X	X	X**	X
	Provider: Interactive	X	X	X**	X
	Provider: Non-Interactive	X	X	X**	X

Table 3: Capabilities by API

CAPABILITY TYPE	CAPABILITY	ENTERPRISE TRANSPORT API 3.X	ENTERPRISE TRANSPORT REACTOR	ENTERPRISE MESSAGE API 3.X	THE ROBUST FOUNDATION API 8.X
General	Batch Request	X	X	X	X
	Batch Re-issue and Close	X	X		X
	Generic Messages	X	X	X	X
	Pause/Resume	X	X	X	X
	Posting	X	X	X	X
	Snapshot Requests	X	X	X	X
	Streaming Requests	X	X	X	X
	Private Streams	X	X	X	X
	Qualified Streams	X	X	X	
	Views	X	X	X	X
Domain Models	Custom Data Model Support	X	X	X	X
	Domain Model: Dictionary	X	X	X	X
	Domain Model: Enhanced Symbol List	X	X	X**	X
	Domain Model: Login	X	X	X	X
	Domain Model: Market Price	X	X	X	X
	Domain Model: MarketByOrder	X	X	X	X
	Domain Model: MarketByPrice	X	X	X	X
	Domain Model: Market Maker	X	X	X	X
	Domain Model: Source Directory	X	X	X	X
	Domain Model: Symbol List	X	X	X	X
	Domain Model: Yield Curve	X	X	X	X
Encoders/Decoders	AnsiPage	X	X**	X**	Legacy
	DACS Lock	X	X**	X**	X
	Open Message Model	X	X	X**	X
	RMTES	X	X	X**	X

Table 3: Capabilities by API (Continued)

CAPABILITY TYPE	CAPABILITY	ENTERPRISE TRANSPORT API 3.X	ENTERPRISE TRANSPORT REACTOR	ENTERPRISE MESSAGE API 3.X	THE ROBUST FOUNDATION API 8.X
Layer Specific	Config: file-based			X	X
	Config: programmatic	X	X	X	X
	Group fanout to items		X	X**	X
	Load balancing: API-based				X
	Logging: file-based			X	X
	Logging: programmatic	X	X		X
	Quality of Service Matching		X	X**	X
	Network Pings: automatic		X	X**	X
	Recovery: connection		X	X**	X
	Recovery: items		X	X**	X
	Request routing				X
	Round trip time	X	X	X	
	Session management		X+	X+	
	Service Groups				X
	Single Open: API-based		X	X**	X
	Warm Standby: API-based (must enable Watchlist)		X	X	X
	Watchlist		X	X**	X
	Controlled fragmentation and assembly of large messages	X	X**	X**	
	Controlled locking/threading model	X			
	Controlled dynamic message buffers with ability to programmatically modify during runtime	X	X**		
	Controlled message packing	X	X**	X**	
	Messages can be written at different priority levels	X	X**	X**	

Table 3: Capabilities by API (Continued)

2.5 API Models

2.5.1 Open Message Model (OMM)

The **Open Message Model** is a collection of message header and data constructs. Some Open Message Model message header constructs (such as the Update message) have implicit market logic associated with them, while others (such as the Generic message) allow for free-flowing bi-directional messaging. You can combine Open Message Model data constructs in various ways to model data ranging from simple (i.e., flat) primitive types to complex multi-level hierarchal data.

The layout and interpretation of any specific Open Message Model (also referred to as a domain model) is described within that model's definition and is not coupled with the API. The Open Message Model is a flexible and simple tool that provides the building blocks to design and produce domain models to meet the needs of the system and its users. The LSEG Real-Time API provide structural representations of Open Message Model constructs and manages the Wire Format binary-encoded representation of the Open Message Model. Users can leverage LSEG-provided Open Message Model constructs to consume or provide Open Message Model data throughout the LSEG Real-Time Distribution System.

2.5.2 Wire Format (RWF)

Wire Format is the encoded representation of the Open Message Model; a highly-optimized, binary format designed to reduce the cost of data distribution compared to previous wire formats. Binary encoding represents data in the machine's native manner, enabling further use in calculations or data manipulations. Wire Format allows for serializing Open Message Model message and data constructs in an efficient manner while still allowing you to model rich content types. You can use Wire Format to distribute field identifier-value pair data (similar to Marketfeed), self-describing data (similar to Qform), as well as more complex, nested hierarchal content.

2.5.3 Domain Message Model

A Domain Message Model describes a specific arrangement of Open Message Model message and data constructs. A Domain Message Model defines any:

- Specialized behavior associated with the domain
- Specific meanings or semantics associated with the message data

Unless a Domain Message Model specifies otherwise, any implicit market logic associated with a message still applies (e.g., an Update message indicates that previously received data is being modified by corresponding data from the Update message).

2.5.3.1 Domain Model

A **Domain Model** is a domain message model typically provided or consumed by an LSEG product (i.e., LSEG Real-Time Distribution System, Data Feed Direct, or DP). Some currently-defined Domain Models allow for authenticating to a provider (e.g., Login), exchanging field or enumeration dictionaries (e.g., Dictionary), and providing or consuming various types of market data (e.g., Market Price, Market by Order, Market by Price). LSEG's defined models have a domain value of less than 128. For extended definitions of the currently-defined Domain Models, refer to the *Transport API Domain Model Usage Guide*.

2.5.3.2 User-Defined Domain Model

A **User-Defined Domain Model** is a Domain Message Model defined by a third party. These might be defined to solve a need specific to a user or system in a particular deployment and which is not resolved through the use of a Domain Model. Any user-defined model must use a domain value between 128 and 255.

Customers can have their domain model designer work with LSEG to define their model as a standard Domain Model. Working directly with LSEG can help ensure interoperability with future Domain Model definitions and with other LSEG products.

3 Consumers and Providers

3.1 Overview

For those familiar with LSEG's API products or concepts from LSEG Real-Time Distribution System, we map how the LSEG Real-Time API implement the same functionality.

At a very high level, the LSEG Real-Time Distribution System system facilitates controlled and managed interactions between many different service **providers** and **consumers**. Thus, LSEG Real-Time Distribution System is a real-time, streaming Service Oriented Architecture (SOA) used extensively as middleware integrating financial-service applications. While providers implement services and expose a certain set of capabilities (e.g. content, workflow, etc.), consumers use the capabilities offered by providers for a specific purpose (e.g., trading screen applications, black-box algorithmic trading applications, etc.). In some cases, a single application can function as both a consumer and a provider (e.g., a computation engine, value-add server, etc.).

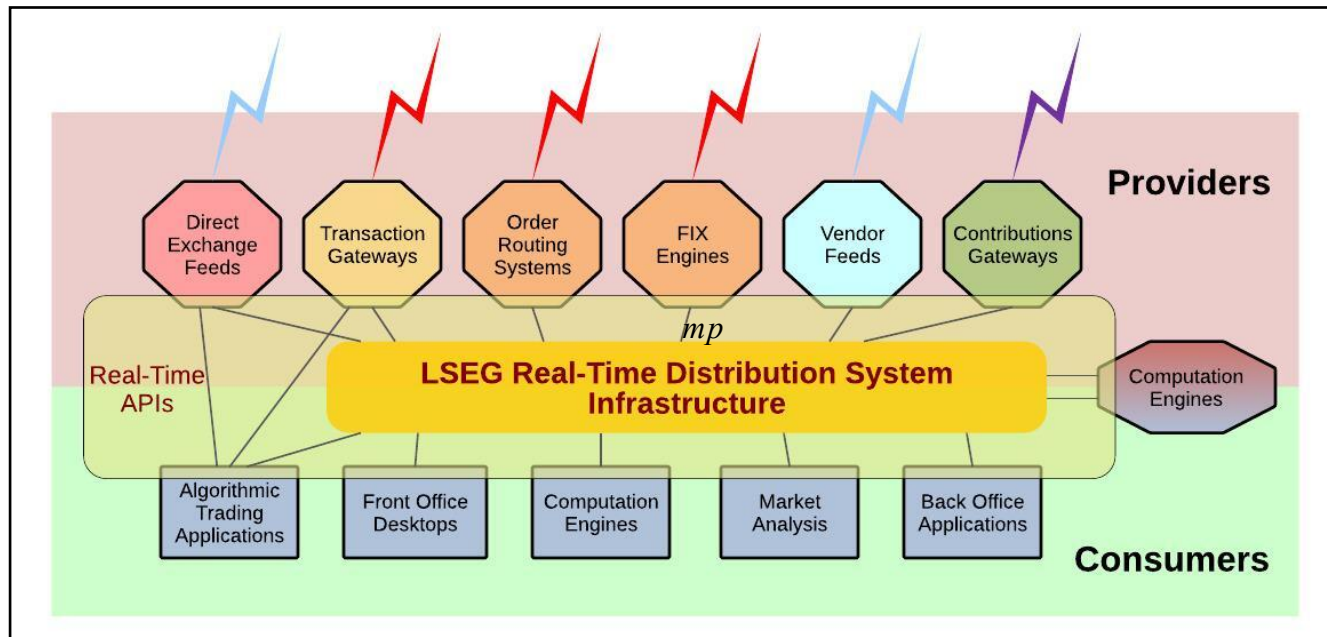


Figure 5. LSEG Real-Time Distribution System Infrastructure

To access needed capabilities, consumers always interact with a provider, either directly and/or via LSEG Real-Time Distribution System. Consumer applications that want the lowest possible latency can communicate directly via LSEG (or LSEG Real-Time Distribution System) APIs with the appropriate service providers. However, you can implement more complex deployments (i.e., integrating multiple providers, managing local content, automated resiliency, scalability, control, and protection) by placing the LSEG Real-Time Distribution System infrastructure between provider and consumer applications.

NOTE: Enterprise Message API C# Edition supports only consumers in current release.

3.2 Consumers

Consumers make use of capabilities offered by providers through access points. To interact with a provider, the consumer must attach to a consumer access point. Access points manifest themselves in two different forms:

- A **concrete access point**. A concrete access point is implemented by the service-provider application if it supports direct connections from consumers. The right-side diagram in the following figure illustrates an API consumer connecting to LSEG via a direct access point.
- A **proxy access point**. A proxy access point is point-to-point based and implemented by an LSEG Real-Time Distribution System Infrastructure component (i.e., an LSEG Real-Time Advanced Distribution Server). The following figure also illustrates an API consumer connecting to the provider by first passing through a proxy access point.

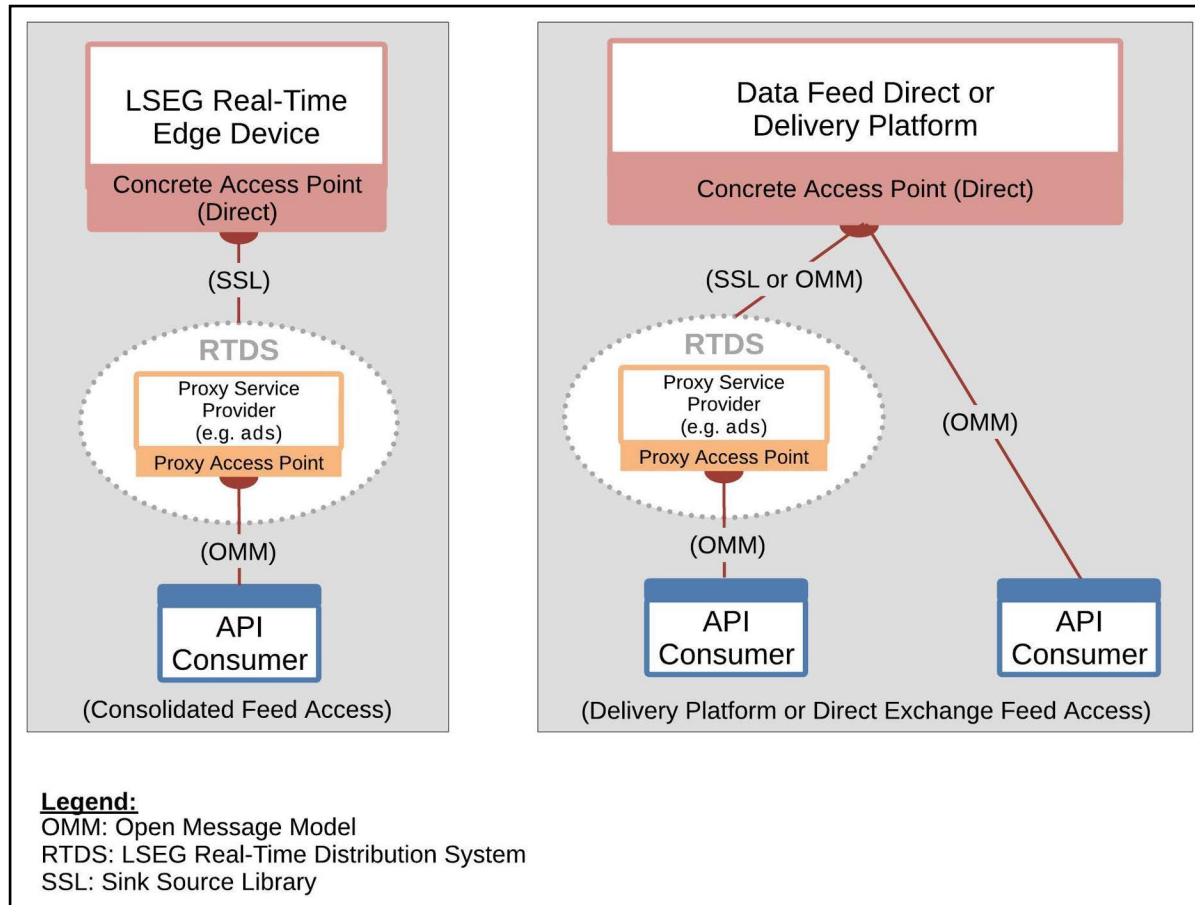


Figure 6. LSEG Real-Time API as Consumers

Examples of consumers include:

- An application that subscribes to data via LSEG Real-Time Distribution System or LSEG.
- An application that posts data to LSEG Real-Time Distribution System or LSEG (e.g., contributions/inserts or local publication into a cache).
- An application that communicates via generic messages with LSEG Real-Time Distribution System or LSEG.
- An application that does any of the above via a private stream.

3.2.1 Subscriptions: Request/Response

After a consumer successfully logs into a provider (i.e., LSEG Real-Time Advanced Distribution Server or LSEG) and obtains a list of available sources, the consumer can then subscribe and receive data for various services. A consumer subscribes to a service or service ID that in turn maps to a service name in the Source Directory. Any service or service ID provides a set of items to its clients.

- If a consumer's request does not specify interest in future changes (i.e., after receiving a full response), the request is a classic **snapshot request**. The data stream is considered closed after a full response of data (possibly delivered in multiple parts) is sent to the consumer. This is typical behavior when a user sends a non-streaming request. Because the response contains all current information, the stream is considered complete as soon as the data is sent.
- If a consumer's request specifies interest in receiving future changes (i.e., after receiving a full response), the request is considered to be a **streaming request**. After such a request, the provider sends the consumer an initial set of data and then sends additional changes or "updates" to the data as they occur. The data stream is considered open until either the consumer or provider closes it. A consumer typically sends a streaming request when a user subscribes for an item and wants to receive every change to that item for the life of the stream.

Specialized cases of request / response include:

- Batches
- Views
- Symbol Lists

3.2.2 Batches

A consumer can request multiple items using a single, client-based, request called a **batch** request. After the consumer sends an optimized batch request to the LSEG Real-Time Advanced Distribution Server, the LSEG Real-Time Advanced Distribution Server responds by sending the items as if they were opened individually so the items can be managed individually.

Figure 7 illustrates a consumer issuing a batch request for "TRI", "GE", and "INTC.O" and the resulting LSEG Real-Time Advanced Distribution Server responses.

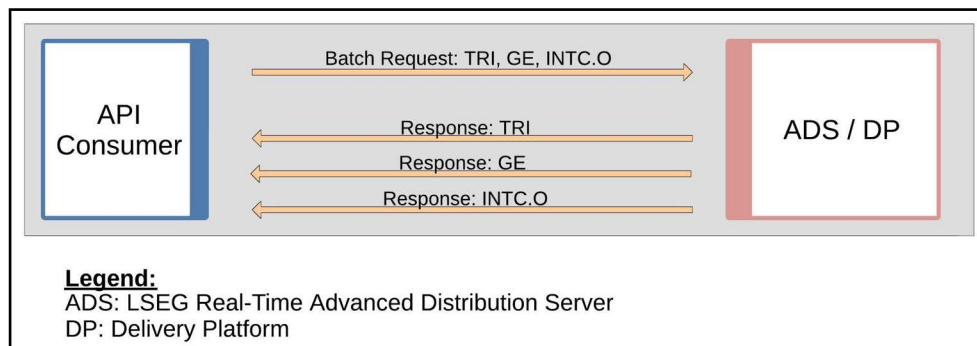


Figure 7. Batch Request

3.2.3 Views

The system reduces the amount of data that flows across the network by filtering out content in which the user is not interested. To improve performance and maximize bandwidth, you can configure the LSEG Real-Time Distribution System to filter out certain fields to downstream users. When filtering, all consumer applications see the same subset of fields for a given item.

Another way of controlling filtering is to configure the consumer application to use **Views**. Using a view, a consumer requests a subset of fields with a single, client-based request (refer to Figure 8). The API then requests (from the LSEG Real-Time Advanced Distribution Server / LSEG) only the fields of interest. When the API receives the requested fields, it sends the subset back to the consumer. This is also called consumer-side (or request-side) filtering.

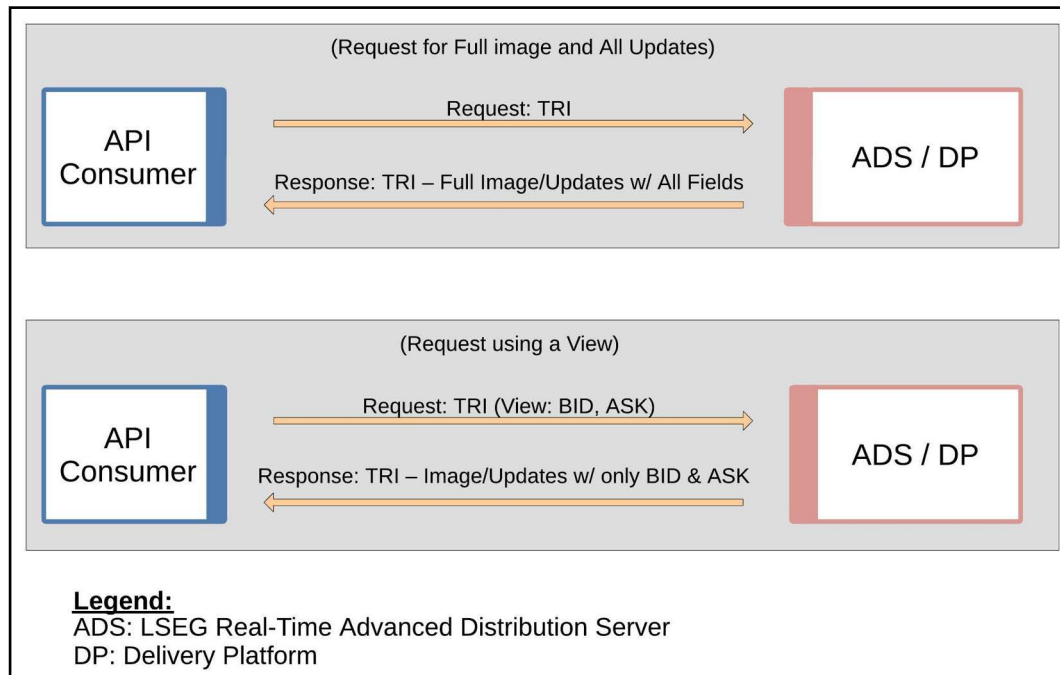


Figure 8. View Request Diagram

Views were designed to provide the same filtering functionality as the System Foundation Classes (based on its own internal cache) while optimizing network traffic.

Views, in conjunction with server-side filtering, can be a powerful tool for bandwidth optimization on a network. Users can combine a view with a batch request to send a single request to open multiple items using the same view.

3.2.4 Pause and Resume

The **Pause/Resume** feature optimizes network bandwidth. You can use Pause/Resume to reduce the amount of data flowing across the network for a single item or for many items that might already be openly streaming data to a client.

To pause/resume data, the client first sends a request to pause an item to the LSEG Real-Time Advanced Distribution Server. The LSEG Real-Time Advanced Distribution Server receives the pause request and stops sending new data to the client for that item, though the item remains open and in the LSEG Real-Time Advanced Distribution Server cache. The LSEG Real-Time Advanced Distribution Server continues to receive messages from the upstream device (or feed) and continues to update the item in its cache (but because of the client's pause request, does not send the new data to the client). When the client wants to start receiving messages for the item again, the client sends a resume to the LSEG Real-Time Advanced Distribution Server, which then responds by sending an aggregated update or a refresh (a current image) to the client. After the LSEG Real-Time Advanced Distribution Server resumes sending data, the LSEG Real-Time Advanced Distribution Server sends all subsequent messages.

By using the Pause/Resume feature a client can avoid issuing multiple open/close requests which can disrupt the LSEG Real-Time Advanced Distribution Server and prolong recovery times. There are two main use-case scenarios for this feature:

- Clients with intensive back-end processing
- Clients that display a lot of data

3.2.4.1 Pause / Resume Use Case 1: Back-end Processing

In this use-case, a client application performs heavy back-end processing and has too many items open, such that the client is at the threshold for lowering the downstream update rate. The client now needs to run a specialized report, or do some other back-end processing. Such an increase in workload on the client application will negatively impact its downstream message traffic. The client does not want to back up its messages from the LSEG Real-Time Advanced Distribution Server and risk having LSEG Real-Time Advanced Distribution Server abruptly cut its connection, nor does the client want to close its own connection (or close all the items on the LSEG Real-Time Advanced Distribution Server) which would require the client to re-open all items after finishing its back-end processing.

In this case, the client application:

- Sends a single PAUSE message to the LSEG Real-Time Advanced Distribution Server to pause all the items it has open.
- Performs all needed back-end processing.
- Sends a Resume request to resume all the items it had paused.

After receiving the Resume request, the LSEG Real-Time Advanced Distribution Server sends a refresh (i.e., current image), to the client for all paused items and then continues to send any subsequent messages.

3.2.4.2 Pause / Resume Use Case 2: Display Applications

The second use case assumes the application displays a lot of data. In this scenario, the user has two windows open. One window has item "TRI" open and is updating (Window 1). The other has "INTC.O" open and is updating (Window 2). On his screen, the user moves Window 1 to cover Window 2 and the user can no longer see the contents of Window 2. In this case, the user might not need updates for "INTC.O" because the contents are obstructed from view. In this case, the client application can:

- Pause "INTC.O" as long as Window 2 is covered and out of view.
- Resume the stream for "INTC.O" when Window 2 moves back into view.

When Window 2 is again visible, the LSEG Real-Time Advanced Distribution Server sends a refresh, or current image, to the client for the item "INTC.O" and then continues to send any subsequent messages.

3.2.5 Symbol Lists

If a consumer wants to open multiple items but doesn't know their names, the consumer can first issue a request using a **Symbol List**. However, the consumer can issue such a request only if a provider exists that can resolve the symbol list name into a set of item names.

This replaces the functionality for clients that previously used Criteria-Based Requests (CBR) with the Source Sink Library 4.5 API.

The following diagram illustrates issuing a basic symbol list request. In this diagram, the consumer issues the request using a particular key name (**FRED**). The request flows through the platform to a provider capable of resolving the symbol list name (the interactive provider with **FRED** in its cache). The provider sends back all names that map to **FRED** (**TRI** and **GE**). After receiving the response, the client can then choose whether to open items; individually or by making a batch request for multiple items. A subsequent request is resolved by the first cache that contains the data (listed in the diagram as optional caches).

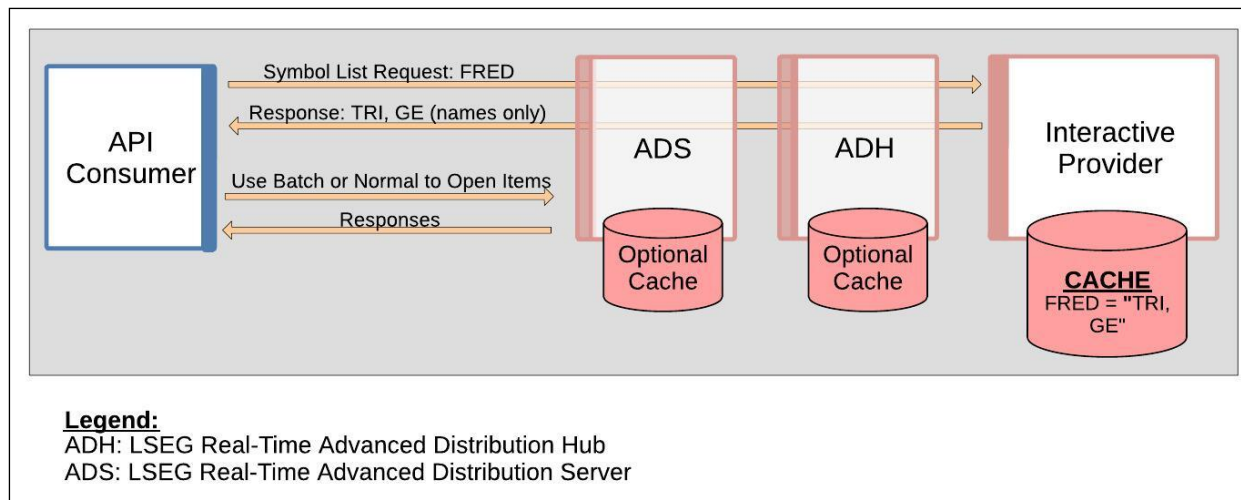


Figure 9. Symbol List: Basic Scenario

The following diagram illustrates how a consumer can access all items in the LSEG Real-Time Advanced Distribution Server cache, effectively dumping the cache to the Open Message Model client. In this scenario, the client requests the symbol list **_ADS_CACHE_LIST**. The LSEG Real-Time Advanced Distribution Server receives the request and responds with the names of all items in its cache. The client can then choose to open items individually, or make a batch request to open multiple items. The LSEG Real-Time Advanced Distribution Server provides an additional symbol list (**_SERVER_LIST**) for obtaining lists of items stored in specific LSEG Real-Time Advanced Distribution Hub instances.

- For details on this symbol list, refer to the *LSEG Real-Time Advanced Distribution Server* and *LSEG Real-Time Advanced Distribution Hub System Administration Manuals*.
- For more detailed information on using symbol lists, refer to the Developer's manual specific to the API you use.

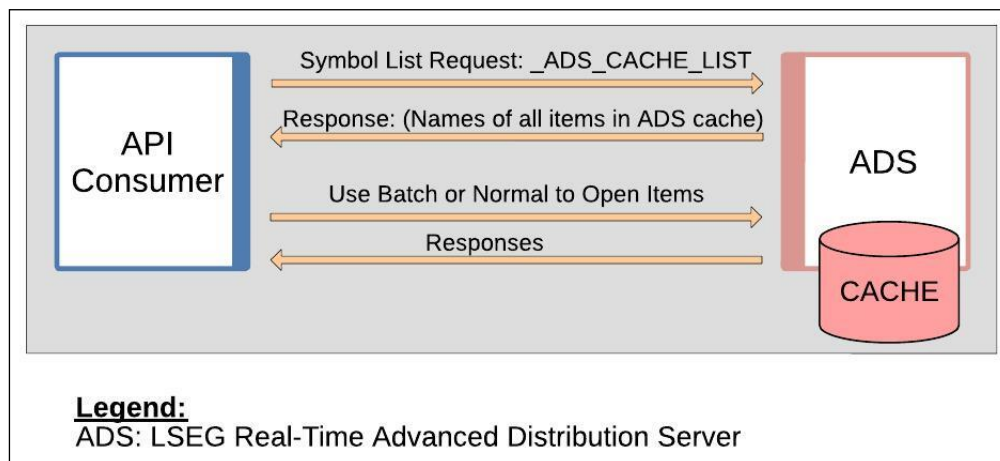


Figure 10. Symbol List: Accessing the Entire LSEG Real-Time Advanced Distribution Server Cache

3.2.6 Posting

Through posting, API consumers can easily push content into any cache within the LSEG Real-Time Distribution System (i.e., an HTTP POST request). Data contributions/inserts into the ATS or publishing into a cache offer similar capabilities today. When posting, API consumer applications reuse their existing sessions to publish content to any cache(s) residing within the LSEG Real-Time Distribution System (i.e., service provider(s) and/or infrastructure components). When compared to spreadsheets or other applications, posting offers a more efficient form of publishing, because the application does not need to create a separate provider session or manage event streams. The posting capability, unlike unmanaged publishing or inserts, offers optional acknowledgments per posted message. The two types of posting are on-stream and off-stream:

- **On-Stream Post:** Before sending an on-stream post, the client must first open (request) a data stream for an item. After opening the data stream, the client application can then send a post. The route of the post is determined by the route of the data stream.
- **Off-Stream Post:** In an off-stream post, the client application can send a post for an item via a Login stream, regardless of whether a data stream first exists. The route of the post is determined by the Core Infrastructure (i.e., LSEG Real-Time Advanced Distribution Server, LSEG Real-Time Advanced Distribution Hub, etc.) configuration.

3.2.6.1 Local Publication

The following diagram illustrates the benefits of posting.

Green and Red services support internal posting and are fully implemented within the LSEG Real-Time Advanced Distribution Hub. In both cases the LSEG Real-Time Advanced Distribution Hub receives posted messages and then distributes these messages to interested consumers. In the right-side segment, the LSEG Real-Time Advanced Distribution Server component has enabled caching (for the Red service). In this case posted messages received from connected applications are cached and distributed to these local applications before being forwarded (re-posted) up into the LSEG Real-Time Advanced Distribution Hub cache. The LSEG Real-Time API can even post to provider applications (i.e., the Purple service in this diagram) that support posting.

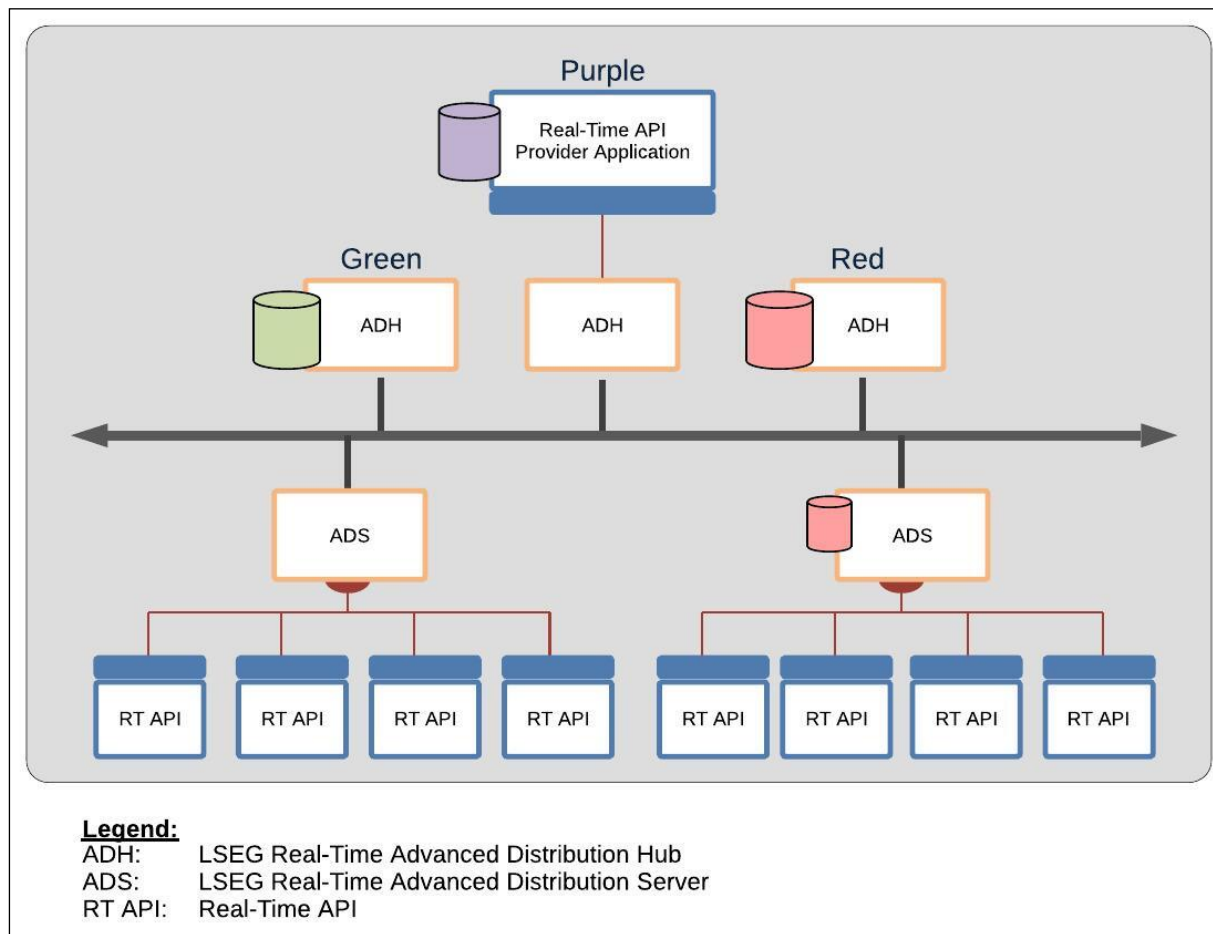


Figure 11. Posting into a Cache

You can use LSEG Real-Time API to post into an LSEG Real-Time Advanced Distribution Hub cache. If a cache exists in the LSEG Real-Time Advanced Distribution Server (the Red service), the LSEG Real-Time Advanced Distribution Server cache is also populated by responses from the LSEG Real-Time Advanced Distribution Hub cache. If you configure LSEG Real-Time Distribution System to allow such behavior, posts can be sent beyond the LSEG Real-Time Advanced Distribution Hub (to the Provider Application in the Purple service). Such posting flexibility is a good solution if one's applications are restricted to a LAN which hosts an LSEG Real-Time Advanced Distribution Server but allows publishing up the network to a cache with items to which other clients subscribe.

3.2.6.2 Contribution/Inserts

Posting also allows Open Message Model-based contributions. Through such posting, clients can contribute data to a device on the head end or to a custom-provider. In the following example, the LSEG Real-Time API send an Open Message Model post to a provider application that supports such functionality.

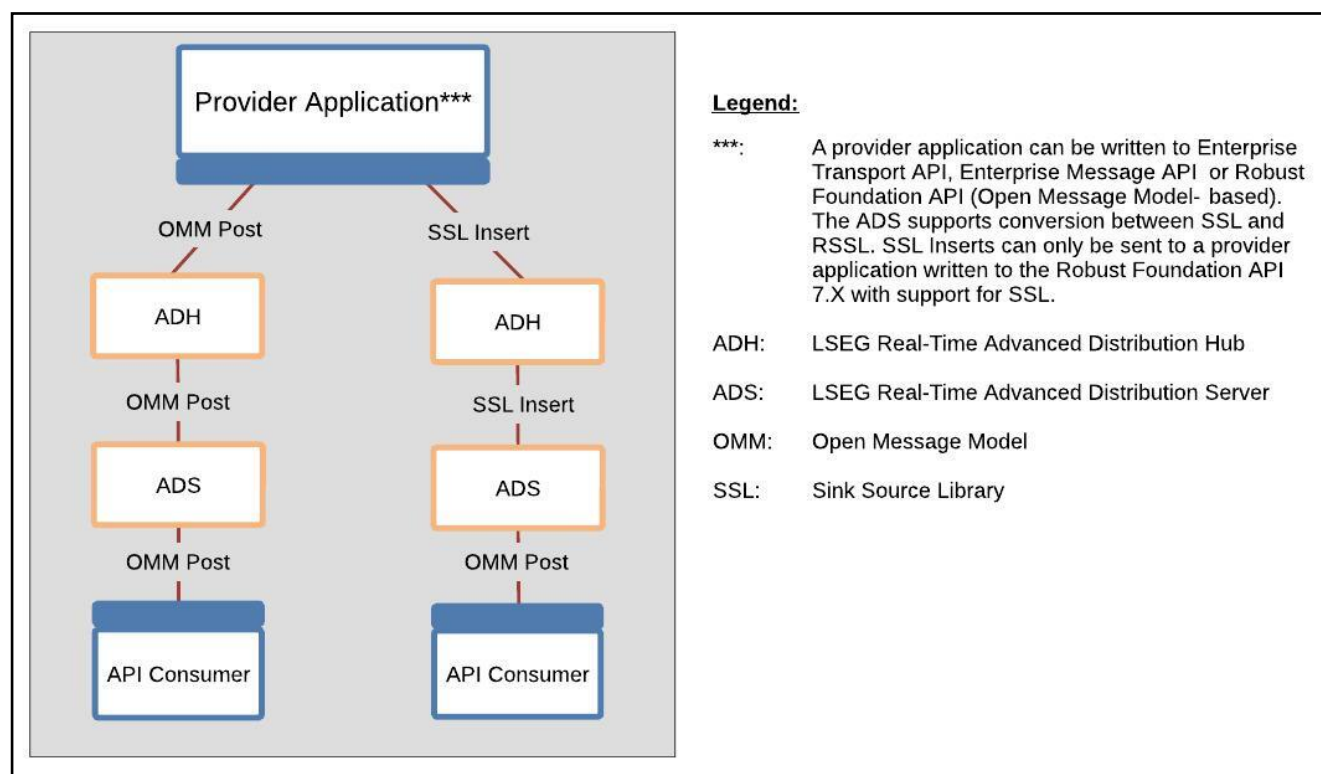


Figure 12. Open Message Model Post with Legacy Inserts

3.2.7 Generic Message

Using a **Generic Message**, an application can send or receive a bi-directional message. A generic message can contain any Open Message Model primitive type. Whereas the request/response type message flows from LSEG Real-Time Distribution System to a consumer application, a generic message can flow in any direction, and a response is not required or expected. One advantage to using generic messages is its freedom from the traditional request/response data flow.

In a generic message scenario, the consumer sends a generic message to an LSEG Real-Time Advanced Distribution Server, while the LSEG Real-Time Advanced Distribution Server also publishes a generic message to the consumer application. All domains support this type of generic message behavior, not just market data-based domains (such as Market Price, etc). If a generic message is sent to a component that does not understand generic messages, the component ignores the message.

3.2.8 Private Streams

Using a **Private Stream**, a consumer application can create a virtual private connection with an interactive provider. This virtual private connection can be either a direct connection, through the LSEG Real-Time Distribution System, or via a cascaded set of platforms. The following diagram illustrates these different configurations.

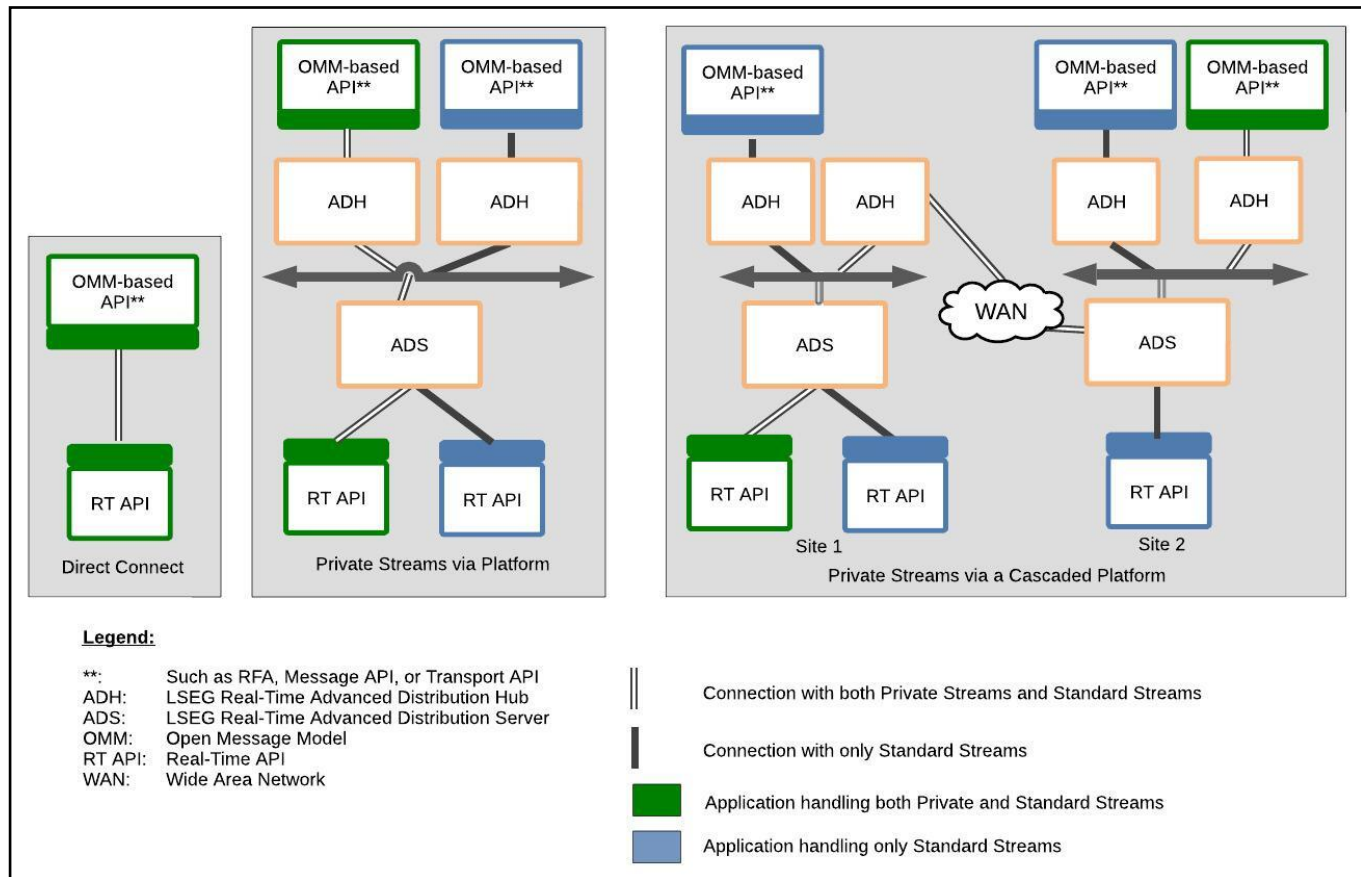


Figure 13. Private Stream Scenarios

A virtual private connection piggy backs on existing, individual point-to-point and multicast connections in the system (Figure 13 illustrates this behavior using a white connector). Messages exchanged via a Private Stream flow between a Consumer and an Interactive Provider using these existing underlying connections. However, unlike a regular stream, the LSEG Real-Time API or LSEG Real-Time Distribution System components do not fan out these messages to other consumers or providers.

In Figure 13, each diagram shows a green consumer creating a private stream with a green provider. The private stream, using existing infrastructure and network connections, is illustrated as a white path in each of the diagrams. When established, communications sent on a private stream flow only between the green consumer and the green provider to which it connects. Blue providers and consumers do not see messages sent via the private stream.

Any break in a “virtual connection” causes the provider and consumer to be notified of the loss of connection. In such a scenario, the consumer is responsible for re-establishing the connection and re-requesting any data it might have missed from the provider. All types of requests, functionality, and Domain Models can flow across a private stream, including (but not limited to):

- Streaming Requests
- Snapshot Requests
- Posting
- Generic Messages
- Batch Requests
- Views

- All LSEG Domain Models & Custom Domain Models

3.2.9 Tunnel Streams (Only Available in the ETA Reactor and in EMA)

The Reactor allows users to create and use special tunnel streams. A tunnel stream is a private stream with additional behaviors, such as end-to-end line of sight for authentication and guaranteed delivery. Tunnel streams are founded on the private streams concept, and the Enterprise Transport API establishes them between consumer and provider endpoints (passing through any intermediate components, such as LSEG Real-Time Distribution System or a LSEG Real-Time Edge Device).

When creating a tunnel, the consumer indicates any additional behaviors to enforce, which is exchanged with the provider application end point. The provider end-point acknowledges creation of the stream as well as the behaviors that it will enforce on the stream. After the stream is established, the consumer can exchange any content it wants, though the tunnel stream will enforce behaviors on the transmitted content as negotiated with the provider.

A tunnel stream allows for multiple substreams to exist, where substreams follow from the same general stream concept, except that they flow and coexist within the confines of a tunnel stream.

In the following diagram, the orange cylinder represents a tunnel stream that connects the consumer application to the provider application. Notice that the tunnel stream passes directly through intermediate components: the tunnel stream has end-to-end line of sight so that the provider and consumer effectively talk to one another directly, though they traverse multiple devices in the system. Each black line flowing through the cylinder represents a different substream, where each substream transmits its own independent stream of information. Each substream could communicate different market content; for example one could be a Time Series request while another could be a request for Market Price content. For further details, refer to the *Enterprise Transport API Value Added Developers Guide* specific to the version of API that you use.

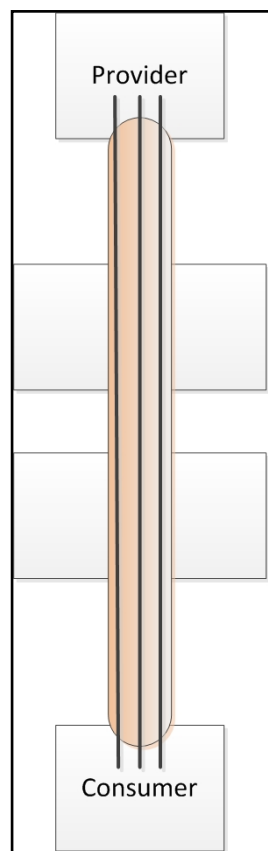


Figure 14. Tunnel Stream Illustration

3.2.10 Building an API Consumer

A consumer application can establish a connection to other interactive provider applications, including the LSEG Real-Time Distribution System, Data Feed Direct, and Data Platform. After connecting successfully, a consumer can then consume (i.e., send data requests and receive responses) and publish data (i.e., post data) or forward data (i.e., Round Trip Time messages).

The general process can be summarized by the following steps¹:

- Establish network communication
- Log in
- Obtain source directory information
- Load or download all necessary dictionary information
- Issue requests, process responses, forward generic messages, and/or post information
- Log out and shut down

The example application included with each LSEG Real-Time API product, provides an example implementation of a consumer application. The application is written with simplicity in mind and demonstrates various aspects and features relevant to the API you use. Portions of functionality have been abstracted and can easily be reused, though you might need to modify it to achieve your own unique performance and functionality goals.

1. Specific APIs might automatically rely on defaults unless overridden by the user.

3.3 Providers

Providers make their services available to consumers through LSEG Real-Time Distribution System infrastructure components. Every provider-based application must attach to a provider access point to inter-operate with consumers. All provider access points are considered concrete and are implemented by an LSEG Real-Time Distribution System infrastructure component (like the LSEG Real-Time Advanced Distribution Hub).

Examples of providers include:

- A user who receives a subscription request from LSEG Real-Time Distribution System.
- A user who publishes data into LSEG Real-Time Distribution System, whether in response to a request or using a broadcast-publishing style.
- A user who receives post data from LSEG Real-Time Distribution System. Providers can handle such concepts as receiving requests for contributions/inserts, or receiving publication requests.
- A user who sends and/or receives generic messages with LSEG Real-Time Distribution System.

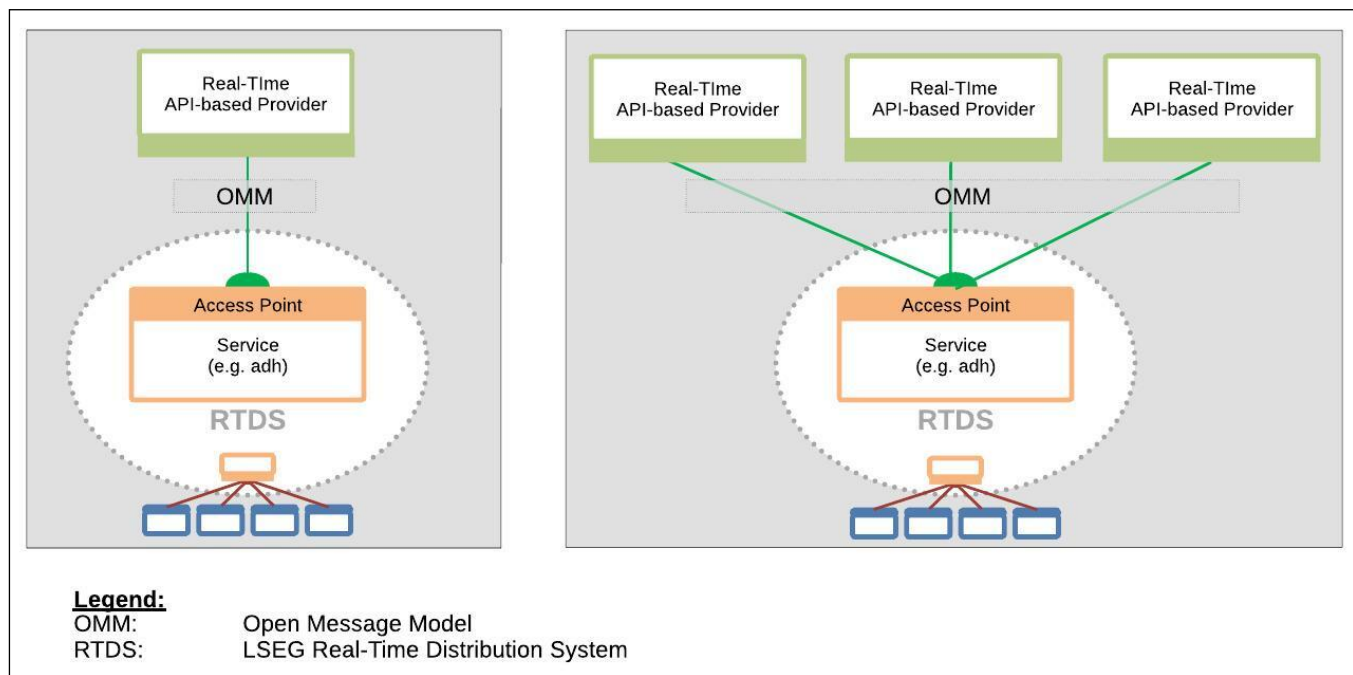


Figure 15. Provider Access Point

3.3.1 Interactive Providers

An **interactive provider** is one that communicates with the LSEG Real-Time Distribution System, accepting and managing multiple connections with LSEG Real-Time Distribution System components. The following diagram illustrates this concept.

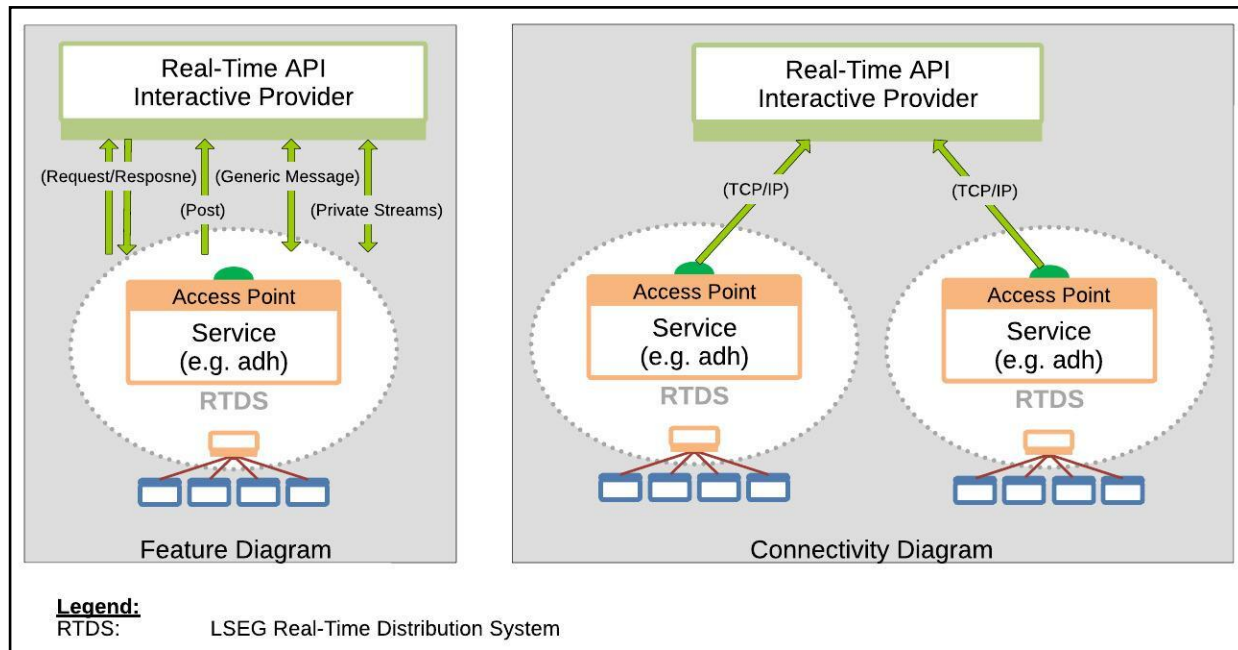


Figure 16. Interactive Providers

An interactive provider receives connection requests from the LSEG Real-Time Distribution System. The Interactive Provider responds to requests for information as to what services, domains, and capabilities it can provide or for which it can receive requests. It may also receive and respond to requests for information about its data dictionary, describing the format of expected data types. After this is completed, its behavior is interactive.

For the LSEG Real-Time Distribution System adopters, the Interactive Provider is similar in concept to the legacy Sink-Driven Server or Managed Server Application. Interactive Providers act like servers in a client-server relationship. An interactive provider can accept and manage connections from multiple LSEG Real-Time Distribution System components.

3.3.1.1 Request /Response

In a standard request/response scenario, the interactive provider receives requests from consumers on LSEG Real-Time Distribution System (e.g., "Provide data for item AAPL"). The consumer then expects the interactive provider to provide a response, status, and possible updates whenever the information changes. If the item cannot be provided by the interactive provider, the consumer expects the provider to reject the request by providing an appropriate response - commonly a status message with state and text information describing the reason. Request and response behavior is supported in all domains, not simply Market-Data-based domains.

Interactive providers can receive any consumer-style request described in the consumer section of this document, including batch requests, views, symbol lists, pause/resume, etc. Provider applications should respond with a negative acknowledgment or response if the interactive application cannot provide the expected response to a request.

3.3.1.2 Posts

The interactive provider can receive post messages via LSEG Real-Time Distribution System. Post messages will state whether an acknowledgment is required. If required, LSEG Real-Time Distribution System will expect the interactive provider to provide a response, in the form of a positive or negative acknowledgment. Post behavior is supported in all domains, not simply Market-Data-based domains. Whenever an interactive provider connects to LSEG Real-Time Distribution System and publishes the supported domains, the provider states whether it supports post messages.

3.3.1.3 Generic Messages

Using generic messages, an application can send or receive bi-directional messages. Whereas a request/response type message flows from LSEG Real-Time Distribution System to an interactive provider, generic messages can flow in any direction and do not expect a response. When using generic messages, the application need not conform to the request/response flow. A generic message can contain any Open Message Model data type.

Interactive providers can receive a generic message from and publish a generic message to LSEG Real-Time Distribution System.

Generic message behavior is supported in all domains, not simply Market-Data-based domains. If a generic message is sent to a component (e.g., a legacy application) which does not understand generic messages, the component ignores it.

3.3.1.4 Private Streams

In a typical private stream scenario, the interactive provider can receive requests for a private stream. Once established, interactive providers can receive any consumer-style request via a private stream, described in the consumer section of this document, including Batch requests, Views, Symbol Lists, Pause/Resume, Posting, etc. Provider applications should respond with a negative acknowledgment or response if the interactive application cannot provide the expected response to a request.

3.3.1.5 Tunnel Streams (Available Only in ETA Reactor and EMA)

An interactive provider can receive requests for a tunnel stream when using the ETA Reactor or EMA. When creating a tunnel stream, the consumer indicates any additional behaviors to enforce, which is exchanged with the provider application end point. The provider end-point acknowledges creation of the stream as well as the behaviors that it will enforce on the stream. After the stream is established, the consumer can exchange any content it wants, though the tunnel stream will enforce behaviors on the transmitted content as negotiated with the provider.

A tunnel stream allows for multiple substreams to exist, where substreams follow from the same general stream concept, except that they flow and coexist within the confines of a tunnel stream.

3.3.1.6 Building an Interactive Provider

An OMM interactive provider application opens a listening socket on a well-known port allowing consumer applications to connect. After connecting, consumers can request data from the interactive provider.

The following steps summarize this process²:

- Establish network communication
- Accept incoming connections
- Handle login requests
- Provide source directory information
- Provide or download necessary dictionaries
- Handle requests and post messages
- Dispatch Round Trip Time messages
- Sends out messages for round trip latency monitoring.
- Disconnect consumers and shut down

The interactive provider example application included with the API package provides one way of implementing an OMM interactive provider. The application is written with simplicity in mind and demonstrates the use of the appropriate . Portions of the functionality are abstracted for easy reuse, though you might need to customize it to achieve your own unique performance and functionality goals.

2. Specific APIs might automatically rely on defaults unless overridden by the user.

3.3.2 Non-Interactive Providers

3.3.2.1 Overview

A **non-interactive provider** writes a provider application that connects to LSEG Real-Time Distribution System and sends a specific set of non-interactive data (services, domains, and capabilities).

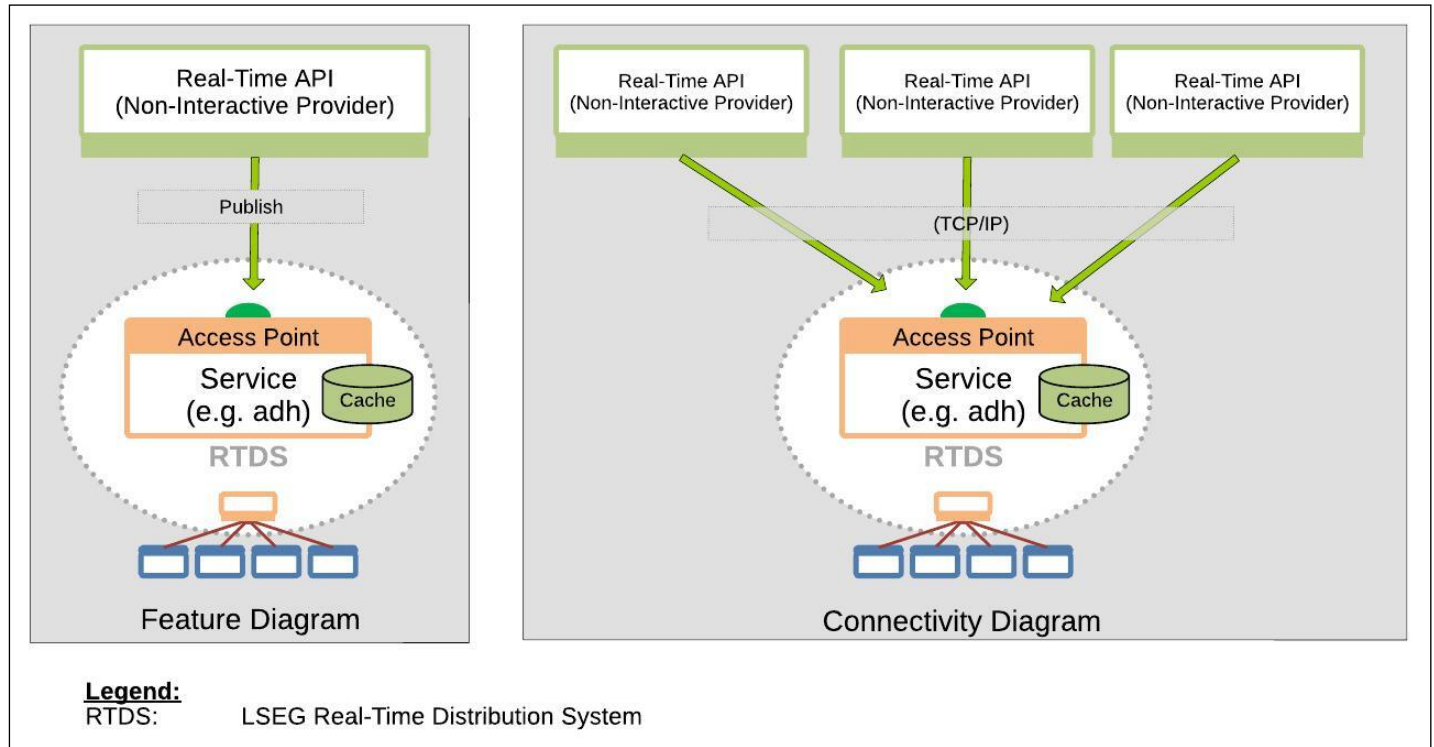
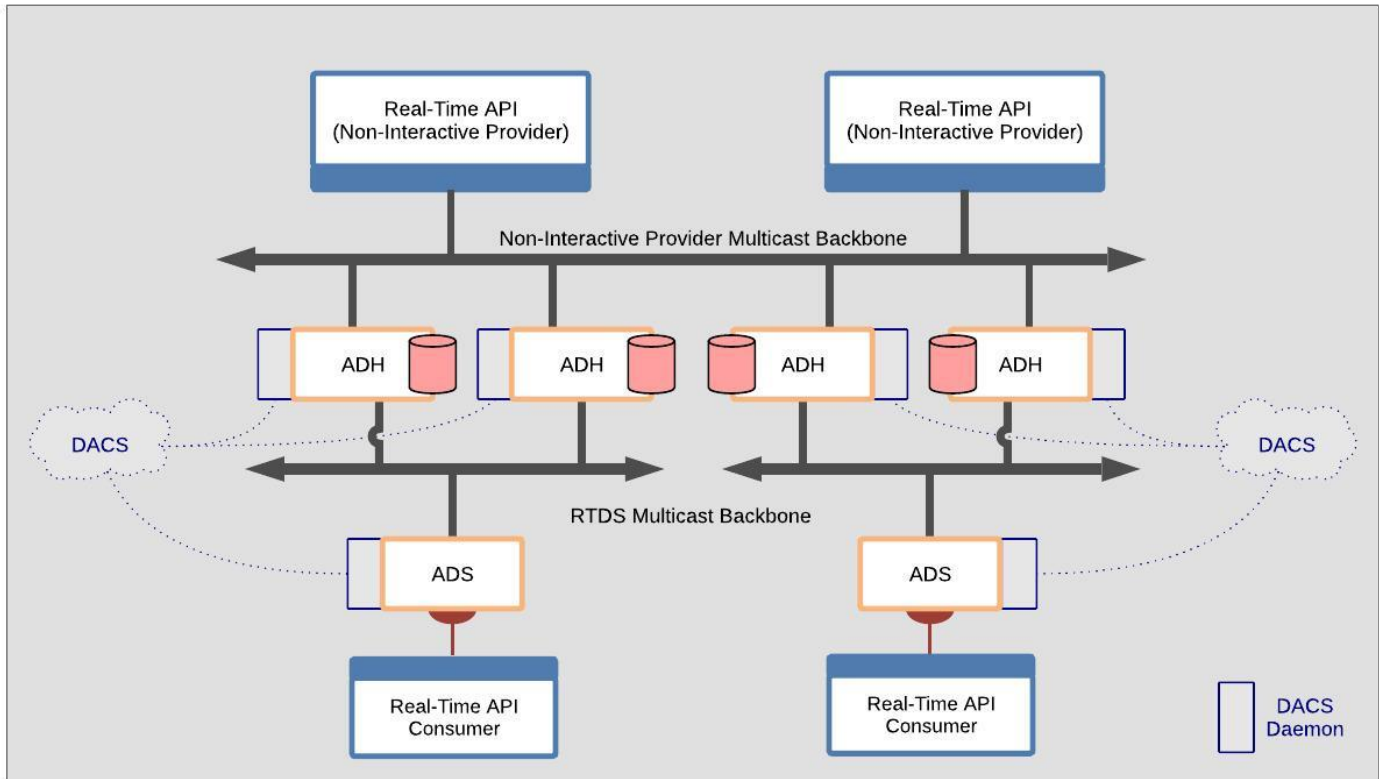


Figure 17. Non-Interactive Provider: Point-To-Point



Legend:

ADH: LSEG Real-Time Advanced Distribution Hub
 ADS: LSEG Real-Time Advanced Distribution Server
 DACS: Data Access Control System
 RTDS: LSEG Real-Time Distribution System

Figure 18. Non-Interactive Provider: Multicast

After a non-interactive provider connects to LSEG Real-Time Distribution System, the non-interactive provider can start sending information for any supported item and domain. For the LSEG Real-Time Distribution System adopters, the non-interactive provider is similar in concept to what was once called the Src-Driven, or Broadcast Server Application.

Non-interactive providers act like clients in a client-server relationship. Multiple non-interactive providers can connect to the same LSEG Real-Time Distribution System and publish the same items and content. For example, two non-interactive providers can publish the same or different fields for the same item "INTC.O" to the same LSEG Real-Time Distribution System.

Non-interactive provider applications can connect using a point-to-point TCP-based transport as shown in Figure ?, or using a multicast transport as shown in Figure ?.

The main benefit of this scenario is that all publishing traffic flows from top to bottom: the way a system normally expects updating data to flow. In the local publishing scenario, posting is frequently done upstream and must contend with a potential Infrastructure bias in prioritization of upstream versus downstream traffic.

3.3.2.2 Building a Non-Interactive Provider

A non-interactive provider can publish information into the LSEG Real-Time Advanced Distribution Hub cache without needing to handle requests for the information. The LSEG Real-Time Advanced Distribution Hub can cache the information and along with other LSEG Real-Time Distribution System components, provide the information to any consumer applications that indicate interest.

The general process can be summarized by the following steps:³

- Establish network communication
- Perform Login process
- Perform Dictionary Download
- Provide Source Directory information
- Provide content
- Log out and shut down

Included with the LSEG Real-Time API package, the **NIP** example application provides an implementation of a non-interactive provider written with simplicity in mind and demonstrates the use of the appropriate LSEG Real-Time API. Portions of the functionality are abstracted for easy reuse, though you might need to modify it to achieve your own performance and functionality goals.

Content is encoded and decoded depending on the API that you use.

3. Specific APIs might automatically rely on defaults unless overridden by the user.

4 System View

4.1 System Architecture Overview

An LSEG Real-Time Distribution System network typically hosts the following:

- Core Infrastructure: LSEG Real-Time Advanced Distribution Server (ADS), LSEG Real-Time Advanced Distribution Hub (ADH), etc.
- Consumer applications that typically request and receive information from the network
- Provider applications that typically write information to the network. Provider applications fall into one of two categories:
 - Interactive provider applications which receive and interpret request messages and reply back with any needed information.
 - Non-interactive provider applications which publish data, regardless of user requests or which applications consume the data.
- Permissioning infrastructure: Data Access Control System
- Devices that interact with the markets: Data Feed Direct and LSEG Real-Time Edge Device

The following figure illustrates a typical deployment of an LSEG Real-Time Distribution System network and some of its possible components. The remainder of this chapter briefly describes the components pictured in the diagram and explains how the LSEG Real-Time API integrate with each.

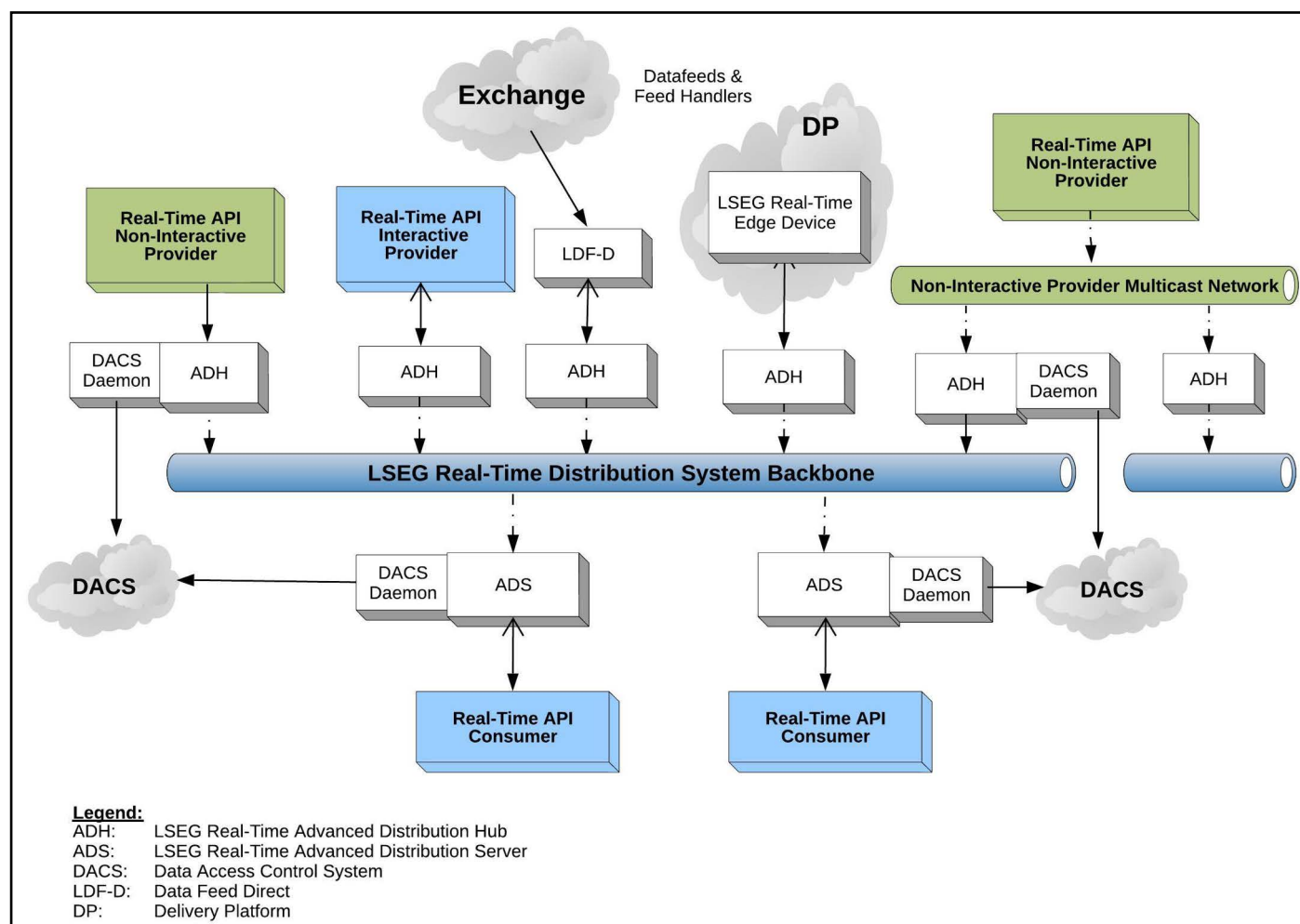


Figure 19. Typical LSEG Real-Time Distribution System Components

4.2 LSEG Real-Time Advanced Distribution Server

The LSEG Real-Time Advanced Distribution Server provides a consolidated distribution solution for LSEG, value-added, and third-party data for trading-room systems. It distributes information using the same Open Message Model and Wire Format protocols exposed by the LSEG Real-Time API.

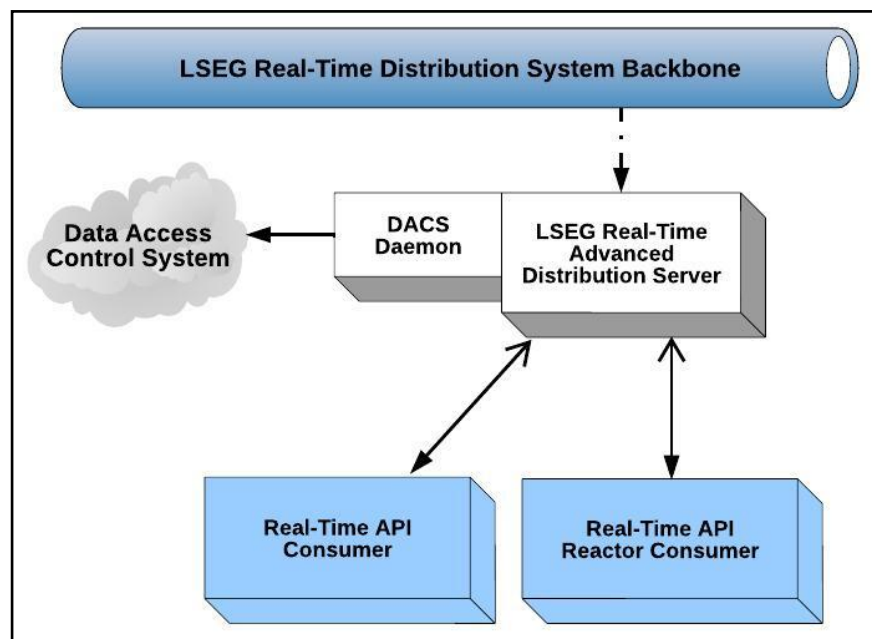


Figure 20. LSEG Real-Time API and LSEG Real-Time Advanced Distribution Server

As a distribution device for market data, the LSEG Real-Time Advanced Distribution Server delivers data from the LSEG Real-Time Advanced Distribution Hub. Because the LSEG Real-Time Advanced Distribution Server leverages multiple threads, it can offload the encoding, fan out, and writing of client data. By distributing its tasks in this fashion, LSEG Real-Time Advanced Distribution Server can support a large number of client applications.

The LSEG Real-Time Advanced Distribution Server communicates with its API clients via point-to-point communication.

4.3 LSEG Real-Time Advanced Distribution Hub

The **LSEG Real-Time Advanced Distribution Hub** is a networked, data distribution server that runs in the LSEG Real-Time Distribution System. It consumes data from a variety of content providers and reliably fans this data out to multiple LSEG Real-Time Advanced Distribution Servers over a multicast backbone. LSEG Real-Time API-based non-interactive or interactive provider applications can publish content directly into an LSEG Real-Time Advanced Distribution Hub, thus distributing data more widely across the network. Non-interactive provider applications can publish content to an LSEG Real-Time Advanced Distribution Hub via TCP or multicast connection types.

The LSEG Real-Time Advanced Distribution Hub leverages multiple threads, both for inbound traffic processing and outbound data fanout. By leveraging multiple threads, the LSEG Real-Time Advanced Distribution Hub can offload the overhead associated with request and response processing, caching, data conflation, and fault tolerance management. By offloading overhead in such a fashion, the LSEG Real-Time Advanced Distribution Hub can support high throughputs.

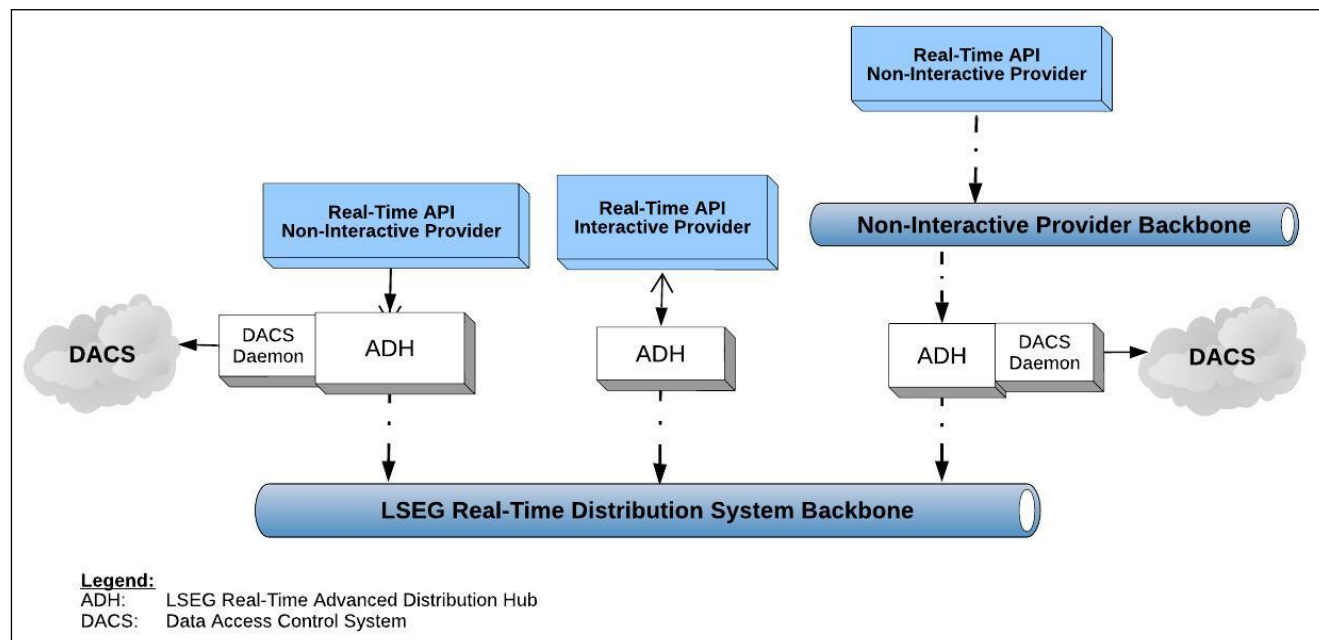


Figure 21. LSEG Real-Time API and the LSEG Real-Time Advanced Distribution Hub

4.4 Delivery Platform

The **Delivery Platform** is an open, global, ultra-high-speed network and hosting environment, which allows users to access and share a variety of content including Real-Time data. The Delivery Platform allows access to information from a wide network of content providers, including exchanges, where all exchange data is normalized using the Open Message Model.

Real-Time content, one of the content sets available via the Delivery Platform, can be obtained by consuming applications written to any Real-Time API or by connecting to on-prem LSEG Real-Time Distribution Systems (i.e., cascaded LSEG Real-Time Advanced Distribution Hub and LSEG Real-Time Advanced Distribution Server). Consumer applications authenticate and can discover endpoints via the Delivery Platform and use that information to connect to Real-Time -- Optimized (LSEG's cloud offering) which ultimately sources data from LSEG Real-Time infrastructure.

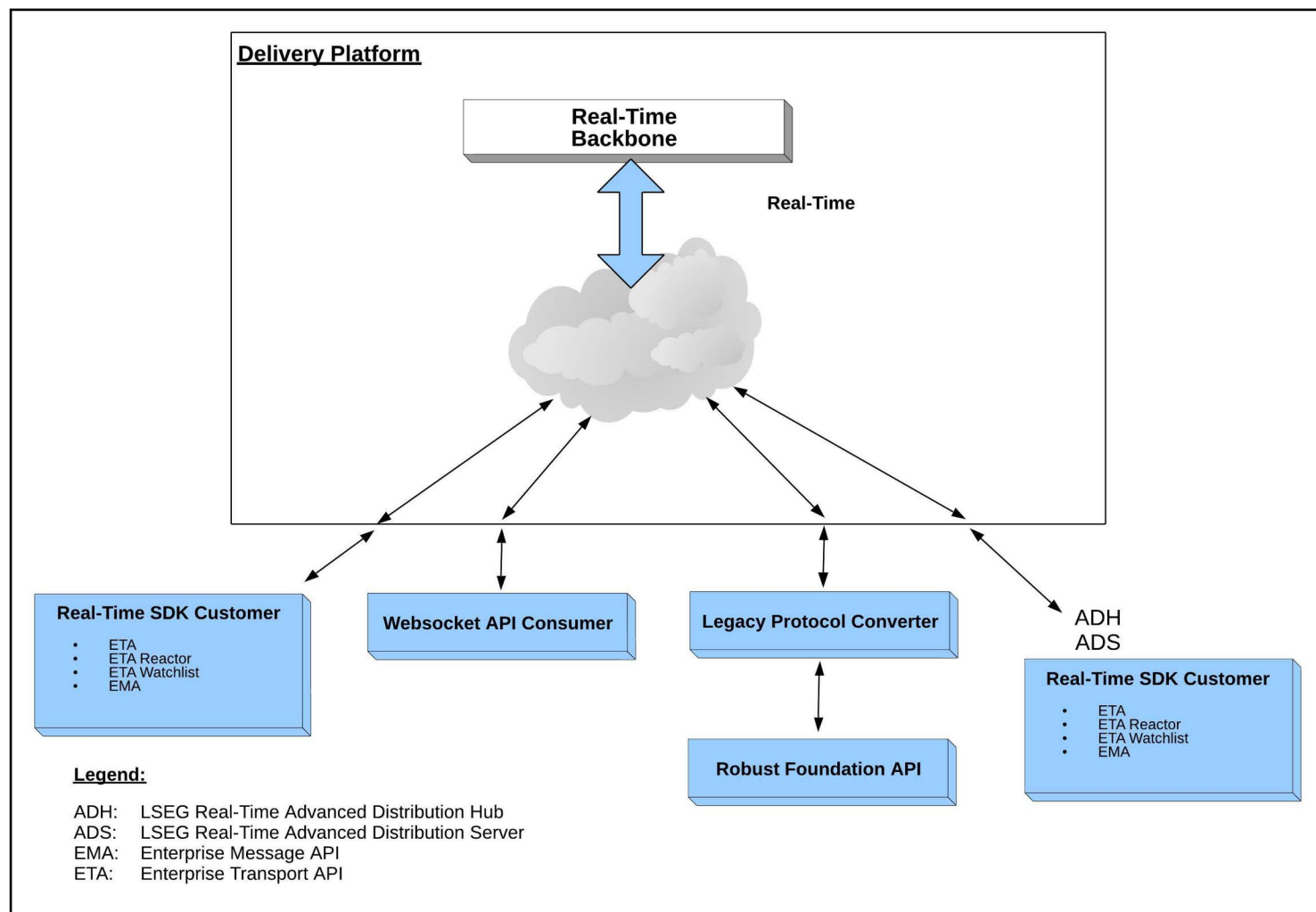


Figure 22. LSEG Real-Time APIs and Delivery Platform

4.5 Data Feed Direct

Data Feed Direct is a fully managed LSEG exchange feed providing an ultra-low-latency solution for consuming data from specific exchanges. The Data Feed Direct normalizes all exchange data using the Open Message Model.

To access this content, a LSEG Real-Time API consumer application can connect directly to the Data Feed Direct or via a cascaded LSEG Real-Time Distribution System architecture.

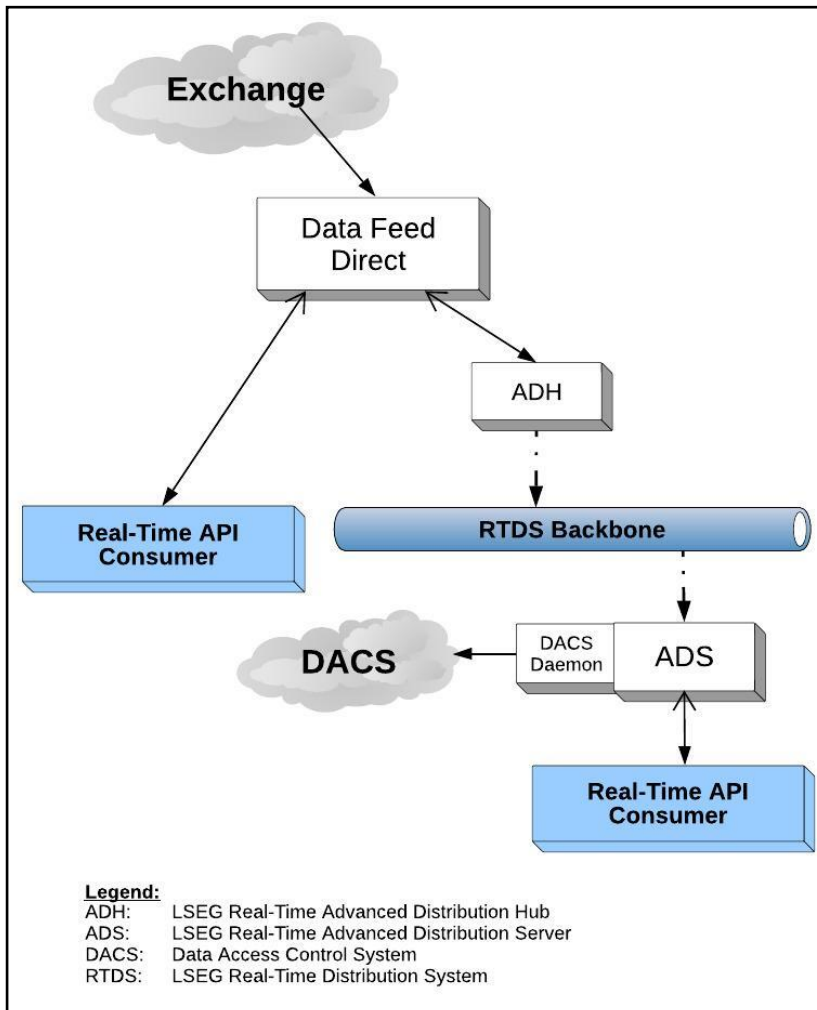


Figure 23. LSEG Real-Time API and Data Feed Direct

4.6 Connectivity via Encrypted Connections, HTTP and HTTPS

Consumer and provider applications can use the LSEG Real-Time API to establish encrypted connections or HTTPS (on certain platforms) over the public Internet.

- Consumer and non-interactive provider applications can establish connections via HTTP tunneling, socket and websocket connections.
- LSEG Real-Time Advanced Distribution Servers and OMM interactive provider applications can accept incoming LSEG Real-Time API connections tunneled via HTTP (such functionality is available across all supported platforms).
- Consumer applications can leverage HTTPS to establish an encrypted tunnel to certain LSEG hosted solutions, performing key and certificate exchange.

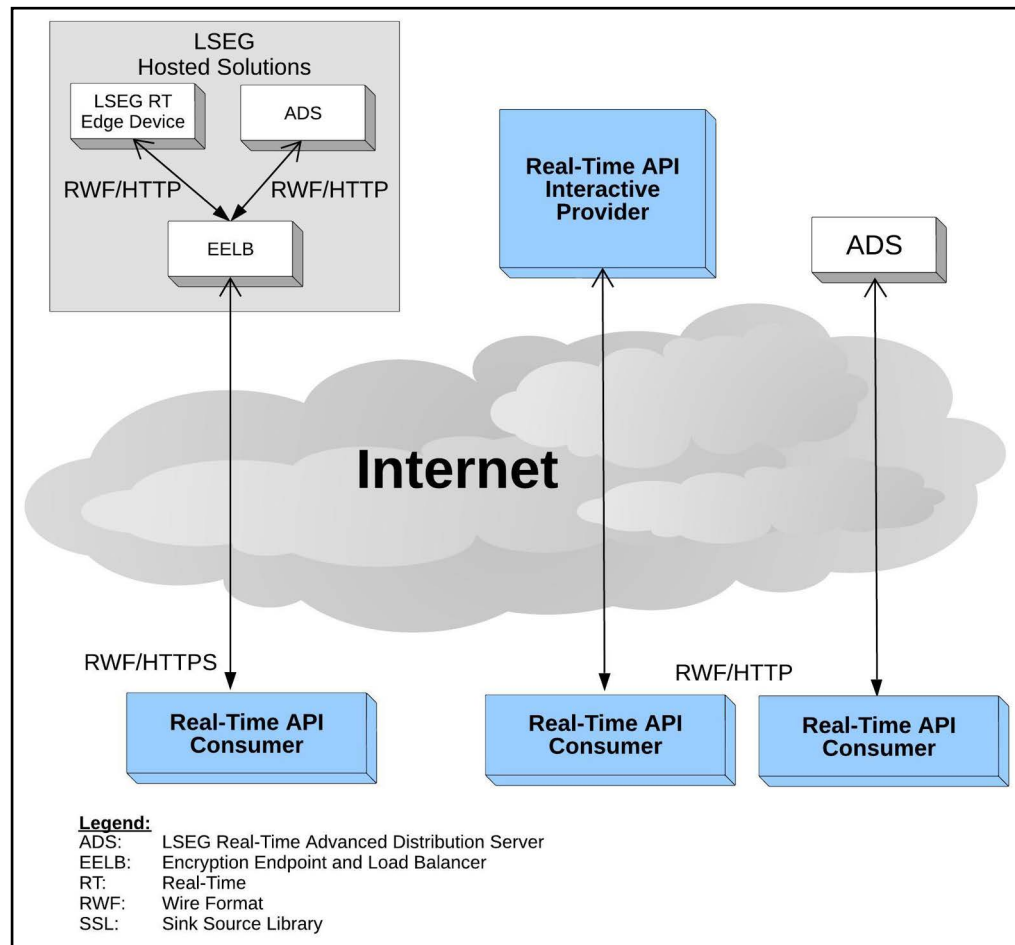


Figure 24. LSEG Real-Time API and Internet Connectivity

4.7 Direct Connect

The LSEG Real-Time API allows OMM interactive provider applications and consumer applications to directly connect to one another. This includes Open Message Model applications written to any LSEG Real-Time API. The following diagram illustrates various direct connect combinations.

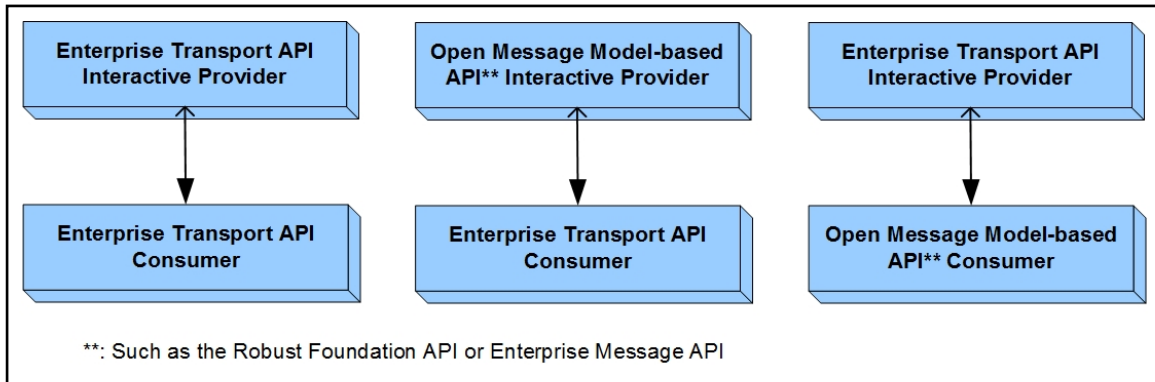


Figure 25. Transport API and Direct Connections

5 Data Types and Messaging Concepts

5.1 Overview of Data Types

The LSEG Real-Time API offer a wide variety of data types categorized into two groups:

- **Primitive Types:** A primitive type represents simple, atomically updating information such as values like integers, dates, and ASCII string buffers (refer to Section 5.2).
- **Container Types:** A container type can model data representations more intricately and manage dynamic content at a more granular level than primitive types. Container types represent complex information such as field identifier-value, name-value, or key-value pairs (refer to Section 5.3). LSEG Real-Time API offers several uniform, homogeneous container types (i.e., all entries house the same type of data). Additionally, there are several non-uniform, heterogeneous container types in which different entries can hold different types of data.

The following diagram illustrates the use of LSEG Real-Time API data types to resemble a composite pattern.

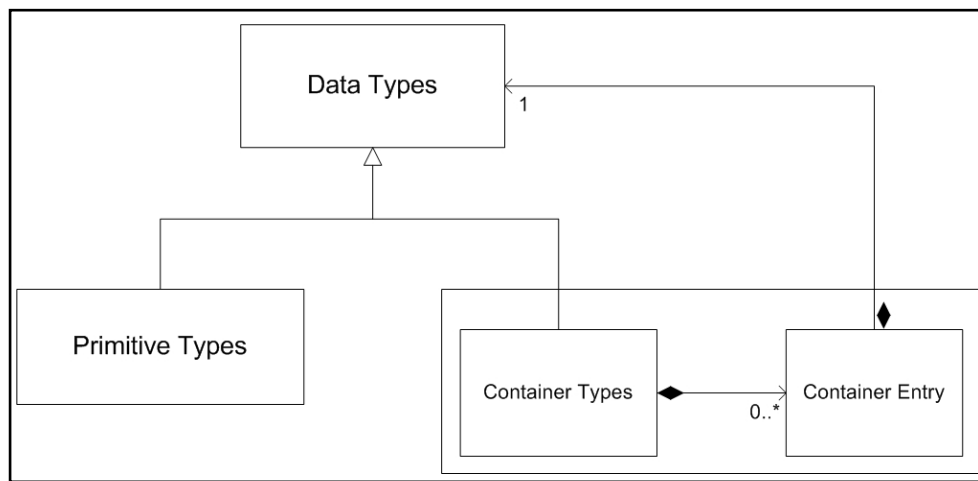


Figure 26. LSEG Real-Time API and the Composite Pattern

The diagram highlights the following:

- Being made up of both primitive and container types, LSEG Real-Time API data type values mirror the composite pattern's component.
- LSEG Real-Time API primitive types mimic the composite pattern's leaf, conveying concrete information for the user.
- The LSEG Real-Time API container type and its entries are similar to the composite pattern's composite. This allows for housing other container types and, in some cases such as field and element lists, housing primitive types.

The housing of other types is also referred to as **nesting**. Nesting allows:

- Messages to house other messages or container types
- Container types to house other messages, container, or primitive types

This provides the flexibility for domain model definitions and applications to arrange and nest data types in whatever way best achieves their goals.

5.2 Primitive Types

A primitive type represents some type of base, system information (such as integers, dates, or array values). If contained in a set of updating information, primitive types update atomically (incoming data replaces any previously held values). Primitive types support ranges from simple primitive types (e.g., an integer) to more complex primitive types (e.g., an array).

The following table provides a brief description of each base primitive type, along with interface methods used for encoding and decoding. Several primitive types have a more detailed description following the table.

PRIMITIVE TYPE	TYPE DESCRIPTION
None	Indicates that the type is unknown. This type is valid only when decoding a Field List type and a dictionary look-up is required to determine the type. This type cannot be passed into encoding or decoding functions.
Int ^a	A signed integer type. Can currently represent a value of up to 63 bits along with a one bit sign (positive or negative).
UInt ^b	An unsigned integer type. Can currently represent an unsigned value with precision of up to 64 bits.
Float	A four-byte, floating point type. Can represent the same range of values allowed with the system Float type. Follows IEEE 754 specification.
Double	An eight-byte, floating point type. Can represent the same range of values allowed with the system Double type. Follows IEEE 754 specification.
Real ^c	An optimized Wire Format representation of a decimal or fractional value which typically requires less bytes on the wire than Float or Double types. The user specifies a value with a hint for converting to decimal or fractional representation.
Date	Defines a date with month, day, and year values.
Time	Defines a time with hour, minute, second, millisecond, microsecond, and nanosecond values.
DateTime	Combined representation of date and time. Contains all members of date and time constructs.
Qos	Defines Quality of Service information such as data timeliness (e.g., real time) and rate (e.g., tick-by-tick). Allows a user to send Quality of Service information as part of the data payload. Similar information can also be conveyed using multiple message headers.
State	Represents data and stream state information. Allows a user to send state information as part of data payload. Similar information can also be conveyed in several message headers.
Enum ^d	Represents an enumeration type, defined as an unsigned, two-byte value. Many times, this enumeration value is cross-referenced with an enumeration dictionary (e.g., enumtype.def) or a well-known, enumeration definition (e.g., those contained in the package).
Array	The array type allows users to represent a simple base primitive type list (all primitive types except Array). The user can specify the base primitive type that an array carries and whether each is of a variable or fixed-length. Because the array is a primitive type, if any primitive value in the array updates, the entire array must be resent.
Buffer ^e	Represents a raw byte buffer type. Any semantics associated with the data in this buffer is provided from outside of the LSEG Real-Time API, either via a field dictionary (e.g., RDMFieldDictionary) or a Domain Model Message definition.
Buffer or String ^e (depends on the API)	Represents an ASCII string which should contain only characters that are valid in ASCII specification. Because this might be NULL terminated, use the provided length when accessing content. The LSEG Real-Time API do not enforce or validate encoding standards: this is the user's responsibility.

Table 4: LSEG Real-Time API Primitive Types

PRIMITIVE TYPE	TYPE DESCRIPTION
Buffer ^e	Represents a UTF8 string which should follow the UTF8 encoding standard and contain only characters valid within that set. Because this might be NULL terminated, use the provided length when accessing content. The LSEG Real-Time API do not enforce or validate encoding standards: this is the user's responsibility.
Buffer or RMTES buffer ^f (depends on the API)	Represents an RMTES string which should follow the RMTES encoding standard and contain only characters valid within that set. . The LSEG Real-Time API provides utility functions to help with proper storage and converting RMTES strings.

Table 4: LSEG Real-Time API Primitive Types (Continued)

- a. This type allows a value ranging from (-2^{63}) to $(2^{63} - 1)$.
- b. This type allows a value ranging from 0 up to $(2^{64} - 1)$.
- c. This type allows a value ranging from (-2^{63}) to $(2^{63} - 1)$. This can be combined with hint values to add or remove up to seven trailing zeros, fourteen decimal places, or fractional denominators up to 256.
- d. This type allows a value ranging from 0 to 65,535.
- e. The LSEG Real-Time API handles this type as opaque data, simply passing the length specified by the user and that number of bytes, no additional encoding or processing is done to any information contained in this type. Any specific encoding or decoding required for the information contained in this type is done outside of the scope of the LSEG Real-Time API, before encoding or after decoding this type. This type allows for a length of up to 65,535 bytes.
- f. This type allows for a length of up to 65,535 bytes.

5.3 Container Types

Container Types can model more complex data representations and have their contents modified at a more granular level than primitive types. Some container types leverage simple entry replacement when changes occur, while other container types offer entry-specific actions to handle changes to individual entries. An LSEG Real-Time API offers several uniform (i.e., homogeneous) container types, meaning that all entries house the same type of data. Additionally, there are several non-uniform (i.e., heterogeneous) container types in which different entries can hold varying types of data.

The **DataTypes** enumeration exposes values that define the type of a container. For example, when a **containerType** is housed in an **Msg**, the message would indicate the **containerType**'s enumerated value. Values ranging from 128 to 224 represent container types. An LSEG Real-Time API's messages and container types can house other LSEG Real-Time API container types. Only the **FieldList** and **ElementList** container types can house both primitive types and other container types.

The following table provides a brief description of each container type and its housed entries.

CONTAINER TYPE	DESCRIPTION	ENTRY TYPE INFORMATION
FieldList	A highly optimized, non-uniform type, that contains field identifier-value paired entries. fieldId refers to specific name and type information as defined in an external field dictionary (such as RDMFieldDictionary). You can further optimize this type by using set-defined data.	Entry type is FieldEntry , which can house any DataType , including set-defined data, base primitive types (Section 5.2), and container types. <ul style="list-style-type: none"> If the information and entry being updated contains a primitive type, previously stored or displayed data is replaced. If the entry contains another container type, action values associated with that type specify how to update the information.
ElementList	A self-describing, non-uniform type, with each entry containing name , dataType , and a value. This type is equivalent to FieldList , but without the optimizations provided through fieldId use. Use of set-defined data allows for further optimization.	Entry type is ElementEntry , which can house any DataType , including set-defined data, base primitive types (Section 5.2), and container types. <ul style="list-style-type: none"> If the updating information and entry contain a primitive type, any previously stored or displayed data is replaced. If the entry contains another container type, action values associated with that type specify how to update the information.
Map	A container of key-value paired entries. Map is a uniform type, where the base primitive type of each entry's key and the containerType of each entry's payload are specified on the Map .	Entry type is MapEntry , which can include only container types, as specified on the Map . Each entry's key is a base primitive type, as specified on the Map . Each entry has an associated action, which informs the user of how to apply the information stored in the entry.
Series	A uniform type, where the containerType of each entry is specified on the Series . This container is often used to represent table-based information, where no explicit indexing is present or required. As entries are received, the user should append them to any previously-received entries.	Entry type is SeriesEntry , which can include only container types, as specified on the Series . SeriesEntry types do not contain explicit actions; though as entries are received, the user should append them to any previously received entries.
Vector	A container of position index-value paired entries. This container is a uniform type, where the containerType of each entry's payload is specified on the Vector . Each entry's index is represented by an unsigned integer.	Entry type is VectorEntry , which can house only container types, as specified on the Vector . Each entry's index is an unsigned integer. Each entry has an associated action, which informs the user on how to apply the information stored in the entry.
FilterList	Entry type is FilterEntry , which can house only container types. Though the FilterList can specify a containerType , each entry can override this specification to house a different type. Each entry has an associated action, which informs the user of how to apply the information stored in the entry.	Entry type is FilterEntry , which can house only container types. Though the FilterList can specify a containerType , each entry can override this specification to house a different type. Each entry has an associated action, which informs the user of how to apply the information stored in the entry.
Msg	Indicates that the contents are another message. This allows the application to house a message within a message or a message within another container's entries. This type is typically used with posting.	None

Table 5: LSEG Real-Time API Container Types

5.4 Summary Data

Some container types allow summary data. **Summary data** conveys information that applies to every entry housed in the container. Using summary data ensures data is sent only once, instead of repetitively including data in each entry. An example of summary data is the currency type because it is likely that all entries in the container share the same currency. Summary data is optional and applications can determine when to employ it.

Specific domain model definitions typically indicate whether summary data should be present, along with information on its content. When included, the **containerType** of the summary data is expected to match the **containerType** of the payload information (e.g., if summary data is present on a **Vector**, the **Vector.containerType** defines the type of summary data and **VectorEntry** payload).

5.5 Messaging Concepts

Messages communicate data between system components: to exchange information, indicate status, permission users and access, and for a variety of other purposes. Many messages have associated semantics for efficient use in market data systems to request information, respond to information, or provide updated information. Other messages have relatively loose semantics, allowing for a more dynamic use either inside or outside market data systems.

An individual flow of related messages within a connection is typically referred to as a **stream**, and the message package allows multiple simultaneous streams to coexist in a connection. An information stream is instantiated between a consuming application and a providing application when the consumer issues a **RequestMsg** followed by the provider responding with a **RefreshMsg** or **StatusMsg**. At this point the stream is established and allows other messages to flow within the stream. The remainder of this chapter discusses streams, stream identification, and stream uniqueness.

5.6 Message Class Information

MESSAGE CLASS	DESCRIPTION
Request Message	Consumers use RequestMsg to express interest in a new stream or modify some parameters on an existing stream; typically results in the delivery of an RefreshMsg or StatusMsg .
Refresh Message	The Interactive Provider can use this class to respond to a consumer's request for information (solicited) or provide a data resynchronization point (unsolicited). The non-interactive provider can use this class to initiate a data flow on a new item stream. Conveys state information, QoS, stream permissioning information, and group information in addition to payload.
Update Message	Providers (of either type) use the UpdateMsg to convey changes to information on a stream. Update messages typically flow on a stream after delivery of a refresh.
Status Message	Indicates changes to the stream or data properties. A provider uses StatusMsg to close streams and to indicate successful establishment of a stream when there is no data to convey. This message can indicate changes: <ul style="list-style-type: none">• In streamState or dataState• In a stream's permissioning information To the item group to which the stream belongs
Close Message	A consumer uses CloseMsg to indicate no further interest in a stream. As a result, the stream should be closed. <ul style="list-style-type: none">• The Transport API allows direct use of the Close message.• The Message API implicitly handles this messaging functionality whenever a user unregisters.
Generic Message	A bi-directional message that does not have any implicit interaction semantics associated with it, thus the name generic. After a stream is established via a request-refresh/status interaction: <ul style="list-style-type: none">• A consumer can send this message to a provider.• A provider can send this message to a consumer.• A non-interactive provider can send this message to the LSEG Real-Time Advanced Distribution Hub.
Post Message	A consumer uses PostMsg to push content upstream. This information can be applied to an LSEG Real-Time Distribution System cache or routed further upstream to a data source. After receiving posted data, upstream components can republish it to downstream consumers.
Ack Message	A provider uses AckMsg to inform a consumer of success or failure for a specific PostMsg or CloseMsg .

Table 6: Message Class Information

5.7 Permission Data

Permission Data is optional authorization information. The DACS Lock API provides functionality for creating and manipulating permissioning information. For more information on Data Access Control System usage and permission data creation, refer to the *LSEG Real-Time API DACS LOCK Library Reference Manual* specific to the API that you use.

Permission data can be specified in some messages. When permission data is included in a **RefreshMsg** or a **StatusMsg**, this generally defines authorization information associated with all content on the stream. You can change permission data on an existing stream by sending a subsequent **StatusMsg** or **RefreshMsg** which contains the new permission data. When permission data is included in an **UpdateMsg**, this generally defines authorization information that applies only to that specific **UpdateMsg**.

Permission data can also be specified in some container entries. When a container entry includes permission data, it generally defines authorization information that applies only to that specific container entry. Specific usage and inclusion of permissioning information can be further defined within a domain model specification.

Permission data typically ensures that only entitled parties can access restricted content. On LSEG Real-Time Distribution System, all content is restricted (or filtered) based on user permissions.

When content is contributed, permission data in a **PostMsg** is used to permission the user who posts the information. If the payload of the **PostMsg** is another message type with permission data (i.e., **RefreshMsg**), the nested message's permissions can change the permission expression associated with the posted item. If permission data for the nested message is the same as permission data on the **PostMsg**, the nested message does not need permission data.

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