SYBASE®
An SAP® Company

Getting Started Guide

SAP Sybase Event Stream Processor 5.1 SP02

DOCUMENT ID: DC01622-01-0512-01
LAST REVISED: April 2013

Sybase, Inc., One Sybase Drive, Dublin, CA 94568.

Contents

CHAPTER 1 Getting Started with SAP Sybase Event Stream Processor

SAP® Sybase® Event Stream Processor enables you to create and run your own complex event processing (CEP) applications to derive continuous intelligence from streaming event data in real time.

Event stream processing is a form of CEP, a technique for analyzing information about events, in real time, for situational awareness. When vast numbers of event messages are flooding in, it is difficult to see the big picture. With event stream processing, you can analyze events as they stream in and identify emerging threats and opportunities as they happen. Event Stream Processor filters, aggregates, and summarizes data to enable better decision making based on more complete and timely information.

SAP Sybase Event Stream Processor includes both:

- A development platform, called ESP Studio, for building and testing event-based applications, without significant programming effort.
- A run-time environment optimized for enterprise-scale, event-driven applications. ESP Server processes data continually as it arrives, before storing it on disk, thus achieving extremely high throughput and low latency, enabling better decision making based on more complete and timely information.

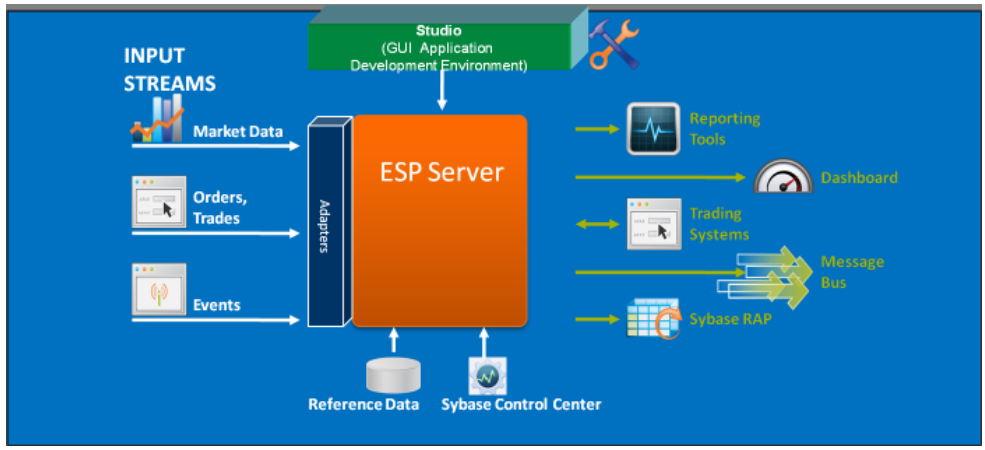
SAP Sybase Event Stream Processor does not replace databases. Unlike traditional databases that are designed for on-demand queries and transaction processing, SAP Sybase Event Stream Processor is optimized for continuous queries. Thus, it complements traditional databases to help solve new classes of problems where continuous, event-driven data analysis is required.

Event Stream Processor Deployments

Data flows into ESP Server from external sources through built-in or custom adapters, which translate incoming messages into a format that is accepted by ESP Server.

This figure shows a typical Event Stream Processor deployment. Continuous queries, developed and tested as projects using the ESP Studio, are deployed to ESP Server. Output adapters translate rows processed by ESP Server into message formats that are compatible with external destinations such as SAP RAP, and send those messages downstream. Sybase Control Center provides an operations console for monitoring and managing ESP Server.

Figure 1: Event Stream Processor Architecture



Next Steps
Use this guide to:

- Learn key concepts
- Try out the development platform by building a simple project
- Watch a running application

Key Terms and Concepts

Events, projects, streams and windows, and continuous queries are the basics of data-flow programming in Event Stream Processor.

Events

A business event is a message that contains information about an actual business event that occurred. Many business systems produce streams of such events as things happen.

Examples of business events that are often transmitted as streams of event messages include:

- Financial market data feeds that transmit trade and quote events, where each event may consist of ticket symbol, price, quantity, time, and so on
- Radio Frequency Identification System (RFID) sensors that transmit events indicating that an RFID tag was sensed nearby
- Click streams, which transmit a message (a click event) each time a user clicks a link, button, or control on a Web site
- Database transaction events, which occur each time a record is added to a database or updated in a database

ESP Projects: Streams, Windows, Adapters, and Continuous Queries

An ESP project is like an application, consisting of a set of event streams, any other required datasources, and the business logic applied to incoming event data to produce results.

At its most basic level, a project consists of:

- **Input streams and windows –** where the input data flows into the project. An input stream can receive incoming event data on an event-driven basis, and can also receive static or semistatic sets of data that are loaded once or periodically refreshed. Input streams that have state—that is, they can retain and store data—are called windows.
- **Adapters –** connect an input stream or window to a datasource. Event Stream Processor includes a large set of built-in adapters as well as an SDK that you can use to build custom adapters. Adapters can also connect an output stream or window to a destination. While an adapter connects the project to external inputs and outputs, technically it is not part of the project.
- **Derived streams and windows –** take data from one or more streams or windows and apply a continuous query to produce a new stream or window. Derived streams that have state are windows.

Streams and Windows

Both streams and windows process events. The difference is that windows have state, meaning they can retain and store data, while streams are stateless and cannot.

Streams process incoming events and produce output events according to the continuous query that is attached to the stream, but no data is retained.

A window consists of a table where incoming events can add rows, update existing rows, or delete rows. You can set the size of the window based on time, or on the number of events recorded. For example, a window might retain all events over the past 20 minutes, or the most recent 1,000 events. A window can also retain all events. In this case, the incoming event stream must be self-managing in that it contains events that both insert rows into the window and delete rows from the window, so that the window does not grow infinitely large. Windows are needed for performing aggregate operations, as this cannot be done on streams.

Data-Flow Programming

SAP® Sybase® Event Stream Processor uses data-flow programming for processing event streams.

In data-flow programming, you define a set of event streams and the connections between them, and apply operations to the data as it flows from sources to outputs.

Data-flow programming breaks a potentially complex computation into a sequence of operations with data flowing from one operation to the next. This technique also provides scalability and potential parallelization, since each operation is event driven and

independently applied. Each operation processes an event only when it is received from another operation. No other coordination is needed between operations.

The sample project shown in the figure shows a simple example of this.

Each of the continuous queries in this simple example—the VWAP aggregate, the IndividualPositions join object, and the ValueByBook aggregate—is a type of derived stream, as its schema is derived from other inputs in the diagram, rather than originating directly from external sources. You can create derived streams in a diagram using the simple query elements provided in the Studio Visual editor, or by defining your own explicitly.

Figure 2: Data-Flow Programming - Simple Example

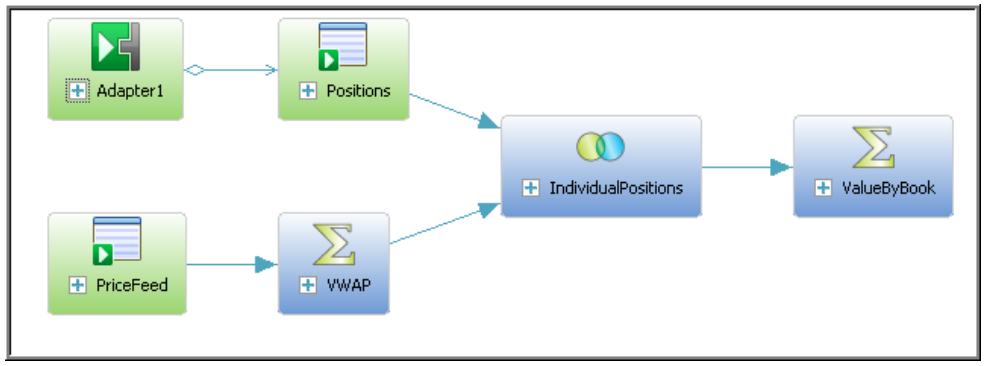
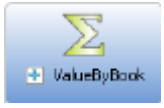


Table 1. Data-Flow Diagram Contents

Element	Description
PriceFeed 	Represents an input window, where incoming data from an external source complies with a schema consisting of five columns, similar to a database table with columns. The difference is that in ESP, the streaming data is not stored in a database.
Positions 	Another input window, with data from a different external source. Both Positions and PriceFeed are included as windows, rather than streams, so that the data can be aggregated.
VWAP 	Represents a simple continuous query that performs an aggregation, similar to a SQL Select statement with a Group By clause.

Element	Description
IndividualPositions 	Represents a simple continuous query that performs a join of Positions and VWAP, similar to a SQL FROM clause that produces a join.
ValueByBook 	Another simple query that aggregates data from the stream Individual Positions.

See also

- *The Sample Project* on page 18
- *Diagrams* on page 12

Getting Results from an ESP Project

Event Stream Processor has four ways to get output from a running project.

- Applications receive information automatically from internal output adapters attached to a stream when you build the project.
- Applications can subscribe to data streams by means of an external subscriber, which users can create using subscription APIs provided with the product.
- Users can start a new project that binds (connects) to a stream in a running project, without reconfiguring the project.
- Users can run on-demand queries against output windows in a running ESP project. This is similar to querying a database table.
  - From the command line, using the esp_query tool. For more information see the *Utilities Guide*.
  - In ESP Studio, using the SQL Query view tools.

Operation Codes

The operation code (opcode) of an event record specifies the action to perform on the underlying store of a window for that event.

In many Event Stream Processor use cases, events are independent of each other: each carries information about something that happened. In these cases, a stream of events is a series of independent events. If you define a window on this type of event stream, each incoming event is inserted into the window. If you think of a window as a table, the new event is added to the window as a new row.

In other use cases, events deliver new information about previous events. The ESP Server needs to maintain a current view of the set of information as the incoming events continuously update it. Two common examples are order books for securities in capital markets, or open

orders in a fulfillment system. In both applications, incoming events may indicate the need to:

- Add an order to the set of open orders,
- Update the status of an existing open order, or,
- Remove a cancelled or filled order from the set of open orders.

To handle information sets that are updated by incoming events, Event Stream Processor recognizes the following opcodes in incoming event records:

- **insert –** Insert the event record.
- **update –** Update the record with the specified key. If no such record exists, it is a runtime error.
- **delete –** Delete the record with the specified key. If no such record exists, it is a runtime error.
- **upsert –** If a record with a matching key exists, update it. If a record with a matching key does not exist, insert this record.
- **safedelete –** If a record with a matching key exists, delete it. If a record with a matching key does not exist, do nothing.

All event records include an opcode. Each stream or window in the project accepts incoming event records and outputs event records. Output events, including opcodes, are determined by their source (stream, window, or delta stream) and the processing specified for it.

Refer to the *Streams*, *Windows*, and *Delta Streams* topics in the *Programmers Guide* for details on how each interprets the opcodes on incoming event records and generates opcodes for output records.

What You Can Do with SAP Sybase Event Stream Processor

Application developers use the ESP Studio, including the Visual editor, Text editor, and testing tools, to develop event-based applications. You can also develop custom adapters using the SDKs.

Table 2. Event Stream Processor Capabilities by User Role

User	What You Can Do
Application developer	Use the ESP Studio to create sophisticated data-flow applications in the Visual editor, a graphical authoring environment. Use the text editor in ESP Studio to develop projects in the Continuous Computation Language (CCL). Switch between the fully integrated editors, and see changes in one editor immediately reflected in the other. Create custom operators and external functions by embedding SPLASH scripts in your CCL code or diagram. Test compiled projects by running them on a local or remote server in ESP Studio Run-Test perspective. Watch data flow through the project, record and play back in-flowing data, trace events, set breakpoints and watch variables on stream inputs and outputs, monitor performance, execute continuous and on-demand queries, and more. Create, run, and test projects using command-line tools as an alternative to ESP Studio.
Adapter developer	Create custom input and output adapters in Java, C/C++, or .NET (C#) using one of the SDKs provided with Event Stream Processor. Integrate custom function libraries using the SDKs.

User	What You Can Do
Business analyst	Design continuous queries in the ESP Studio Visual editor with minimal knowledge of programming. Run projects in ESP Studio before production deployment, to ensure that they satisfy your business requirements. Issue on-demand queries on a running ESP project.
Administrator	Configure ESP server clusters for production scale processing volume and performance. Run multiple projects simultaneously, apply centralized security, manage connections. Ensure stability with high availability and failover options. Monitor and manage ESP Server and user access in the Sybase Control Center operations console, and using command-line tools.

Beyond the Basics

An ESP project can take advantage of a broad set of features.

In addition to the basic elements of input streams, adapters, and output streams, a project may include:

- Derived streams
- SPLASH code
- External C code
- Custom adapters
- Modules that can be developed independently and loaded into a project
- Named schemas that store reusable schema definitions

See the *Examples Guide* for code samples that demonstrate CCL and SPLASH.

See the *Adapters Guide* for sample code for custom adapters.

See also

- *SPLASH* on page 41
- *CCL for Sample Project with Modules* on page 46

CHAPTER 2 Getting Started in ESP Studio

To begin developing a project, start ESP Studio, review workspace basics, and optionally step through an example before creating your own project.

Starting ESP Studio

Start ESP Studio from the desktop shortcut, Windows Start menu, or the command line. From your desktop or workstation:

Platform	Method
Windows	• Double-click the **SAP Sybase ESP Studio** shortcut on your computer desktop, or, • Select **Start** > **Programs** > **Sybase** > **Event Stream Processor 5.1** > **Studio** > **Studio**.
Linux or UNIX	• Double-click the **SAP Sybase ESP Studio** shortcut on your computer desktop, or, • At the command line, enter `$ESP_HOME/studio/esp-studio`.

See also

- *Exploring the ESP Studio Workspace* on page 9
- *Studio Authoring Views and Editors* on page 11
- *Diagrams* on page 12
- *Sample Projects in the Learning Perspective* on page 13
- *Running a Sample Project* on page 15
- *Project Execution and Testing* on page 16

Exploring the ESP Studio Workspace

Explore ESP Studio perspectives and views to discover what you can do.

Use the sample projects to see examples of different project structures and diagrams in the Visual editor.

1. (Optional) On the Welcome screen, use the buttons to navigate to the help, or close the Welcome screen tab.

- Click **Product Overview** or **Getting Started** to open the help.
- Click **Learning** to open Studio in the Learning perspective.
- Click **Studio** to open Studio in the Authoring perspective.

2. To switch to another perspective, click its tab just below the main menu bar.
3. Click **Learning** to:
   - Load example projects
   - Step through example projects so that you can follow what happens when you subscribe to streams, publish demonstration data, and view results

   Note: Activities you initiate in Learning perspective open in Authoring and Run-Test perspectives.
4. Click the **Authoring** tab in Studio to:
   - Create and edit projects
   - Develop projects and diagrams in the Visual editor, a graphical editing environment
   - Develop projects in the CCL editor, a text-oriented editing environment where you edit CCL code
   - Compile projects
   - Import Aleri models
5. Click the **Run-Test** tab in Studio to:
   - Connect to servers
   - Run projects
   - Enter test data by uploading data files to a server, or entering data manually to a stream
   - Publish data
   - Execute a query against a running project
   - Use the Event Tracer and Debugger to set breakpoints and watchpoints, and trace the flow of data through a project
   - Record incoming event data to a playback file, and play back captured data into a running project
   - Monitor performance

Note: For more information on tasks and concepts introduced in this *Getting Started Guide*, see the *Studio Users Guide*.

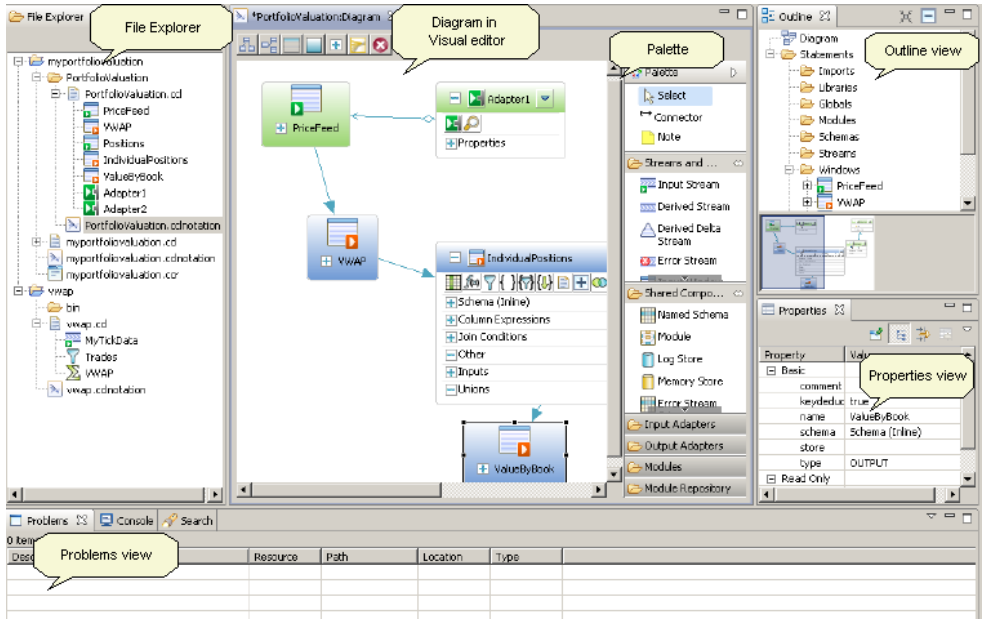
See also

- *Starting ESP Studio* on page 9
- *Studio Authoring Views and Editors* on page 11
- *Diagrams* on page 12
- *Sample Projects in the Learning Perspective* on page 13
- *Running a Sample Project* on page 15
- *Project Execution and Testing* on page 16

Studio Authoring Views and Editors

The Visual editor, CCL editor, and other tools and views in the Authoring perspective allow you to create, view, and edit a diagram or CCL file.

Figure 3: Authoring Perspective Views



- **Editor –** canvas at the center of the Authoring perspective where you edit the diagram (in the Visual editor) or CCL (in the CCL editor). The Visual and CCL text editors are completely integrated. When you save and switch to the other editor, your work is saved there as well.
- **Palette –** includes groups of tools used to create new CCL elements on the diagram. Most shapes on the Palette correspond to a CCL statement.
- **File Explorer –** provides a hierarchical tree structure of folders and files.
- **Properties view –** displays the properties of the object selected in the diagram. You can also set properties in this view, and edit expressions.
- **Outline view –** provides an index to all elements in the diagram as a hierarchical tree structure. Also shows the order in which adapters are started. Right-click an element in this view to show it in the diagram, delete it, modify it, or add a child element.

- **Overview –** helps you understand the big picture, and navigate easily to different areas of a large, complex diagram. For large diagrams you can scroll the editor by dragging the gray box in the overview.
- **Search –** provides full-text search capability for finding text strings in the workspace. Useful in navigating File Explorer, and project contents in the CCL editor. You can filter search results, and copy, remove, or replace results found.
- **Problems –** displays errors found when you compile a project or convert an Aleri model to CCL.
- **Console –** displays messages generated when interacting with ESP components.

Note: ESP Studio lets you customize the arrangement of views in your perspectives. See *Customizing the Studio Work Environment* in the *Studio Users Guide*.

See also

- *Starting ESP Studio* on page 9
- *Exploring the ESP Studio Workspace* on page 9
- *Diagrams* on page 12
- *Sample Projects in the Learning Perspective* on page 13
- *Running a Sample Project* on page 15
- *Project Execution and Testing* on page 16

Diagrams

In visual authoring, you use diagrams to create and manipulate the streams, windows, connections, and other components of a project, and create simple queries.

When you open a project in the Visual editor, the project shows a collection of stream and window shapes that are connected with arrows showing the flow of data. You develop the project by selecting new input and output streams, windows, and other elements from the Palette, dropping them onto the diagram, connecting them, and configuring their behavior.

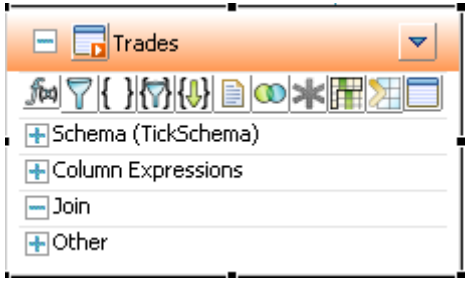
Every project has at least one diagram. A diagram in the Visual editor is a projection of the associated CCL statements in the project.

When you add a shape or other element to a diagram, it is automatically added to the project when you save. You can delete an element from a diagram only, or from the project.

Display diagrams in verbose or iconic mode:

- **iconic –** compartments are collapsed to save space.

- **verbose –** all compartments in elements are visible.



- To expand or collapse all shapes in the diagram, use the All Verbose or All Iconic buttons on the main toolbar.
- To expand an individual shape, select it and click the "+" box in the shape.
- To collapse an individual shape, select it and click the "-" box in the shape header.

See also

- *Starting ESP Studio* on page 9
- *Exploring the ESP Studio Workspace* on page 9
- *Studio Authoring Views and Editors* on page 11
- *Sample Projects in the Learning Perspective* on page 13
- *Running a Sample Project* on page 15
- *Project Execution and Testing* on page 16
- *Data-Flow Programming* on page 3

Sample Projects in the Learning Perspective

Event Stream Processor Studio includes several example projects.

You can view the examples in ESP Studio and run them against sample data installed with the product. Stepping through examples in the Studio Learning perspective is an ideal way to watch a simplified set of event data flow through the system.

The examples include:

- **IndexesCalculation –** Shows how continuous computations can be applied to a stream of market prices to deliver insight into the market. This example demonstrates reusable modules. Each of the market calculations is defined in an external module, that is, a

module defined in a separate CCL file, and then imported into the project. Parameters (in this case, time and itnervals) are set when the module is called.

- **Pattern Matching –** Simple example of situation detection: watching for a pattern of events. The scenario in this example is to watch for employee fraud in a retail setting, based on transaction patterns from a point-of-sale system. The example applies three Filter queries to an input stream of transactions, and then uses a Pattern query (CCL MATCHING clause) to produce a Possible Fraud Alert event when all of the criteria occur in the defined time interval.
- **Prepay Biller –** Loads call events (CDRs), such as those generated from a telephone carrier network, and applies account and call plan information to create a billing record for each call, and maintain a balance of prepaid minutes. The example demonstrates joins, aggregation, and using joins to augment the events with reference data.
- **Top 3 Prices –** Creates a window showing the top three distinct trade prices for each symbol. The example uses a Flex operator to create a custom operator with an embedded SPLASH script. A Flex operator creates a single output stream or window, and allows greater flexibility and control than a simple SELECT statement. The example also uses a named schema, which can be defined once and shared by the input stream and output window.
- **VWAP –** Defines an input stream of stock market prices, as they might be reported from an exchange, and computes a moving average price called the volume weighted average price (VWAP). Uses a filter, and a simple aggregation (GROUP BY).

For details of each example, click the example name in the Learning Perspective.

For more examples of CCL and SPLASH code, see the *Examples Guide* and the *Programmers Guide*.

See also

- *Starting ESP Studio* on page 9
- *Exploring the ESP Studio Workspace* on page 9
- *Studio Authoring Views and Editors* on page 11
- *Diagrams* on page 12
- *Running a Sample Project* on page 15
- *Project Execution and Testing* on page 16
- *The Sample Project* on page 18
- *Chapter 3, Building a Simple Project* on page 17

Running a Sample Project

Load and run one of the example projects installed with the product, so that you can view end-to-end project execution in your workspace.

Prerequisites

To run these examples, you may need to disable McAfee host intrusion prevention. See your McAfee documentation for details.

Task

1. Navigate to the Learning perspective.
2. Close the Welcome view.
3. In Examples view, click example titles to see descriptions.
4. Click **LOAD** to load an example into your workspace and start the Examples project. File Explorer shows all example projects, plus any other projects you have created.
5. If the Add Local Password dialog appears, enter the password for the studio user.

   You define a password for the studio user once per ESP Studio session. The first time you are asked for a password, Studio accepts any value. The next time you are prompted within the same session, you need to specify the same password. In your next Studio session, you can select a new password or keep the same one.
6. Click **Proceed**.
   The dialog shows Progress Information. Server view shows ESP localhost and connection information.
7. Click **Proceed** to subscribe to the example stream.
   The Console shows a series of status messages.
8. Click **Proceed** to publish example data.
   Stream view shows each stream in a separate tab. For example, the IndexesCalculation example opens four tabs, with one input stream and three output streams. You may need to expand the project in Server view and double-click each stream to open it in Stream view.

Next

Run a second example. Server View now shows both examples. Expand it to show all streams for each example.

See also

- *Starting ESP Studio* on page 9
- *Exploring the ESP Studio Workspace* on page 9
- *Studio Authoring Views and Editors* on page 11
- *Diagrams* on page 12

- *Sample Projects in the Learning Perspective* on page 13
- *Project Execution and Testing* on page 16

Project Execution and Testing

ESP Studio lets you run and test all aspects of a project.

During development, you can use ESP Studio to run any compiled project against a local or remote server, view data flowing through the streams and windows defined in the project, execute queries, and use debugging tools. Your project configuration and licensing determine the type of server connections you can use when running projects. Some adapters also have special licensing requirements.

In ESP Studio you can connect immediately to a local cluster to run projects, using default security established for ESP Studio during installation. A cluster consists of a group of server nodes, which are processes that run on hosts. A cluster can have a single node or multiple nodes.

In a production environment, you typically run projects on a remote server. Administrators monitor and manage ESP Server nodes, clusters, and projects using Sybase Control Center, a Web-based administrative tool for production deployments, and using the command-line utilities and procedures discussed in the *Administrators Guide*.

See also

- *Starting ESP Studio* on page 9
- *Exploring the ESP Studio Workspace* on page 9
- *Studio Authoring Views and Editors* on page 11
- *Diagrams* on page 12
- *Sample Projects in the Learning Perspective* on page 13
- *Running a Sample Project* on page 15
- *Chapter 4, Testing Your Project* on page 33

CHAPTER 3 Building a Simple Project

Walk through this hands-on tutorial to create a simple project in the Visual editor.

The sample project demonstrates how you can easily define event streams and windows by attaching a previously configured adapter and discovering its schema, or by manually defining a window and its schema. It shows you how to define continuous queries—aggregations, joins, and more—using the visual tools.

Begin by reviewing background information that helps you understand the project. Then complete the tasks to build the project.

1. *Reviewing Concepts*

   Begin the tutorial by reading a description of the sample project, and concepts applied in it.
2. *Creating the Sample Project*

   Use the Studio to define a new set of processing instructions for event data.
3. *Editing a Project Diagram*

   Edit projects in the Visual editor by adding shapes from the Palette to the project diagram, connecting them, and completing the configuration of each shape.
4. *Adding an Input Adapter*

   Attach an adapter by inserting it in the diagram, connecting it to a stream or window, and setting properties.
5. *Discovering a Schema*

   Use the Schema Discovery button in the Adapter shape to discover and automatically create a schema based on the format of the data from the adapter.
6. *Adding an Input Window Manually*

   Add an input window to the diagram in the sample PortfolioValuation project.
7. *Creating an Aggregate as a Simple Query*

   Add to the sample diagram an Aggregate simple query to create a volume weighted average price (VWAP).
8. *Creating a Join as a Simple Query*

   Add a join to the sample project. A join combines events from two or more inputs to create a single stream or window. It is similar to a join in SQL.
9. *Completing the Sample Project*

   Add a new aggregate, and clean up the diagram by removing unused elements.

Reviewing Concepts

Begin the tutorial by reading a description of the sample project, and concepts applied in it.

See also

- *Creating the Sample Project* on page 21

The Sample Project

The PortfolioValuation project that you build in this tutorial applies current prices to a portfolio of investments to compute the value of each investment and of the portfolio. It uses simple queries to aggregate and join data from two input windows.

The example:

1. Receives a stream of prices in an input window called PriceFeed. The schema for this window has five columns: Id, Symbol, Price, Shares, and TradeTime. The window uses the Id field as a primary key, and is set to keep the last 10 minutes of price events.
2. Applies an Aggregate simple query to create a 10-minute moving average—a volume weighted average price (VWAP). With the VWAP, you can see the value of positions based on the average price, rather than see the value of your positions change with every small price movement. The VWAP formula is calculated as:

   ```
   sum(PriceFeed.Price *
        PriceFeed.Shares) /
        sum(PriceFeed.Shares)
   ```
3. Reads data from another input window, Positions, with three columns: BookId, Symbol, and SharesHeld.
4. Applies a Join simple query, joining the market price (from the VWAP aggregate) to your holdings (Positions), so that you can see the value of your position in each stock:

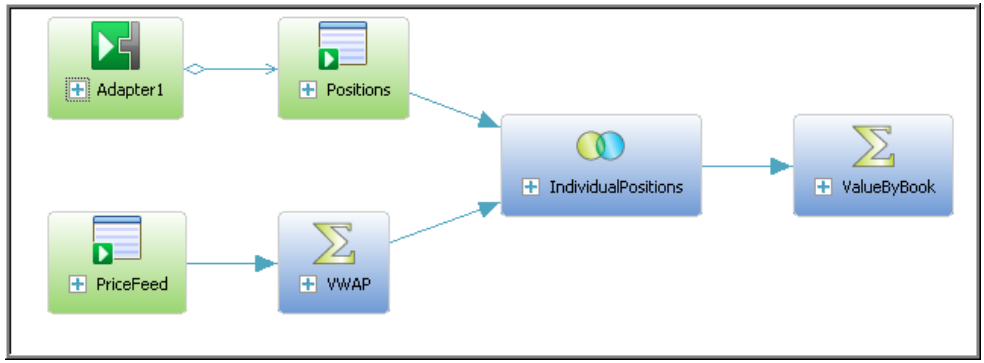
   ```
   FROM VWAP
   RIGHT JOIN Positions
   ON
   VWAP.Symbol = Positions.Symbol
   ```
5. Applies one more aggregation to show the total value of each "book." This aggregate, ValueByBook, groups current and average values for individual positions into different "books." Each book may comprise a set of investment portfolios or funds. In the CCL, a GROUP BY clause performs the aggregation:

   ```
   CREATE  OUTPUT  WINDOW ValueByBook

        PRIMARY KEY DEDUCED
        AS
        SELECT IndividualPositions.BookId  BookId,
           sum(IndividualPositions.CurrentPosition)
   CurrentPosition,
           sum(IndividualPositions.AveragePosition)  AveragePosition
   ```

```
    FROM IndividualPositions
    GROUP BY IndividualPositions.BookId ;
```

Figure 4: Portfolio Valuation Sample Diagram (Iconic Mode)



See also

- *CCL for the Sample Project* on page 44

Schema Discovery Using Input Adapters

In the tutorial you use the schema discovery feature to discover an external schema and create a CCL schema based on the format of the data from the datasource connected to an adapter.

Input Adapters in the Diagram

An input adapter identifies the external source for the input stream or window, and translates it into a format that Event Stream Processor Server accepts. You can add adapters to the diagram before or after adding input and output streams or windows.

ESP provides a set of built in adapters for common databases, message bus, file systems, sockets, and more. You can also develop custom adapters using the SDK, in C/C++, Java, or .NET. Most adapters provided can be used as input or output adapters.

Schema Discovery Basics

Every row in a stream or window must have the same structure, or schema, which includes the column names, the column datatypes, and the order in which the columns appear. Multiple streams or windows may use the same schema, but a stream or window can only have one schema.

Rather than manually creating a new schema, you can use schema discovery to discover and automatically create a schema based on the format of the data from the datasource connected to your adapter. For example, for the Database Input adapter, you can discover a schema that corresponds to a specific table from a database the adapter is connected to. In the tutorial, you discover the schema for the PriceFeed input window from the File XML Input adapter.

To discover a schema, you need to first configure the adapter properties. Each adapter that supports schema discovery has unique properties that must be set to enable schema discovery.

For a list of adapters that support schema discovery and properties to configure, see the *Studio Users Guide*. For property details, see your adapter type in the *Adapters Guide*.

See also

- *Adding an Input Adapter* on page 23
- *Discovering a Schema* on page 24

Simple Queries

Accomplish most common querying tasks using a set of simple queries available in the Visual editor: filter, aggregate, join, compute, union, and pattern.

The tools for these six queries are available as objects in the Palette, in Streams and Windows.

- **Filter –** allows you to filter a stream down to only the events of interest, based on a filter expression. Similar to SQL WHERE clause.
- **Aggregate –** allows you to group events that have common values and compute summary statistics for the group, such as an average. You can also define a window size, based on either time or number of events. Uses the CCL GROUP BY clause, similar to SQL GROUP BY.
- **Join –** allows you to combine records from multiple streams or windows, forming a new record with information from each source. Comparable to a join in SQL, where you specify two or more sources in the FROM clause.
- **Compute –** allows you to create a new event with a different schema, and compute the value to be contained in each column (field) of the new event. Comparable to a projection in SQL, where you use a SELECT statement to specify the column expressions, and FROM to specify a single source.
- **Union –** allows you to combine multiple streams or windows that all share a common schema into a single stream or window. Similar to SQL UNION operator.
- **Pattern –** lets you watch for patterns of events within a single stream or window or across multiple streams and windows. When ESP Server detects an event pattern in a running project, it produces an output event. This uses the CCL MATCHING clause.

See also

- *Creating an Aggregate as a Simple Query* on page 27
- *Creating a Join as a Simple Query* on page 28
- *Completing the Sample Project* on page 31

Creating the Sample Project

Use the Studio to define a new set of processing instructions for event data.

Prerequisites

Start ESP Studio.

Task

1. Select **File** > **New** > **Project...**.
2. In the **Name** field, enter `my_portfolio_valuation`.

   A valid project name:
   - Must start with a lowercase letter, underscore, or dollar sign
   - All other characters must be lowercase letters, numbers, underscores, or dollar signs
   - Must not contain spaces

   For your own projects you can use any name. To ensure that you can run the sample project you are creating, use the values listed here.
3. In the **Directory** field, accept the default location or browse to a directory in which to store the new project folder.
   Studio creates three files in the named directory:
   - ***project_name*`.ccl`** – contains the CCL code.
   - ***project_name*`.cclnotation`** – contains the diagram that corresponds to the `.ccl` file.
   - ***project_name*`.ccr`** – contains the project configuration.

   For example, for a project directory named "trades," Studio creates a `trades.ccl`, `trades.cclnotation`, and `trades.ccr` file in the `trades` directory.
4. Click **Finish** to create the project files.
   The new project opens in the Visual editor with one input stream, NEWSTREAM, and an inline schema ready for editing.

See also

- *Reviewing Concepts* on page 18
- *Starting ESP Studio* on page 9

Editing a Project Diagram

Edit projects in the Visual editor by adding shapes from the Palette to the project diagram, connecting them, and completing the configuration of each shape.

1. If the sample project diagram is not already open in the Visual editor, open it now:
   a) In Authoring perspective, in **File Explorer**, open the sample project, my_portfolio_valuation.
   b) Navigate to the `.cclnotation` file in your project folder and double-click `my_portfolio_valuation.cclnotation`.
2. Click in the diagram to begin editing using the Palette.

   Tip: To make the Visual editor window full-screen, double-click the ***name*:Diagram** tab at the top. Double-click again to revert.
3. Select the input stream element NEWSTREAM that was added automatically when you created the project, right-click, and choose **Delete Element**.
   To run the sample project with example data, you must delete this element from the project before compiling.
   - **Delete Element** — removes the element from the project.
   - **Delete from Diagram** — removes the element from the diagram, but retains it in the project. When you run the project, everything in the project runs, even elements that are not on the diagram.
4. (Optional) To toggle between the Visual editor and the CCL editor, choose **Switch to Text** or **Switch to Visual**  (**F4**).

   Note: The Visual editor, like other graphical user interfaces, offers several ways to accomplish most tasks, although this guide may not list all of them. For example, in many contexts you can carry out an action by:
   - Clicking a button or other icon in a shape, or on the main toolbar
   - Using a shortcut key
   - Double-clicking an element to open it
   - Right-clicking to select from the context menu
   - Selecting from the main menu bar
   - Editing element values in the Properties view

Adding an Input Adapter

Attach an adapter by inserting it in the diagram, connecting it to a stream or window, and setting properties.

This example shows you how to insert an adapter, enable it for schema discovery, then generate and attach the input window and its schema automatically. This is the best practice for creating a schema when using an adapter that supports schema discovery.

Alternatively, ESP Studio allows you to create the stream or window and then attach an adapter. Use this method for adapters that do not support schema discovery, or where you want to explicitly create an inline schema for input streams or windows.

1. Open the **Input Adapters** compartment in the Palette (to the right of the diagram) and locate the adapter you want.
   For this example, choose the **File XML Input** adapter, which reads data from an XML file.
2. Click the adapter in the Palette, then click in the diagram.
   Do not try to drag-and-drop from the Palette into the diagram.
   The adapter shape is inserted but its border is red, indicating it is not complete, until you define its properties and attach it to a stream or window.
3. In the adapter shape toolbar, click **Edit Properties** ( ) .
4. (Optional) In the Adapter Properties dialog, change **Name** to identify your adapter.
5. Configure the adapter for schema discovery:
   Required properties are in red.

   Note: Leave **Use named property set** unchecked, as this option does not allow you to discover the schema for this adapter.

   a) Click in the Value column for Directory and click the Browse button ( ).
   b) Click the Browse button in the Directory dialog to select the folder with the data files you want the adapter to read. Click OK.
   For this example, specify the absolute path to the sample data installed with the product.

Property	Value
Directory	*workspace_install_path*\exampledata Windows default: `C:\Documents and Settings\`*username*`\My Documents\SybaseESP\5.1\workspace\exampledata` Linux and Solaris default: *your_home_directory*`/SybaseESP/5.1/workspace/exampledata`

Note: The file property is set automatically in the next task, when you select a file for schema discovery.

6. Click **OK**, then press **Ctrl+S** to save.

Next

Import the schema and create a connected input stream or window with the same schema as the data file.

See also

- *Schema Discovery Using Input Adapters* on page 19

Discovering a Schema

Use the **Schema Discovery** button in the Adapter shape to discover and automatically create a schema based on the format of the data from the adapter.

Prerequisites

Add the adapter to the diagram and set its properties.

Task

1. Click **Schema Discovery** on the adapter toolbar.
   Studio displays a Progress Information box and looks for the configuration.
   - If the schema is configured properly and one or more data sets are found, a Schema Discovery: Select Schema dialog appears where you can view and select a schema.
   - If the schema is not successfully discovered, an error message appears stating that no schema was discovered for the adapter. You can:
     - Check that the adapter properties are configured for schema discovery.
     - Check the *Studio Users Guide* to see if the adapter supports schema discovery.
2. Select the schema you need.

   You can expand the data set to view the schema.

   For this example, select **positions.xml**, then click **Next**.
3. In the Schema Discovery: Create Element dialog, choose **Create new input window (with inline schema)**.

   This option creates and attaches a new window to the adapter, creates an inline schema for the window, and populates the window with the schema discovered from the adapter.

   When the adapter is not yet attached to a stream or window, other options are:

- **Create a new input stream (with inline schema). –** creates and attaches a new stream to the adapter, creates an inline schema for the stream, and populates the stream with the schema discovered from the adapter.
- **Create a new input stream (with attached schema). –** Creates and attaches a new stream to the adapter, creates and attaches a new named schema to the stream, and populates the stream with the schema discovered from the adapter.
- **Create a new input window (with attached schema). –** Creates and attaches a new window to the adapter, creates and attaches a new named schema to the window, and populates the window with the schema discovered from the adapter.
- **Create new named schema. –** creates a new named schema and populates it with the schema discovered from the adapter.

4. Click **Finish**.
   - The new input window appears with the default name positions_xml_window1, and is automatically connected to the File XML Input adapter.
   - The adapter file property is set. The red warning border disappears, indicating that the element is now valid.
5. In the Schema compartment of the input window, click the **Toggle Key** buttons for the BookId and Symbol columns to specify the primary key.
   The button indicates primary key columns.With the primary key, the shape becomes valid.
6. Click the input window **Edit** button and name it `Positions`.

Next

Create another input window, PriceFeed. Either:

- Create the PriceFeed input window manually, following steps in the next task, or,
- Insert another File XML Input adapter and configure it for schema discovery. This time, when you discover the schema, choose `pricefeed.xml` in the `exampledata` directory. Name the input window PriceFeed, and click the Id column to make it the primary key.

See also

- *Schema Discovery Using Input Adapters* on page 19

Adding an Input Window Manually

Add an input window to the diagram in the sample PortfolioValuation project.

These steps let you create an input window directly, and define the schema, without importing a schema.

If you used the input adapter to discover the schema and generated both input windows automatically, skip these steps and go directly to the next task.

1. In the Visual editor, in the Palette to the right of the diagram, open the **Streams and Windows** compartment.
2. Click **Input Window**.
3. Click in an empty area in the diagram where you want to insert the input window.
   The input window object is added to the project. The red border indicates that it needs more definition to be valid.
4. To set the name of the input window, either:
   - In iconic mode, click once to select the shape, then click again to edit the name.
   - In verbose mode, click the edit icon next to the name.

   For this example, enter the name `PriceFeed`.
5. Click the "plus" sign to expand the shape to verbose mode if necessary, and click **Add Column** ( ) on the toolbar in the input window, to add each new column.

   Tip: Hover over any icon to see its name.

   A new column is created with a default name, and default datatype of integer.
6. Specify additional columns.
   a) Double-click each column name to edit it.
   b) Then double-click each datatype to select the correct datatype.

   For this example, enter these column names and datatypes:
   - **Id –** integer
   - **Symbol –** string
   - **TradeTime –** date
   - **Price –** float
   - **Shares –** integer
7. Click the button for the Id column to toggle it to the Key symbol.
   Input windows require a primary key.
   The Id column is now the primary key for the PriceFeed input window. The red warning border disappears, indicating that the element is now valid.
8. Create a retention window.
   a) Click **Set Keep Policy** .
   b) In the Edit Keep Policy dialog, choose **Time**, and enter `10 MIN` in the text box to its right. Click **OK**.

   The default policy is to keep all rows of incoming data.

This step defines a CCL **KEEP** clause, and retains all price events received in the last 10 minutes. Without a **KEEP** clause, the PriceFeed window would grow infinitely large. For more information on specifying a retention policy, see the *Studio Users Guide*.

9. Save (**Ctrl+S**).
   This saves changes to both the `.cclnotation` file (the diagram) and the `.ccl` file (the CCL).

The input window and its schema (or deduced schema) are in the diagram.

Creating an Aggregate as a Simple Query

Add to the sample diagram an Aggregate simple query to create a volume weighted average price (VWAP).

An Aggregate query groups events that have common values, and computes summary statistics for the group.

1. In the Visual editor Palette, in **Streams and Windows**, click **Aggregate**.
2. Click in the diagram to create the object.
3. Change the default name, Aggregate1, to VWAP.
4. Connect PriceFeed to the VWAP aggregate:
   a) Click the **Connector** tool in the Palette.
   b) Click the **PriceFeed** input window, then click the **VWAP** aggregate.
      Click the shape that produces the output first, then the shape that receives the data, to indicate the direction of data flow. Watch for visual indicators that show you when the connection is valid.

Indicator	Meaning
	Connection is allowed
	Connection is not allowed

5. Enter Column Expressions:
   a) Click **Copy Columns from Input** () in the shape toolbar to select the columns to copy into the schema for the aggregate window.
      For this example, copy these columns:
      - PriceFeed.Symbol
      - PriceFeed.TradeTime
      - PriceFeed.Price
   b) Edit column names to clarify that these columns will hold the most recent price and time for the group:

- Change TradeTime to LastTime
- Change Price to LastPrice

c) Add additional columns by clicking **Add Column Expression** in the shape toolbar.

For this example, add another column and edit its name to `VWAP`.

6. Edit column expressions by double-clicking to open the inline editor, or by selecting the expressions and pressing **Ctrl+F2** to open the expression in the pop-up editor.
   For this example, edit the VWAP column expression to:

```
sum ( PriceFeed.Price *
PriceFeed.Shares ) /
sum ( PriceFeed.Shares )
```

7. Click **Add GroupBy Clause** (**{ }**) to edit the grouping of columns in the aggregate object.

Note: The Aggregate shape must have exactly one GROUP BY expression.

For this example, select **PriceFeed.Symbol** as the grouping column.

The red warning border disappears, indicating that the element is now valid. The aggregate element is now valid.

By default, the Aggregate is created as Output, which allows external applications to subscribe to or query it, and allows you to view it using the Streamviewer in the Run-Test perspective.

See also

- *Simple Queries* on page 20

Creating a Join as a Simple Query

Add a join to the sample project. A join combines events from two or more inputs to create a single stream or window. It is similar to a join in SQL.

Event Stream Processor supports inner joins, left and right outer joins, and full outer joins, with join syntax comparable to SQL ANSI join syntax and comma-separated syntax. For more information about joins, see the *Studio Users Guide* or the *Programmers Guide*.

1. In the Visual editor Palette, in **Streams and Windows**, select **Join**.

   If necessary, close the compartments below **Streams and Windows**, or use the arrow below the compartment, so that **Join** is visible.
2. Click in the diagram to create the object.
   For this example, edit the join object name to be `IndividualPositions`.
3. Using the Connector tool, connect the join object to the appropriate stream or window.

   Attach join objects to any stream, window, or Flex operator. Join objects have multiple inputs, but only one output.

Note: Streams, windows and delta streams can participate in a join. However, a delta stream may participate in a join only if it has a KEEP clause specified. Only one stream can participate in a join.

For this example, connect the VWAP aggregate object and the Positions input window to the IndividualPositions join object, in that order.

Tip: To add multiple connections, **Shift+click** and hold the **Connector** tool and add connections. To return to normal selection, press **Esc** or click the **Select** tool in the Palette to release it.

4. Click **Copy Columns** () in the join shape toolbar and select columns to copy.

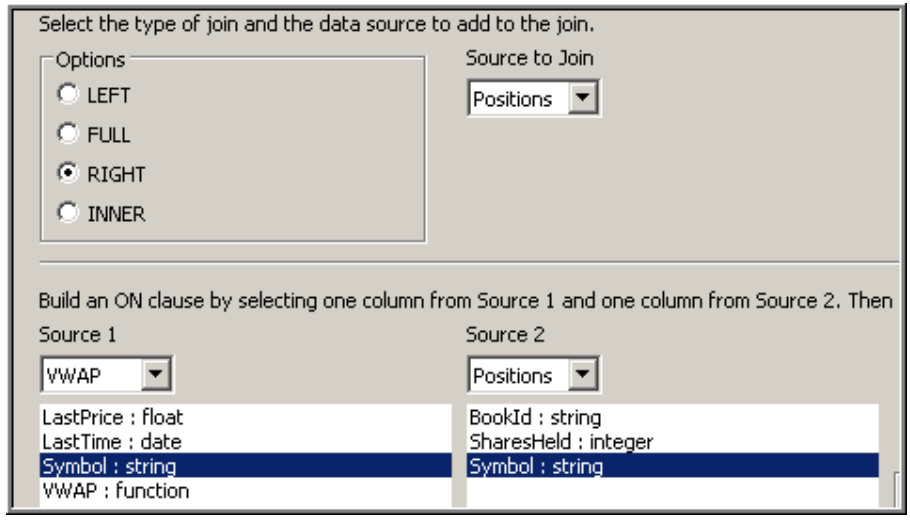
Tip: If you get an error, or do not see all columns from both inputs listed, try reconnecting the new Join element to the Positions or VWAP shapes as needed.

For this example, choose **Select All**, then clear the check box on **VWAP.Symbol** so that you don't get the symbol field twice.

5. Click **Add Column Expressions** ().
For this example add two columns: CurrentPosition and AveragePosition.
6. To modify column expressions, either:
   - Double-click on the expression to open the inline editor, and either type directly or press **Ctrl+Space** for syntax completion assistance, to pick from column names and functions, or,
   - Press **Ctrl+F2** to open the expression editor. Press **Ctrl+Space** to display the available input columns and built-in functions, or enter the desired expression manually, or,
   - Modify the expression in the Properties view.

   For this example, create these Column Expressions:
   - `CurrentPosition ( VWAP.LastPrice * Positions.SharesHeld )`
   - `AveragePosition ( VWAP.VWAP * Positions.SharesHeld )`
7. In the Join Conditions compartment of the join shape, set up the join conditions.
If you connected the join to the VWAP and Positions inputs, in that order, there are now two elements in the Join Conditions compartment. The first defines the leftmost element for the join. If you connected to VWAP first, the first element (left side of the join) is VWAP. For this example, you must configure the second join element.
   a) Double-click the second join element to open the Edit Join Expression dialog.
   b) Choose a join type.
   For this example, use **RIGHT**, which is a right outer join. You want RIGHT because VWAP is the first, or left input, and Positions is the second, or right input. You only want your positions in the output; you do not need prices for symbols that are not held in the portfolio.
   c) Select the columns to join on.
   You cannot edit join constraints manually in the Visual editor.
   For this example:.

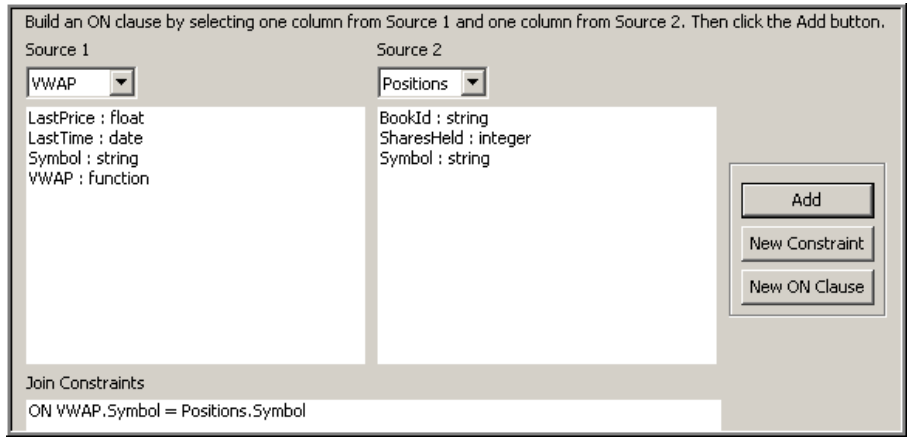
- As Source 1, ensure that **VWAP** is in the dropdown, and select **Symbol:string** as the column.
- As Source 2, ensure that **Positions** is in the dropdown, and select **Symbol:string** as the column.



d) Click **Add**.
The columns chosen appear in Join Constraints, where you should now see:

```
ON VWAP.Symbol=Positions.Symbol
```

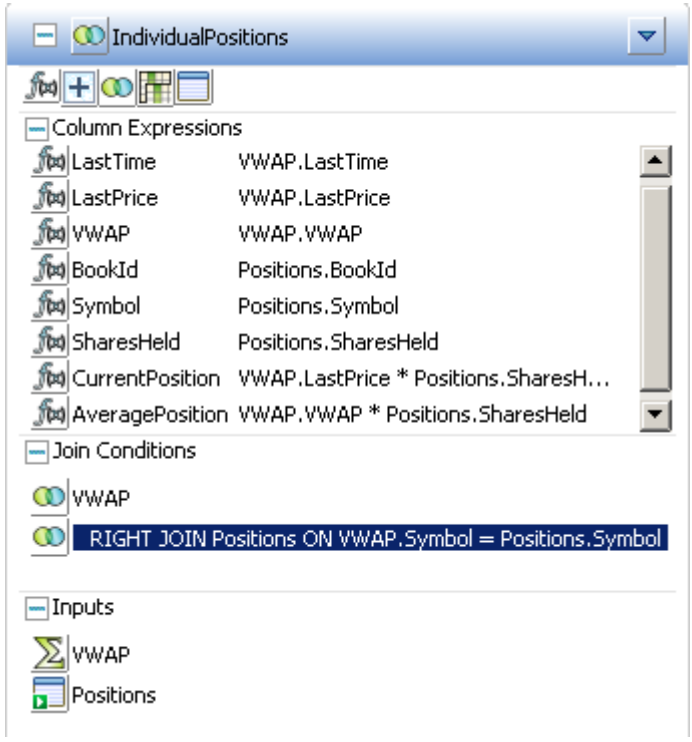
The dialog shows:



e) Click **OK**.

8. In the join shape, click (Toggle Type to OUTPUT).

The IndividualPositions join shape now shows the completed join, as shown in the figure.



See also

- *Simple Queries* on page 20

Completing the Sample Project

Add a new aggregate, and clean up the diagram by removing unused elements.

1. Create an additional Aggregate Simple Query and name it ValueByBook.
   a) Connect it to the IndividualPositions join object.
   b) Click **Copy Columns** () in the shape toolbar and copy columns BookId, CurrentPosition, and AveragePosition.
   c) Set column expressions:
      - `BookId IndividualPositions.BookId`
      - `CurrentPosition sum ( IndividualPositions.CurrentPosition )`
      - `AveragePosition sum ( IndividualPositions.AveragePosition )`

Tip: Use the inline editor. Double-click on the column expression, and use the **Home** and **End** keys to quickly edit the expression.

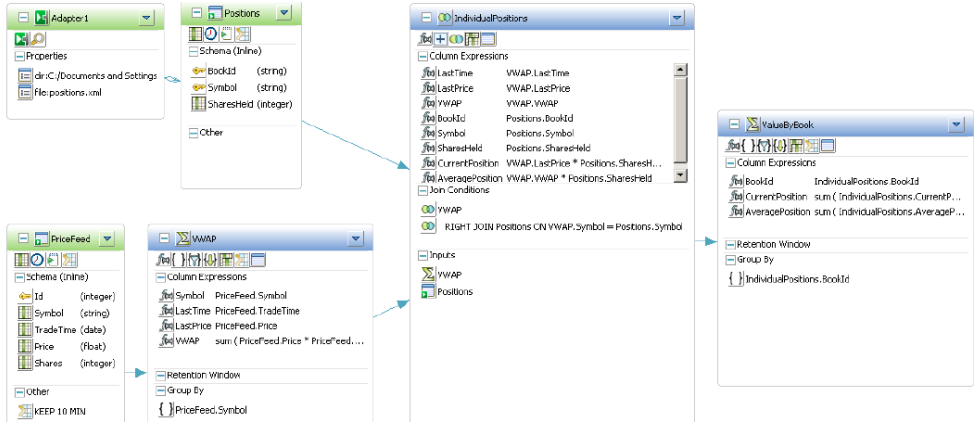
d) Add the Group By clause (**{ }**) `IndividualPositions.BookId`.

e) Toggle to OUTPUT.

2. Delete any used elements from the project so that you can run it.
   For example, if you have not done so, remove the unused input stream element NEWSTREAM that was added automatically when you created the project.
3. (Optional) Toggle to Iconic mode or Verbose mode..
   - Click the Toggle Image button in the upper left corner of a shape, or,
   - Click the All Iconic or All Verbose button in the toolbar.
4. (Optional) Click Layout left to right to line up shapes.
5. (Optional) To close the diagram, press **Ctrl+W** or **Ctrl+F4**, or click the **X** on the tab at the top of the editor .

The completed diagram should look like this in Verbose mode. You might need to open some compartments and click again to see details for all elements.

Figure 5: Completed Sample Portfolio Valuation Diagram



Next

Follow the procedures in the next chapter, *Testing Your Project*, to compile and test the sample project in ESP Studio, using test data provided in your installation.

See also

- *Simple Queries* on page 20

CHAPTER 4 Testing Your Project

Compile, run, and test the simple project you created previously, using tools in Run-Test perspective.

1. *Compiling the Sample Project*

   Compile a project before running it to check for errors and make corrections.
2. *Viewing Problems*

   Use the Problems view to view error details when trying to validate, upload, and compile projects.
3. *Deploying the Sample Project*

   Run the project and watch it open in Run-Test perspective.
4. *Loading Data into the Sample Project*

   Test the sample project by loading reference data into the Positions window.
5. *Testing the Project with Recorded Data*

   Play back the previously recorded price feed data, and view the continuous portfolio valuations in the sample project.
6. *Other Tools for Running and Testing Projects*

   ESP Studio includes many other tools for testing projects, including those in the Run-Test perspective.

See also

- *Project Execution and Testing* on page 16

Compiling the Sample Project

Compile a project before running it to check for errors and make corrections.

1. If the sample project is not already open in the Visual editor, open it now.
   a) Go to Authoring perspective.
   b) In File Explorer, expand the **my_portfolio_valuation** folder.
   c) Right-click **my_portfolio_valuation.cclnotation** and choose **Open With > Studio Visual Editor**.
2. To compile the project, either:

   - Click the **Compile Project** button in the main toolbar, or,
   - Press **F7**.

The project compiles and reports any errors found. Compilation errors are displayed in the **Problems** or **Console** view, depending on the type of error.

Next

Review and resolve any problems. If it compiles with no errors, you can skip *Viewing Problems*.

Viewing Problems

Use the Problems view to view error details when trying to validate, upload, and compile projects.

Prerequisites

Open the Authoring Perspective.

Task

1. Click on a problem in Problems view, or expand the group to see individual errors.

   By default, Problems view is at the bottom of the screen, and problems are grouped by severity.

   Error details appear in Problems view and in the status bar at the bottom left side of the screen.

   Tip: If you double-click on a problem in the problems view while the project is open in the Visual editor, the CCL editor opens read-only to show you where the problem is. To fix the problem, either:
   - Return to the Visual editor and fix it there, or,
   - Close both the Visual editor and CCL editor for the project, and then reopen the project in the CCL editor.
2. If the error message is too long to show the entire message, click it to read the full text in the status bar at the bottom of the Studio window.
3. Right-click an item to choose from the context menu:

Option	Action
Go to	Highlight the problem in the .ccl file. The CCL editor opens in read-only mode.
Copy	Copy error details to the clipboard. When you exit Studio, the contents of problems view are removed. Use this option to save off errors.
Show in	Display details in Properties view.

Option	Action
Quick Fix	(Disabled)
Properties	Display details in a dialog box.

4. (Optional) Click the View menu dropdown to see more options.
5. Click the **Console** tab to view compiler results.

Deploying the Sample Project

Run the project and watch it open in Run-Test perspective.

Prerequisites

Make sure the project compiles without errors. You must correct any problems before you can run the project.

Task

1. With the diagram open in the editor, click **Run Project** in the main toolbar.
2. If the Add Local Password dialog appears, enter the password for the studio user.

   You define a password for the studio user once per ESP Studio session. The first time you are asked for a password, Studio accepts any value. The next time you are prompted within the same session, you need to specify the same password. In your next Studio session, you can select a new password or keep the same one.
3. Review the running project in Run-Test perspective.

See also

- *Loading Data into the Sample Project* on page 37

Run-Test Perspective

In the Run-Test perspective, you access tools to test, monitor, debug, and fine-tune a project.

In Run-Test perspective you can test your projects using these view and tools. Numbers refer to annotations in the figure. (Locations are in default perspective setup; yours may differ.)

- **Server View (1) –** (Upper left) Start and connect to available servers. Your first project is there, already running.
- **Activate Project view (2) –** (Below Server View) Quickly connect multiple views to a given project.
- **Manual Input view (3) –** (Below Activate Project, leftmost tab) Manually create and publish events as input to a stream or window.

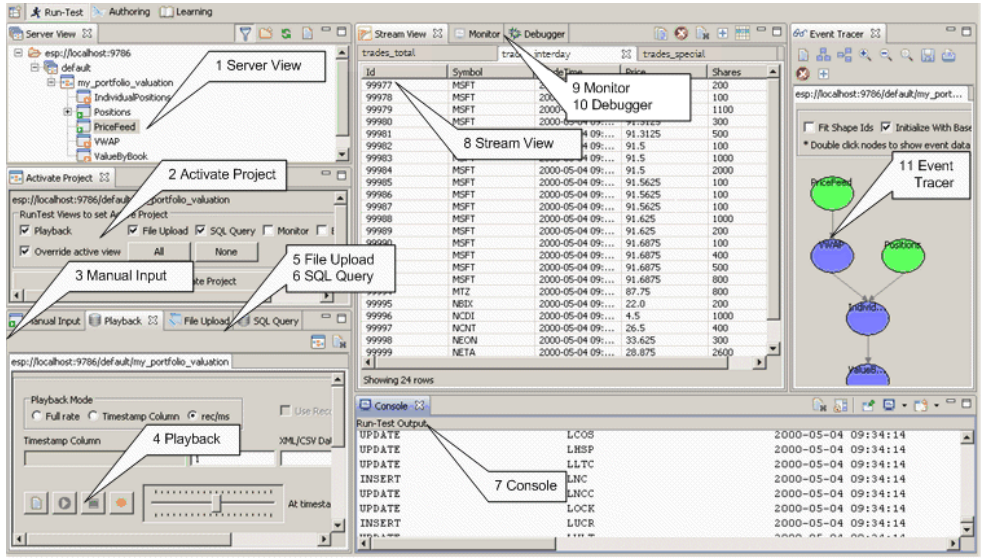
- **Playback view (4) –** Record data flowing into a running project, or play back recorded files.
- **File Upload view (5) –** (Below Activate Project, third tab) Publish an existing data file to an input stream or window.
- **SQL Query view (6) –** (Below Activate Project, rightmost tab) Run a snapshot SQL query. It captures a snapshot of the current window state and displays results in the Console.
- **Console view (7) –** (Lower right) Review log messages and other tracing and debugging information useful to developers.
- **Stream view (8) –** (Upper right, leftmost tab) Show the events of an output stream or the retained events in an output window of a running project.
- **Monitor view (9) –** (Tabbed to the right of Stream view) Monitor performance of a running project.
- **Debugger view (10) –** (Tabbed to the right of Stream view) Debug a project by setting breakpoints and watchpoints.
- **Event Tracer view (11) –** (Tabbed to the right of Stream view by default) Trace the flow of data through a project.

Other Run-Test tools include:

- Run Project button, same as in Authoring perspective.

The figure shows the sample project running in Run-Test perspective.

Figure 6: Run-Test Perspective



Loading Data into the Sample Project

Test the sample project by loading reference data into the Positions window.

If your project has the File XML Input adapter attached to the Positions input window, data is loaded automatically when you start the project. If you removed or omitted the adapter, use this alternative process to load the sample data.

1. In Server View, expand the **my_portfolio_valuation** project to show the list of windows and streams in the project.
2. Double-click the Positions input window to open it in Stream View.
   Stream View is in the upper right-hand portion of Run-Test perspective.
   - If your diagram has the File XML Input adapter connected to the Positions input window, Stream View shows sample data for Positions, loaded automatically from the adapter.
   - If you removed the adapter, go to the next step to load the data manually.
3. Load positions data from a file into the Positions window.
   a) Go to File Upload view.
   b) When you have only one project, Studio selects it for you. Otherwise, click the Select Project button in the view toolbar, select the **my_portfolio_valuation** project in the dialog, and click **OK**.
   c) Click the **Browse** button, navigate to your `...\SybaseESP\5.1\workspace\exampledata` folder, and select `positions.xml`.

      If you do not see the `positions.xml` file, try changing the file name extension filter in the lower right corner of the dialog to `*.xml`.
   d) Click **Open**.
   e) With `positions.xml` highlighted in File Upload view, click the **Upload** button.

   Watch the data flow in Stream View, as Studio loads the three positions for Book1 and Book2.

See also

- *Deploying the Sample Project* on page 35

Testing the Project with Recorded Data

Play back the previously recorded price feed data, and view the continuous portfolio valuations in the sample project.

1. In Server View, double-click the IndividualPositions, VWAP, and ValueByBook output windows.

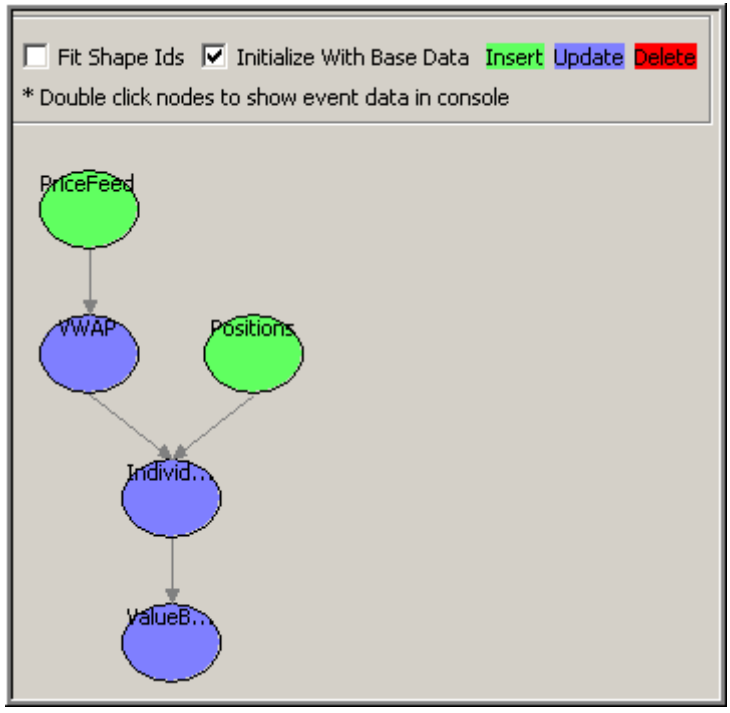
In the Server View list, a red arrow in the lower right corner of the window icon ( ) indicates the output windows.

2. Click the **Playback** tab.
3. If necessary, click the **Select Project** button in the upper right corner of Playback view.
   - If you only have one project running, Studio selects it for you.
   - Otherwise, select the **my_portfolio_valuation** project in the dialog and click **OK**.
4. Click the **Select Playback File** button.
5. Navigate to your *install_path*`\SybaseESP\5.1\workspace\exampledata` folder, and select `pricefeed.xml`. Click **Open**.

   If you do not see the `pricefeed.xml` file, change the file name extension filter to `*.xml`.
6. In Playback view, in the Playback Mode frame, click the **rec/ms** button, then enter a **rec/ms** value of 1.

   A value of 1 plays back at a rate of 1000 records per second.
7. Click the green **Start Playback** button to start playback of the price feed.
8. While the data plays back, click each of the output windows in Stream View to see the calculations revised in real-time.
9. (Optional) Click Event Tracer view, choose Select Running Project, and click Initialize with Base Data.
   In this example, Event Tracer shows the PriceFeed and Positions elements in green to indicate Insert operations. VWAP, IndividualPositions, and ValueByBook are in blue, indicating Updates. Colors change as different event types are processed.

   Double-click each node to watch event data in the Console.



10. To stop the playback, click **Stop** .
11. When you are done testing the project, right-click it in Server View and choose **Stop Project**.

    If you omit this step, the project stops when you exit Studio, but you may get an error.

Tip: If you see an error when you restart Studio, or when you try to open a `.ccl` file after running a project, there may be multiple instances of Studio trying to use the same Studio workspace location. If this occurs, close Studio and restart it.

Other Tools for Running and Testing Projects

ESP Studio includes many other tools for testing projects, including those in the Run-Test perspective.

For information beyond the scope of this guide on running, configuring, monitoring, querying, and debugging projects, see the *Studio Users Guide*.

See also

- *Run-Test Perspective* on page 35

CHAPTER 5 Continuous Computation Language

CCL is the primary event processing language of the Event Stream Processor. ESP projects are defined in CCL.

CCL is based on Structured Query Language (SQL), adapted for event stream processing.

CCL supports sophisticated data selection and calculation capabilities, including features such as: data grouping, aggregations, and joins. However, CCL also includes features that are required to manipulate data during real-time continuous processing, such as windows on data streams, and pattern and event matching.

The key distinguishing feature of CCL is its ability to continuously process dynamic data. A SQL query typically executes only once each time it is submitted to a database server and must be resubmitted every time a user or an application needs to reexecute the query. By contrast, a CCL query is continuous. Once it is defined in the project, it is registered for continuous execution and stays active indefinitely. When the project is running on the ESP Server, a registered query executes each time an event arrives from one of its datasources.

Although CCL borrows SQL syntax to define continuous queries, the ESP server does not use an SQL query engine. Instead, it compiles CCL into a highly efficient byte code that is used by the ESP server to construct the continuous queries within the data-flow architecture.

CCL queries are converted to an executable form by the CCL compiler. ESP servers are optimized for incremental processing, hence the query optimization is different than for databases. Compilation is typically performed within Event Stream Processor Studio, but it can also be performed by invoking the CCL compiler from the command line.

SPLASH

Stream Processing LAnguage SHell (SPLASH) is a scripting language that brings extensibility to CCL, allowing you to create custom operators and functions that go beyond standard SQL.

The ability to embed SPLASH scripts in CCL provides tremendous flexibility, and the ability to do it within the CCL editor maximizes user productivity. SPLASH also allows you to define any complex computations that are easier to define using procedural logic rather than a relational paradigm.

SPLASH is a simple scripting language comprised of expressions used to compute values from other values, as well as variables, and looping constructs, with the ability to organize instructions in functions. SPLASH syntax is similar to C and Java, though it also has

similarities to languages that solve relatively small programming problems, such as AWK or Perl.

See also

- *CCL Authoring* on page 42
- *Editing in the CCL Editor* on page 42
- *CCL for the Sample Project* on page 44
- *CCL for Sample Project with Modules* on page 46

CCL Authoring

The CCL editor is a text authoring environment within ESP Studio for editing CCL code.

You can work in the CCL editor exclusively, or use it as a supplement to the Visual editor. The CCL editor offers syntax completion options, syntax checking, and error validation.

A single CCL file can be open in only one editor at a time. The Visual and CCL editors are completely integrated: when you save and switch to the other editor, your work is saved there as well.

Most users new to Event Stream Processor find it easier to get started in the Visual editor. As you gain experience with the product, and learn to successfully compile and run a simple project, you may want to use the CCL editor to add advanced features to your projects.

The *Studio Users Guide* explains use of the CCL editor within ESP Studio.

For CCL language usage and reference details, see the *CCL Programmers Guide*.

See also

- *SPLASH* on page 41
- *Editing in the CCL Editor* on page 42
- *CCL for the Sample Project* on page 44
- *CCL for Sample Project with Modules* on page 46

Editing in the CCL Editor

Update and edit CCL code as text in the Studio CCL editor.

1. Click the **Authoring** tab.
2. In File Explorer, expand the project container, and double-click the `.ccl` file name to open it in the CCL editor.

Note: Advanced CCL users can include multiple CCL files in the same project, by using an IMPORT statement to import shared schemas and module definitions from another file.

3. Begin editing text in the CCL editor window.

Tip: If you open a `.ccl` file in the CCL editor when the same project is open in the Visual editor, the CCL editor opens in read-only mode and you cannot edit the file.

Close both the Visual editor and CCL editor for the project, and then reopen the project in the CCL editor.

Note: Backslashes within string literals are used as escape characters. Any Windows directory paths must therefore be specified with two backslashes.

4. (Optional) Press **Ctrl+Space** to show a syntax completion proposal.
5. (Optional) To insert CREATE statement template code, right-click, choose **Create**, and then choose the element to create.
6. Choose **File > Save** (**Ctrl+S**) to save the `.ccl` file and the project.

See also

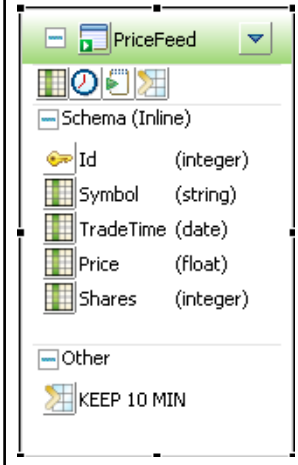
- *SPLASH* on page 41
- *CCL Authoring* on page 42
- *CCL for the Sample Project* on page 44
- *CCL for Sample Project with Modules* on page 46

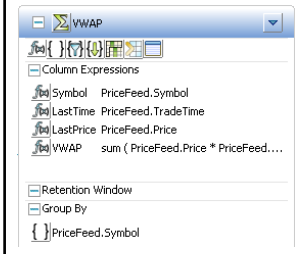
CCL for the Sample Project

The CCL for the Portfolio Valuation sample project created in the Studio Visual editor is shown here, with the corresponding shape in the diagram for each element. Line breaks are added for readability.

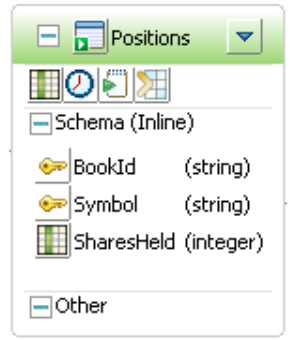
Table 3. Portfolio Valuation Project CCL and Diagram Elements

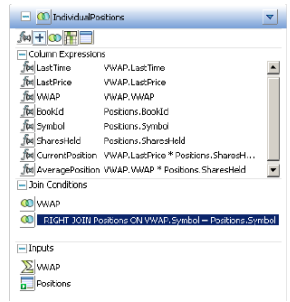
CCL	Diagram

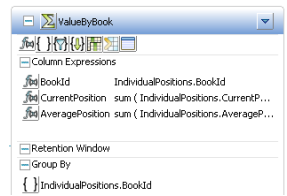
`CREATE INPUT WINDOW PriceFeed`
`SCHEMA`
`  ( Id integer ,`
`    Symbol string ,`
`    TradeTime date ,`
`    Price float ,`
`    Shares integer )`
`PRIMARY KEY ( Id )`
`KEEP 10 MIN ;`
	

`/**@SIMPLEQUERY=AGGREGATE*/`
`CREATE OUTPUT WINDOW VWAP`
`PRIMARY KEY DEDUCED`
`  AS`
`  SELECT`
`      PriceFeed.Symbol Symbol ,`
`      PriceFeed.TradeTime LastTime ,`
`      PriceFeed.Price LastPrice ,`
`      sum ( PriceFeed.Price * PriceFeed.Shares ) /`
`      sum ( PriceFeed.Shares ) VWAP`
`  FROM PriceFeed`
`  GROUP BY PriceFeed.Symbol ;`
	

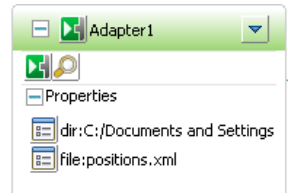
CCL	Diagram

`CREATE INPUT WINDOW Positions`
`  SCHEMA`
`   ( BookId string ,`
`     Symbol string ,`
`     SharesHeld integer )`
`  PRIMARY KEY ( BookId, Symbol) ;`
	

`/**@SIMPLEQUERY=JOIN*/`
`CREATE OUTPUT WINDOW IndividualPositions`
`PRIMARY KEY DEDUCED`
` AS`
` SELECT`
`   VWAP.LastTime LastTime ,`
`   VWAP.LastPrice LastPrice ,`
`   VWAP.VWAP VWAP ,`
`   Positions.BookId BookId ,`
`   Positions.Symbol Symbol ,`
`   Positions.SharesHeld SharesHeld ,`
`   VWAP.LastPrice *`
`     Positions.SharesHeld CurrentPosition ,`
`   VWAP.VWAP *`
`     Positions.SharesHeld AveragePosition`
` FROM VWAP RIGHT JOIN Positions ON`
`VWAP.Symbol = Positions.Symbol ;`
	

`/**@SIMPLEQUERY=AGGREGATE*/`
`CREATE OUTPUT WINDOW ValueByBook`
`PRIMARY KEY DEDUCED`
` AS`
`  SELECT`
`     IndividualPositions.BookId BookId ,`
`     sum ( IndividualPositions.CurrentPosition )`
`           CurrentPosition ,`
`     sum ( IndividualPositions.AveragePosition )`
`           AveragePosition`
`  FROM IndividualPositions`
`  GROUP BY IndividualPositions.BookId ;`
	

CCL	Diagram

`ATTACH INPUT ADAPTER Adapter1`
`TYPE xml_in`
`TO`
`Positions`
`PROPERTIES dir =`
`'C:/Documents and Settings/`*`username`*`/My Documents/`
`SybaseESP/5.1/workspace/exampledata' ,`
`file = 'positions.xml' ;`
	

See also

- *SPLASH* on page 41
- *CCL Authoring* on page 42
- *Editing in the CCL Editor* on page 42
- *CCL for Sample Project with Modules* on page 46

CCL for Sample Project with Modules

This variation of the portfolio valuation project uses a defined module with a named schema to easily scale out the application in a very high volume deployment.

The module, `valuation.ccl`, computes the VWAP aggregate, and does the join to the Positions window. The project uses the module to divide the moving data into smaller partitions, based on the first letter of the Symbol column. This strategy spreads the load out to more cores, thereby increasing throughput. By using modules, with very little coding you can easily double, quadruple, and so on, the number of partitions.

This example also implements the streaming tick data in PriceFeed as a stream rather than as an input window. Because keeping every tick would use a lot of memory, and because the state is never updated or queried, a stream is a more likely choice than a window in a real-world scenario for this event stream.

Create Module valuation

The valuation module:

1. Defines the input stream TradesIn.
2. Defines a stream, Filter1, that filters TradesIn data into a substream based on the declared parameters `afrom` and `ato`.
3. Defnes the input window Portfolio.
4. Defines the VWAP aggregate as an output window.
5. Defines another output window, ValueBySymbol, that performs a join similar to the Join simple query in the simple PortfolioValuation project, with the addition of a `cast` for the `float` data.

```
CREATE MODULE valuation
IN TradesIn,Portfolio
OUT ValueBySymbol,   VWAP

BEGIN
    IMPORT 'import.ccl';

    DECLARE
        PARAMETER STRING afrom;
        PARAMETER STRING ato;
    END;

    CREATE INPUT STREAM TradesIn
       SCHEMA TradesSchema ;
    CREATE  STREAM Filter1  AS
       SELECT * FROM TradesIn
         WHERE substr(TradesIn.Symbol,1,1) >= afrom
               and substr(TradesIn.Symbol,1,1) <= ato
    ;

    CREATE INPUT WINDOW Portfolio
       SCHEMA PortfolioSchema
       PRIMARY KEY (BookId, Symbol);
    CREATE OUTPUT WINDOW VWAP
       PRIMARY KEY DEDUCED AS
       SELECT Filter1.Symbol Symbol ,
       (sum((Filter1.Price * cast(FLOAT ,Filter1.Shares))) /
          cast(FLOAT ,sum(Filter1.Shares)))
       AS VWAP,
       sum (Filter1.Shares ) Total_Shares ,
       valueinserted(Filter1.Price) LastPrice,
       valueinserted(Filter1.TradeTime) TradeTime
       FROM Filter1
       GROUP BY Filter1.Symbol ;

    CREATE  OUTPUT  WINDOW ValueBySymbol
       SCHEMA (BookId STRING, Symbol STRING, CurrentPosition FLOAT,
AveragePosition FLOAT)
        PRIMARY KEY (BookId, Symbol) AS
        SELECT
            Portfolio.BookId  AS BookId,
            Portfolio.Symbol  AS Symbol,
            (VWAP.LastPrice * cast(FLOAT ,Portfolio.SharesHeld))
                AS CurrentPosition,
            (VWAP.VWAP * cast(FLOAT ,Portfolio.SharesHeld))
                AS AveragePosition
            FROM Portfolio JOIN
              VWAP
                 ON Portfolio.Symbol = VWAP.Symbol;

END;
```

Create Named Schema TradesSchema

```
CREATE SCHEMA  TradesSchema
    ( Id integer ,
    Symbol string ,
```

```
    TradeTime date ,
    Price float ,
    Shares integer )  ;
```

Create Named Schema PortfolioSchema

```
CREATE SCHEMA PortfolioSchema
    ( BookId string ,
    Symbol string ,
    SharesHeld integer ) ;
```

Import and Load the valuation Module

In the parent scope, the valuation module is loaded three times, as Valuation1, Valuation2, and Valuation3.

1. The IN clause binds the input streams in the module to streams in the parent scope. TradesIn is bound to InputStream1, and Portfolio is bound to InputPositions.
2. The OUT clause binds the output window in the module, ValueBySymbol, with the three parameterized output windows, VbySym1, VbySym2, and VbySym3, and partitions the VWAP aggregate as VWAP1, VWAP2, and VWAP3.

- **InputStream1 –** Input stream based on the imported schema, TradesSchema.
- **InputPositions –** Input window based on the imported schema, PortfolioSchema.
- **UnionVWAP –** Output window created as a UNION of the partitioned VWAP aggregate.

```
IMPORT 'import.ccl';
IMPORT 'valuation.ccl';
DECLARE
    PARAMETER STRING afrom :='A';
    PARAMETER STRING ato := 'Z';
END;

CREATE INPUT STREAM InputStream1 SCHEMA TradesSchema  ;


CREATE INPUT WINDOW InputPositions
  SCHEMA PortfolioSchema PRIMARY KEY ( BookId , Symbol ) ;
  LOAD MODULE valuation as Valuation1
    in TradesIn = InputStream1, Portfolio = InputPositions
    OUT ValueBySymbol = VbySym1,  VWAP = VWAP1
    PARAMETERS afrom = 'A', ato = 'J'
    ;
  LOAD MODULE valuation as Valuation2
    in TradesIn = InputStream1, Portfolio = InputPositions
    OUT ValueBySymbol = VbySym2, VWAP = VWAP2
    PARAMETERS afrom = 'K', ato = 'Q'
    ;
  LOAD MODULE valuation as Valuation3
    in TradesIn = InputStream1, Portfolio = InputPositions
    OUT ValueBySymbol = VbySym3,  VWAP = VWAP3
    PARAMETERS afrom = 'R', ato = 'Z'
    ;

CREATE OUTPUT WINDOW UnionVWAP
```

```
 PRIMARY KEY DEDUCED
 AS SELECT * FROM VWAP1
    UNION SELECT * FROM VWAP3
    UNION SELECT * FROM VWAP2 ;

CREATE OUTPUT WINDOW ValueBySymbol
 PRIMARY KEY (BookId,Symbol)
 AS SELECT * FROM VbySym1
    UNION SELECT * FROM VbySym3
    UNION SELECT * FROM VbySym2 ;

// -----------------------------
//  stream ValueByBook

CREATE  OUTPUT  WINDOW ValueByBook
    SCHEMA (BookId STRING, CurrentPosition FLOAT, AveragePosition
FLOAT)
     PRIMARY KEY DEDUCED AS
    SELECT ValueBySymbol.BookId AS BookId,
        sum(ValueBySymbol.CurrentPosition) AS CurrentPosition,
        sum(ValueBySymbol.AveragePosition) AS AveragePosition
    FROM ValueBySymbol
    GROUP BY ValueBySymbol.BookId;


ATTACH INPUT ADAPTER Adapter1 TYPE xml_in TO InputStream1
GROUP nostartGroup
PROPERTIES dir = '../exampledata' ,
file = 'pricefeed.xml' ,
matchStreamName = FALSE ,
repeatCount = 0 ,
repeatField = '-' ,
filePattern = '*.xml' ,
pollperiod = 0 ,
safeOps = FALSE ,
skipDels = FALSE ,
dateFormat = '%Y-%m-%dT%H:%M:%S' ,
timestampFormat = '%Y-%m-%dT%H:%M:%S' ,
blockSize = 1 ;

ATTACH INPUT ADAPTER Adapter2 TYPE xml_in TO InputPositions
PROPERTIES dir = '../exampledata' ,
file = 'positions.xml' ,
matchStreamName = FALSE ,
repeatCount = 0 ,
repeatField = '-' ,
filePattern = '*.xml' ,
pollperiod = 0 ,
safeOps = FALSE ,
skipDels = FALSE ,
dateFormat = '%Y-%m-%dT%H:%M:%S' ,
timestampFormat = '%Y-%m-%dT%H:%M:%S' ,
blockSize = 1 ;

ADAPTER START GROUPS nostartGroup nostart   ;
```

See also

- *SPLASH* on page 41
- *CCL Authoring* on page 42
- *Editing in the CCL Editor* on page 42
- *CCL for the Sample Project* on page 44

Index

A

C

D

E

F

I

J

L

M

O

P

Q

R

S

T

U

V

W