

Course Guide

Developing Solutions with IBM Decision Server Insights V8.10

Course code WB403 / ZB403 ERC 1.0



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Course description

Developing Solutions with IBM Decision Server Insights V8.10

Duration: 4 days

Purpose

In this course, you learn about the main features of the Decision Server Insights component of IBM Operational Decision Manager V8.10.

Decision Server Insights combines rules and events on a highly available platform. By using Decision Server Insights, you can build applications that make decisions in near real time and in situational contexts. You experience how to use time-based reasoning and location-based reasoning to build a real-world solution that detects and responds to business situations. You also learn the key capabilities of the multi-agent architecture of Decision Server Insights by developing several agents that are bound to a single entity for different purposes.

This course focuses on solution development, deployment, testing, and administration. You learn how to implement the business logic that detects business situations and uses situational context to decide and take the next best action.

The course begins with an overview of the programming model for Decision Server Insights and the architecture for the Decision Server Insights runtime environment. You learn how to design a Decision Server Insights solution, model the business entities and events that you care about, and implement the business logic. You work with a realistic test client to test the behavior of your implementation after deployment.

The course also covers administration topics, including installation, configuration of the Decision Server Insights reference topology, solution deployment in a grid environment, and grid administration.

Audience

This course is designed for developers.

Prerequisites

Before taking this course, you should have:

- Experience with the Java programming language and object-oriented concepts
- Basic knowledge of Extensible Markup Language (XML)
- Basic knowledge of the WebSphere Application Server Liberty profile
- Familiarity with the Representational State Transfer (REST) architectural style
- Familiarity with WebSphere eXtreme Scale

Objectives

- Describe the Decision Server Insights programming model and architecture
- Design and create a Decision Server Insights solution
- Define the business model for the events, entities, and concepts that are relevant to your domain
- Work with aggregates for calculations across events
- Implement business logic with rule agents and rules to detect and respond to business situations
- Deploy solutions to the Insight Server runtime and test runtime behavior
- Explain Decision Server Insights integration capabilities
- Install, configure, and administer a Decision Server Insights grid environment

Curriculum relationship

Decision Server Insights is a module of IBM Operational Decision Manager V8.10.

- Developer topics for IBM Operational Decision Manager V8.9.2 are covered in the course: WB402-ZB402, Developing Rule Solutions in IBM Operational Decision Manager V8.9.2

Agenda



Note

The following unit and exercise durations are estimates, and might not reflect every class experience.

Day 1

- (00:30) Course introduction
- (01:30) Unit 1. Introducing IBM Decision Server Insights
- (01:30) Exercise 1. Getting started with Decision Server Insights
- (01:30) Unit 2. Designing Decision Server Insights solutions
- (00:15) Exercise 2. Creating a solution in Insight Designer
- (01:00) Unit 3. Creating the business model
- (00:30) Exercise 3. Defining the business model

Day 2

- (01:30) Unit 4. Authoring the business logic
- (00:30) Exercise 4. Creating a rule agent
- (00:30) Exercise 5. Writing and testing rules
- (00:45) Unit 5. Working with aggregates
- (00:45) Exercise 6. Using event and shared aggregates in rules
- (00:30) Exercise 7. Testing for the absence of events
- (01:00) Unit 6. Testing solutions
- (00:30) Exercise 8. Testing solutions

Day 3

- (01:00) Unit 7. Modeling and defining connectivity
- (00:30) Exercise 9. Defining connectivity
- (01:00) Unit 8. Integrating Decision Server Insights
- (01:00) Unit 9. Configuring Insight Server
- (01:00) Exercise 10. Installing Decision Server Insights
- (02:00) Exercise 11. Configuring Decision Server Insights

Day 4

- (01:00) Exercise 11. Configuring Decision Server Insights
- (01:00) Unit 10. Managing deployment
- (02:00) Exercise 12. Deploying solutions
- (01:00) Unit 11. Administering Decision Server Insights
- (01:00) Exercise 13. Administering Decision Server Insights
- (00:30) Unit 12. Course summary

Unit 1. Introducing IBM Decision Server Insights

Estimated time

01:30

Overview

This unit introduces you to the Decision Server Insights programming model and architecture.

How you will check your progress

- Review
- Exercise

Unit objectives

- Describe Decision Server Insights and explain how it works
- Explain the programming model
- Describe the Decision Server Insights architecture
- Outline the user roles that are associated with Decision Server Insights

[Introducing IBM Decision Server Insights](#)

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Figure 1-1. Unit objectives

This unit introduces you to the Decision Server Insights architecture and programming model.



How to check online for course material updates



Note: If your classroom does not have Internet access, ask your instructor for more information.

Instructions

1. Enter this URL in your browser:
ibm.biz/CloudEduCourses
2. Find your course in the list and then click the link.
3. The wiki page displays information for the course. If there is a course corrections document, this page is where it is found.
4. If you want to download an attachment, such as a course corrections document, click the **Attachments** tab at the bottom of the page.
5. To save the file to your computer, click the document link and follow the prompts.



Figure 1-2. How to check online for course material updates

Topics

- Overview of Decision Server Insights
- How Decision Server Insights works
- Decision Server Insights architecture
- Decision Server Insights roles
- Installing Decision Server Insights

[Introducing IBM Decision Server Insights](#)

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Figure 1-3. Topics

1.1. Overview of Decision Server Insights

Overview of Decision Server Insights

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Figure 1-4. Overview of Decision Server Insights

What is Decision Server Insights?

- Decision Server Insights is a module in IBM Operational Decision Manager
- Combines rules and events on a highly available platform
 - Performs situation detection on a continuous basis
 - Helps applications to decide and act at the precise moment your business needs it
 - Helps build scalable solutions that listen for and respond to events that affect your business
 - Lets you use the insights that are generated from these business activities to make informed decisions and initiate appropriate actions

[Introducing IBM Decision Server Insights](#)

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Figure 1-5. What is Decision Server Insights?

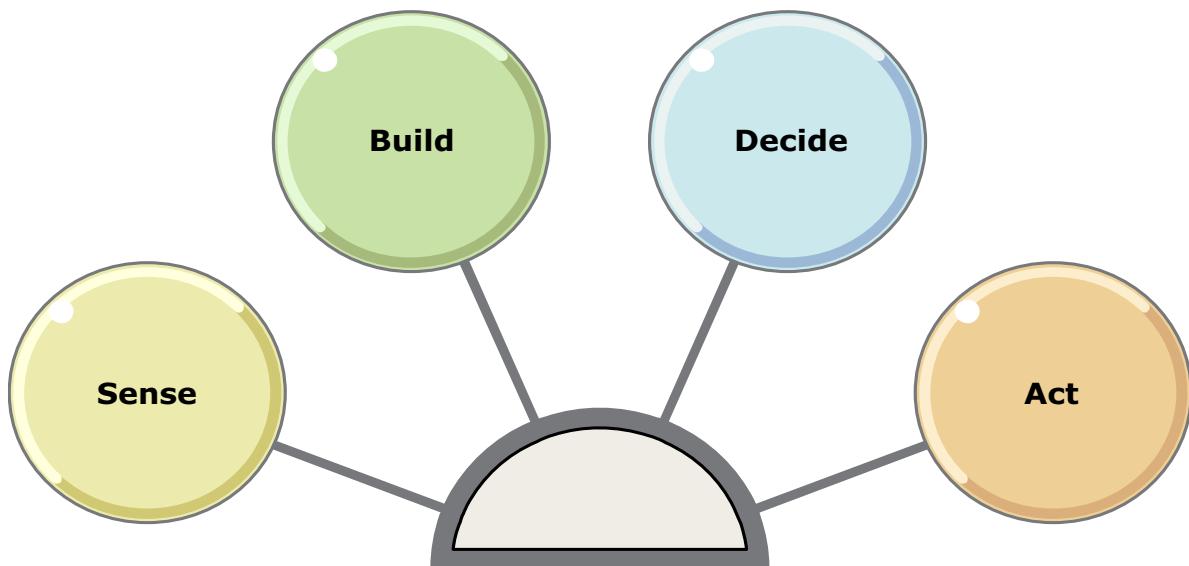
Decision Server Insights provides the flexibility and agility of **prescriptive decision management** in a situational context.

Decision Server Insights combines rules and events on a highly available platform. By using Decision Server Insights, you can build applications that make decisions in near real time and in situational contexts.

Decision Server Insights adds value for use cases where businesses need to make sense and take advantage of past and present events and data to proactively detect typical business situations. These situations include both risks and opportunities, and businesses can use Decision Server Insights to respond with the right action at the right time.

Four steps from data collection to intelligent business action

Goal: Gain insight from your data in real time, so you can act while it can make the greatest difference



Introducing IBM Decision Server Insights

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Figure 1-6. Four steps from data collection to intelligent business action

The revolution of mobile, the advent of the Internet of Things, and the emergence of the digital economy have all contributed to an overwhelming increase in data. Also, the pattern of interaction between an enterprise and its customers and its employees is changing. Customers and clients do not expect the enterprise to respond only. They expect the enterprise to anticipate their needs without them asking.

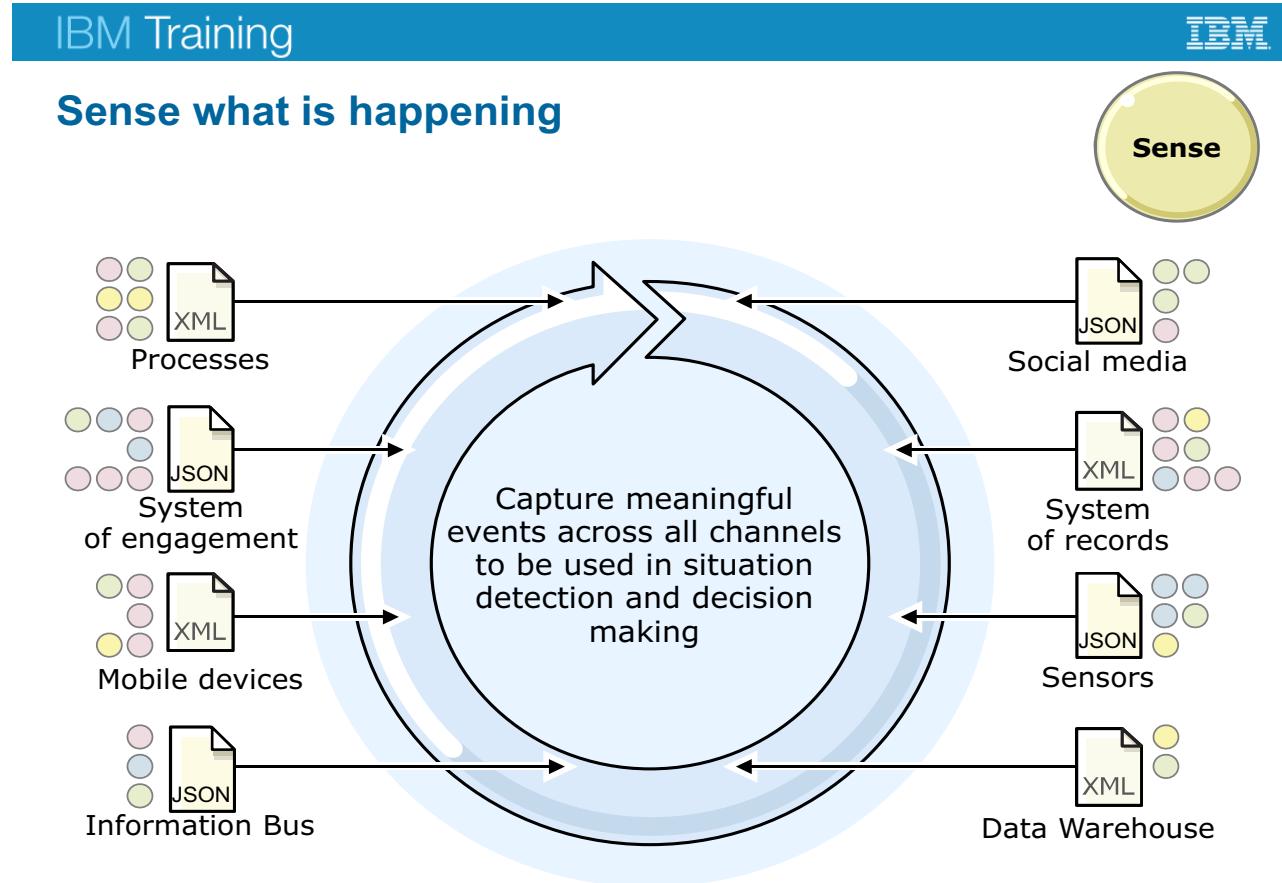
Decision Server Insights is about putting events and data into context to extract relevant insight to support further decisions. From those insights, you can then apply analytical models and rules to make the decisions and then propagate those decisions to the places that need the action, including processes and applications.

However, merely collecting data does not help you manage the response. The goal of data collection is to gain insight from what the data tells you, so you can act in real time to improve business results.

Decision Server Insights helps you accomplish this goal through a four-step process summarized as **Sense, Build, Decide, Act**:

- Sense what is happening.
- Build the context of your situation.
- Decide what to do when something happens that affects the situation.

- Then, Act **on the changed situation** quickly and consistently.



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Figure 1-7. Sense what is happening

To sense what is happening, you must be able to recognize and capture events from the outside world.

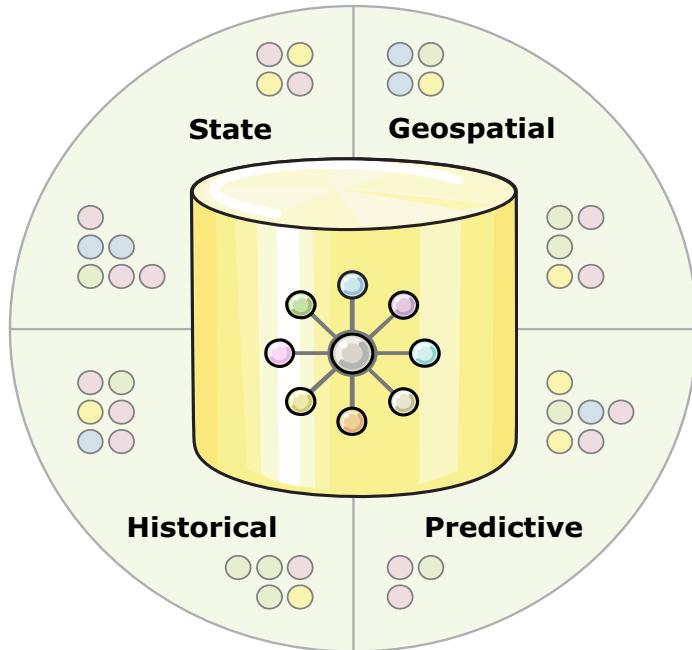
Decision Server Insights listens to a wide range of event providers, such as social media, physical sensors, mobile devices, and other channels or systems as depicted here. The Internet of Things, mobile networks, social networks, and call centers provide the data that Decision Server Insights needs. Decision Server Insights uses this data to listen for use cases such as healthcare, fleet management, banking, real-time promotions, and real-time churn management.

Events are received as XML or JSON messages by Decision Server Insights.

While many organizations have silo applications for each of the event sources, Decision Server Insights captures meaningful events across all channels, systems, and devices to be used in situation detection and decision making.



Build the context



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Figure 1-8. Build the context

Next, building the context involves putting data and events into context to make sense of the data and evaluate correlations.

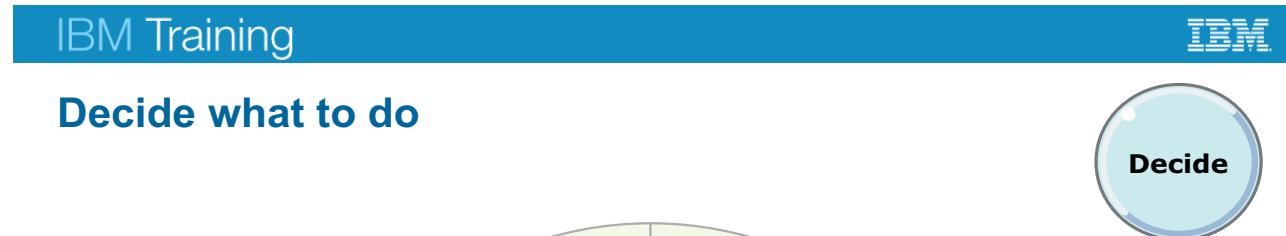
The context is built from basic state information, geospatial information such as locations, predictive information from using predictive models, and from historical information that you recorded.

As events occur that involve the business entities that you care about, such as customers or accounts, Decision Server Insights builds a context for each entity.

The context captures what is known about:

- The past of the entity, which is modeled by accumulated entities
- The present, which is modeled by the current state, including the current geospatial position
- The future, which is represented by predictive score that indicates what is likely to happen, such as the propensity of your client to churn, or switch to another company

You depend on the context that you've built to determine when a business situation has occurred, when you can take advantage of a potential opportunity, or when you can avoid a risk. After you have this type of insight, you can then determine how to act.



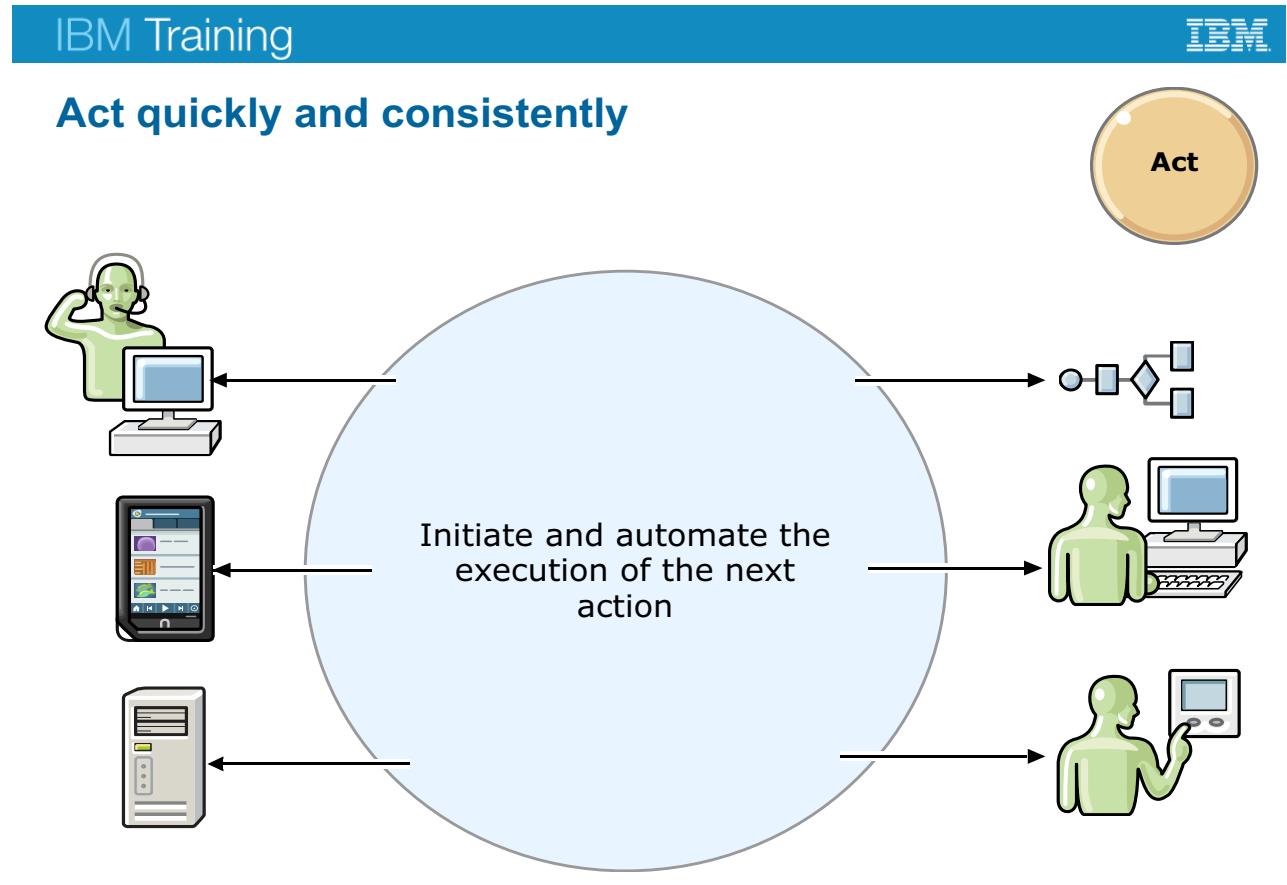
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Figure 1-9. Decide what to do

In Decision Server Insights, you implement the business logic to apply the models, policies, and suggested practices as established by your subject matter experts.

The business rules are expressed as *situation detection* patterns. When a relevant business situation is detected, the rules tell you the next best action to take.



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Figure 1-10. Act quickly and consistently

Finally, you act.

Decision Server Insights emits a response event. That event is published as an XML or JSON message on the outbound queue or posted to a URL as HTTP for some external system to pick up. The message can be transformed into something that the external system can use to interact with the outside world.

Actions can range from alerting systems to risk and opportunity, to maximizing the efficiency of your operations, to predicting equipment maintenance.

1.2. Decision Server Insights programming model

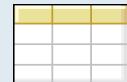
Decision Server Insights programming model

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Figure 1-11. Decision Server Insights programming model

Core building blocks

Entity



Some business-relevant thing or piece of information

- In Decision Server Insights, entities have an identifier and are composed of a set of attributes and relationships

Event



Specific action or measurement that occurred at a specific time and place

- Decision Server Insights encodes events as objects that have a time stamp

Agent



Business logic that is applied to an incoming event to detect situations

- Rule agent
- Java agent

Figure 1-12. Core building blocks

Decision Server Insights uses three core building blocks: events, entities, and agents.

Entities model real-life objects, such as the client of a bank or an ATM. The entity provides insight into what happened in the past, what events came in, the current state of the entity and what is likely to happen in the future.

Events are actions or occurrences that happen in real life, at a certain moment. Every event is timestamped, and potentially geo-localized.

An event can affect one or more entities. For example, a withdrawal event relates to an ATM entity, a client entity, and an account entity.

The third building block is the agent. Decision Server Insights provides two types of agents:

- Rule agents
- Java agents

Rule agents take advantage of ODM rules language, making it possible for business stakeholders to manage the business logic to react to the events.

Java agents are written in Java code.

Programming model

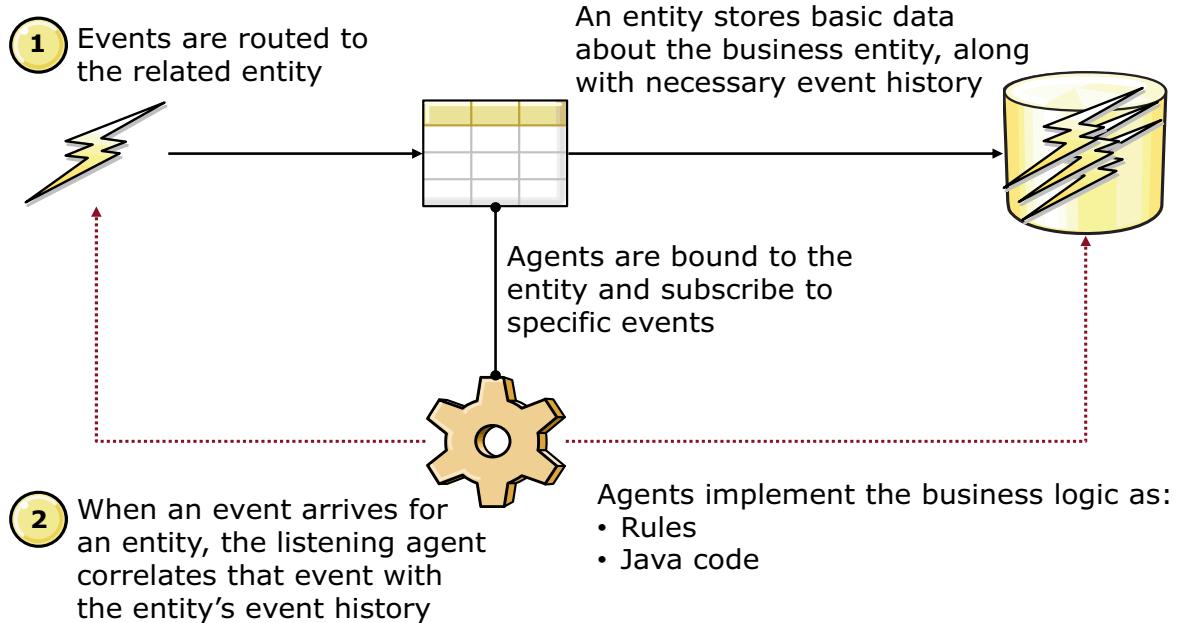


Figure 1-13. Programming model

This diagram outlines how the programming model works with those building blocks.

Starting with an event, the event is routed to the entity.

The entity stores basic data about the business entity, and any event history that is needed to detect the situation and patterns, and to calculate the analytics.

At the same time, the agents are bound to entities and process-specific events. The agents are logic fragments that implement the business logic.

At design time, an agent is bound to an entity and subscribes (or listens) to certain types of events. Multiple agents can be bound to the same entity and listen for the same events, but for different purposes.

When an event arrives and invokes an agent, the agent evaluates the event that occurred, the state of the entity, and most importantly the context. The context contains insight into the past events that are related to the entity. The agent also evaluates the current state and location of the entity, and the likely future of the entity through predictive scores.

This access enables the agent to do event fusion by looking for patterns across these three streams. Agents can emit new events, either internal to the solution to trigger additional event-entity-agent bindings, or externally, to trigger system actions.

1.3. Decision Server Insights architecture

Decision Server Insights architecture

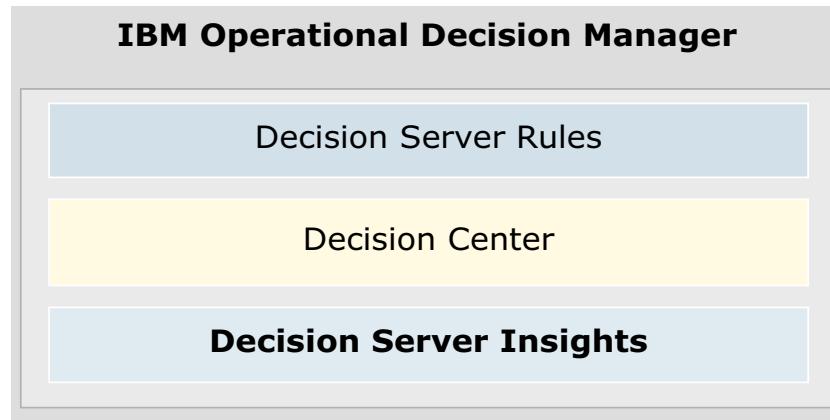
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Figure 1-14. Decision Server Insights architecture



IBM Operational Decision Manager offering

- Decision Server Insights is a module in IBM Operational Decision Manager V8.10



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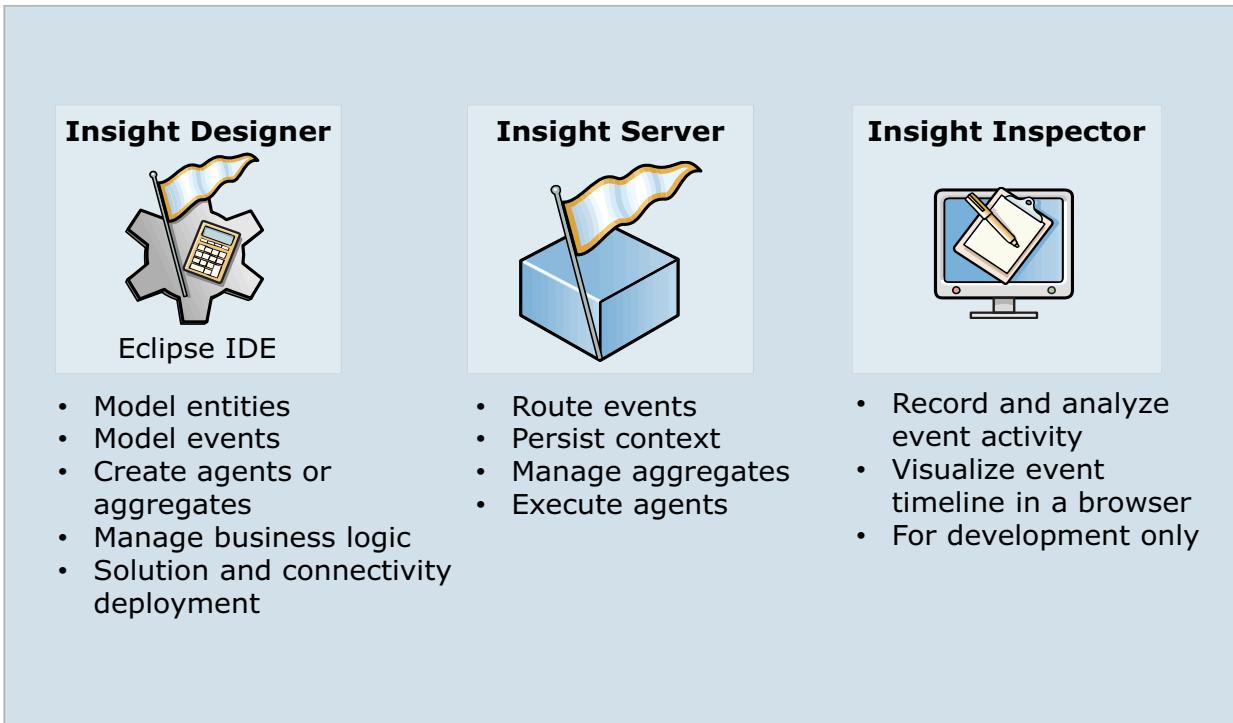
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Figure 1-15. IBM Operational Decision Manager offering

Decision Server Insights is available with IBM Operational Decision Manager.

For more information about the IBM ODM packaging, see the product documentation.

Decision Server Insights components



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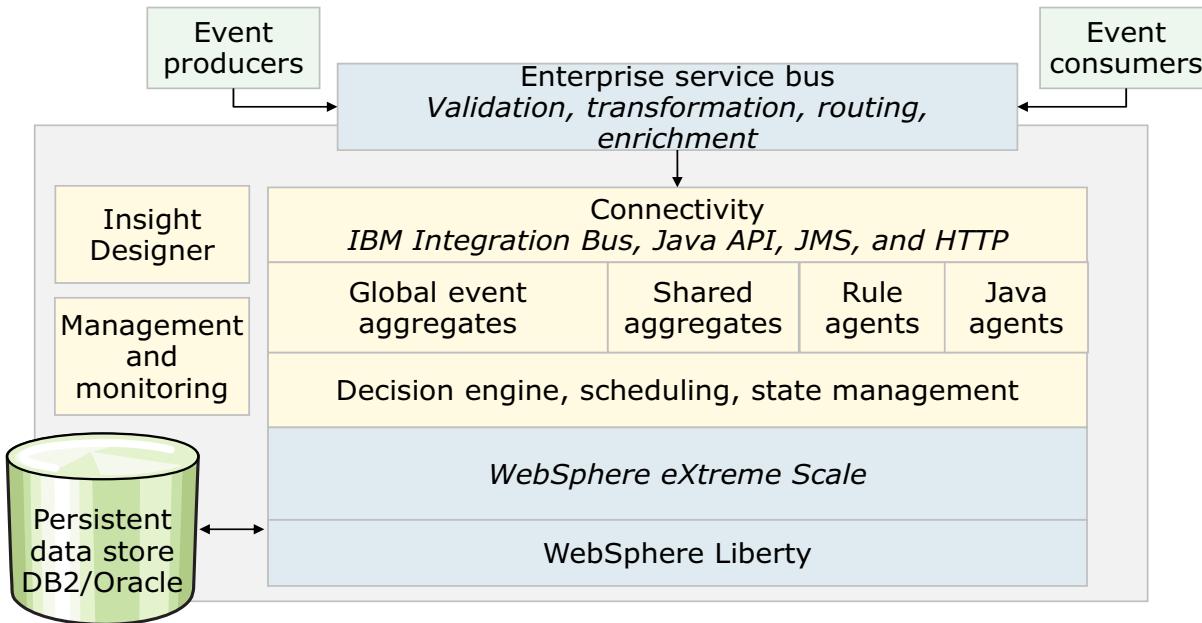
Figure 1-16. *Decision Server Insights components*

Decision Server Insights has a similar structure as ODM Decision Server Rules, but for the moment it has no interaction with Decision Center. Decision Server Insights includes Insight Designer, which is a development environment in Eclipse. Insight Server is a runtime environment that handles complex event processing and agent execution. You use Insight Inspector, which is a browser-based tool, to visualize event processing.

During the course, you work extensively with Insight Designer and Insight Server. You also work with Insight Inspector.

Decision Server Insights high-level architecture

- Integrates business rule and event processing in a single platform



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Figure 1-17. Decision Server Insights high-level architecture

The Decision Server Insights architecture provides reliability, elastic, horizontal scalability, and automatic state management to evaluate your business logic. It integrates business rules, events, and predictive analytics capabilities in a single platform.

As shown in this diagram, Decision Server Insights uses WebSphere Liberty, which is a modular OSGi micro kernel, and WebSphere eXtreme Scale. WebSphere eXtreme Scale is an elastic, scalable, in-memory data-and-compute grid that can store millions of entities and large event histories. Extreme scale is used as a data grid for high-performance access to data.

Next, you see the core components of the runtime, including the decision engine for rule execution, the scheduling capability, and state management.

With this architectural design, the Insights runtime takes care of all the complexity and horizontal scalability for you, so that you can concentrate on building solutions. And you do that in the Eclipse-based Insight Designer. Insight Designer helps you easily model the entities and events, implement the business logic agents, and build the aggregates.

Management is done by a set of JMX MBeans and RESTful web services.

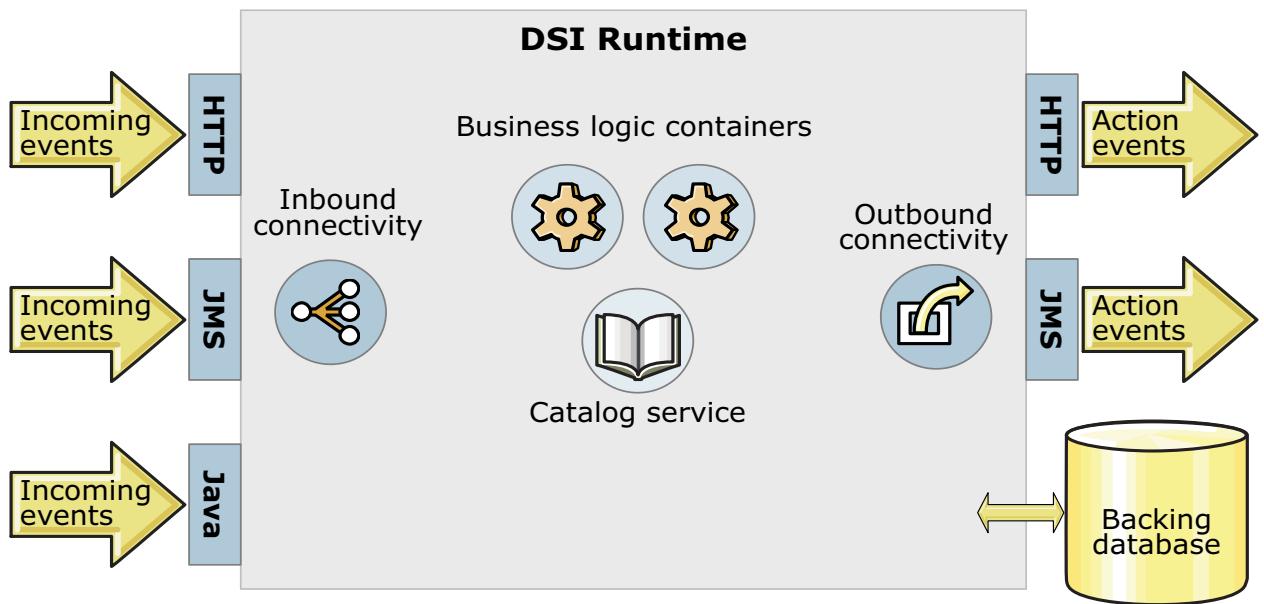
The runtime receives events through connectivity infrastructure (shown as the top layer). The connectivity tier works with an Enterprise Service Bus, which connects to external systems to produce the events and consume the actions. Event bus is not part of the product, but is a desirable

prerequisite to facilitate integration by having one single place where all the events are published. You can define the connectivity by using HTTP, JMS, Java API, or IBM Integration Bus protocols. For disaster recovery, you can choose to write runtime state to a backend data store. DB2 is the supported database for restoring persistent data.

IBM Training



Insight Server



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Figure 1-18. *Insight Server*

The business logic containers are the servers where you store your events and run the agents.

With this architecture, you can dynamically add connectivity and computing resources to keep up with the workload. It collocates the rules and analytics computing resources with context data. By running the computations where the data is, data movement is minimized, which results in the best performance.

This architecture provides the capability to analyze millions of interactions and maintain the context over periods of days, weeks, or even months.

1.4. Decision Server Insights roles

Decision Server Insights roles

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Figure 1-19. *Decision Server Insights roles*

Decision Server Insight roles

Business users		
	Modeler	Models the definitions that are required for the solution and authors rules
Technical users		
	Architect	Integrates configurations for insight solutions, identifies incoming events that require updates to entities, outbound events that are emitted to external systems, and general management of integration touch points
	Developer	Develops, tests, and deploys solutions that include entity models, event definitions, and agents to process the events
	Administrator	Installs, configures, and maintains all the tools across the development, staging, and production environments

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Figure 1-20. *Decision Server Insight roles*

Who works with Decision Server Insights?

As you see listed here, users are usually categorized by four main roles: modeler, architect, developer, and administrator.

Keep in mind that the roles do not necessarily correspond to individuals within the organization, but instead refer to tasks and responsibilities, which might overlap for certain individuals. So the same person might have several roles.

The one business user role that is defined for Decision Server Insights is the Modeler role, whose tasks would include defining the models that are required for the solution and authoring the rules.

The architect is generally responsible for designing and managing the integration touch points: what does Decision Server Insights need to listen to in terms of incoming events and what outbound events need to go to which systems.

The developer builds, tests, and deploys the solutions, including entity models, event definitions, and agents.

The administrator installs, configures, and maintains all the tools across the development, staging, and production environments.

1.5. Installing Decision Server Insights

Installing Decision Server Insights

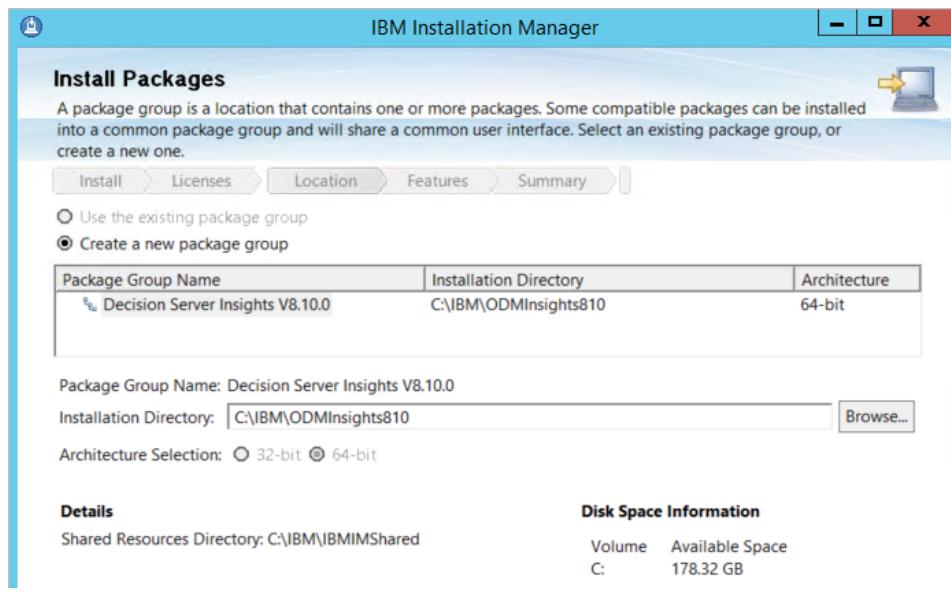
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Figure 1-21. Installing Decision Server Insights



Installing: Defining the installation path

- To avoid conflicts with Operational Decision Manager, choose a separate installation directory
 - Do not use “Program Files” or “Program Files (x86)”



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Figure 1-22. *Installing: Defining the installation path*

You use Installation Manager to install Decision Server Insights.

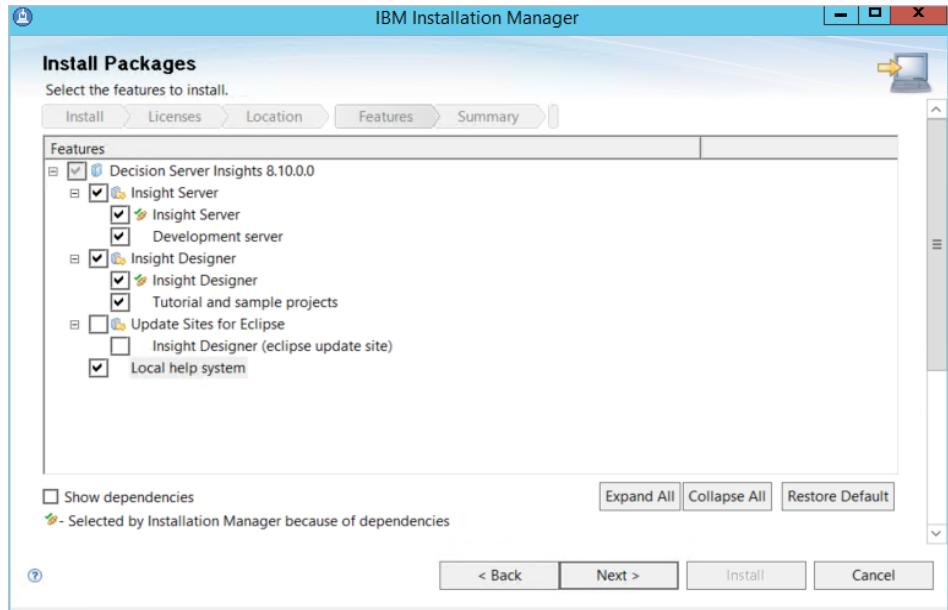
To avoid conflicts with Operational Decision Manager, you use a separate *package group* or installation path, such as the one you see here, to install Decision Server Insights.



Installing: Choosing the product features

- Installing for development

- Keep the default selection of features



- When installing for production, you install Insight Server only

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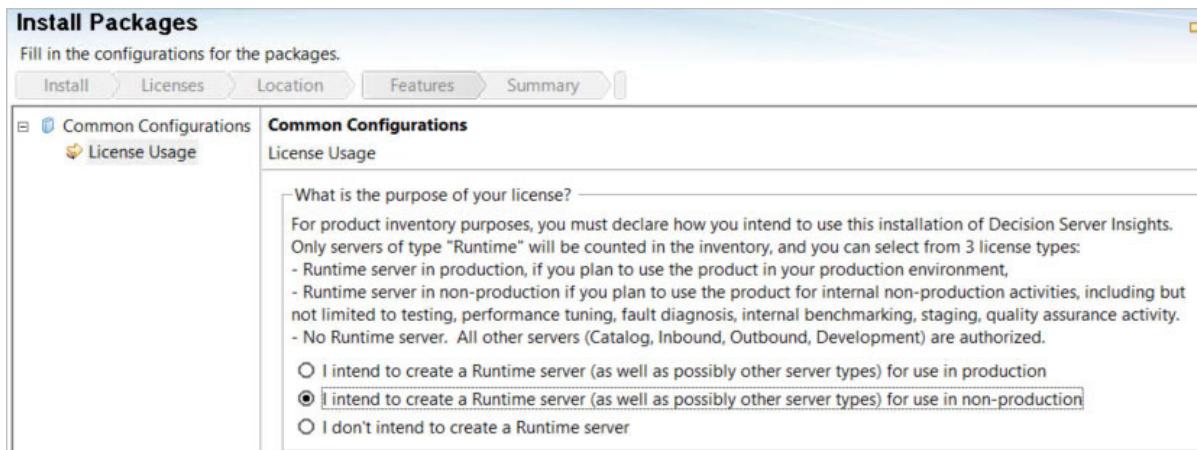
Figure 1-23. Installing: Choosing the product features

When you install Decision Server Insights for development, you can keep the default selection of features. When you install for production, you do not need to install Insight Designer. You install Insight Server only.



Installing: Choosing the installation type

- Choose the installation type that is supported by your license
 - During the exercises, you install for non-production



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Figure 1-24. Installing: Choosing the installation type

You choose the installation type that is supported by your license. For example, if you want to install multiple server types to develop and test solutions in a grid environment, you choose the second option: I intend to create a Runtime server (as well as possibly other server types) for use in non-production

Installing Decision Server Insights on multiple servers

- Use the `CIS_Silent.xml` template for silent installation to install the product features on multiple workstations
 - Provided in the `InstallDir\doc\silent` directory
 - Must install Decision Server Insights on a workstation to obtain the Decision template
- Edit placeholders (delimited with “!”) with actual values

Parameter	Description
<code>!CIS_REPOSITORY!</code>	Location of Decision Server Insights installation files
<code>!CIS_HOME!</code>	Installation path for Decision Server Insights

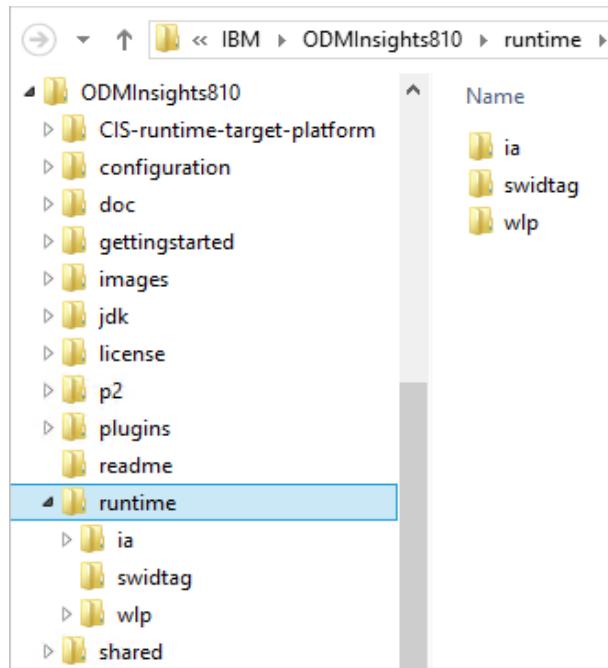
Figure 1-25. *Installing Decision Server Insights on multiple servers*

You can also run silent installation of Decision Server Insights by using the template that is provided with Decision Server Insights.

The template includes place holders for the location of the installation files and the target installation path. During the exercises, you see how to use silent installation to install Decision Server Insights on remote hosts.

Verifying your installation

- Development environment
 - Full Decision Server Insights installation
 - Includes Insight Designer and sample cisDev server
- Production environment
 - Install only Insight Server on multiple hosts
- Runtime tools installed in <InstallDir>/runtime directory
- Production servers created in the WebSphere Liberty Profile (wlp) folder:
`runtime/wlp/usr/servers`



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Figure 1-26. Verifying your installation

To verify your installation, you open the target installation directory that you specified.

During the exercises, you work with the runtime tools that are installed in the **runtime** folder.

Unit summary

- Describe Decision Server Insights and explain how it works
- Explain the programming model
- Describe the Decision Server Insights architecture
- Outline the user roles that are associated with Decision Server Insights

Figure 1-27. Unit summary

Review questions

1. **True or False:** Global event aggregates provide the ability to run calculations across all events of a given type.
2. The development component of Decision Server Insights is an Eclipse plug-in that is called:
 - a. Insight Studio
 - b. Insight Designer
 - c. Event Designer

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Figure 1-28. Review questions

Write your answers here:

1.

2.

Review answers

1. **True or False:** Global event aggregates provide the ability to run calculations across all events of a given type.

Answer: True

2. The development component of Decision Server Insights is an Eclipse plug-in that is called
 - a. Insight Studio
 - b. Insight Designer
 - c. Event Designer

Answer: b. *Insight Designer*

Exercise: Getting started with Decision Server Insights

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Figure 1-30. Exercise: Getting started with Decision Server Insights

Exercise introduction

- Install Decision Server Insights with IBM Installation Manager
- Prepare a workspace in Insight Designer
- Set the debug port for your installation



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Figure 1-31. Exercise introduction

Unit 2. Designing Decision Server Insights solutions

Estimated time

01:30

Overview

This unit teaches you how to plan and design a Decision Server Insights solution.

How you will check your progress

- Review
- Exercise

Unit objectives

- Model a solution
- Outline design factors
- Describe the solution project

Figure 2-1. Unit objectives

Topics

- Design considerations
- Planning for development and test environments
- Creating solutions

Figure 2-2. Topics

2.1. Designing a solution

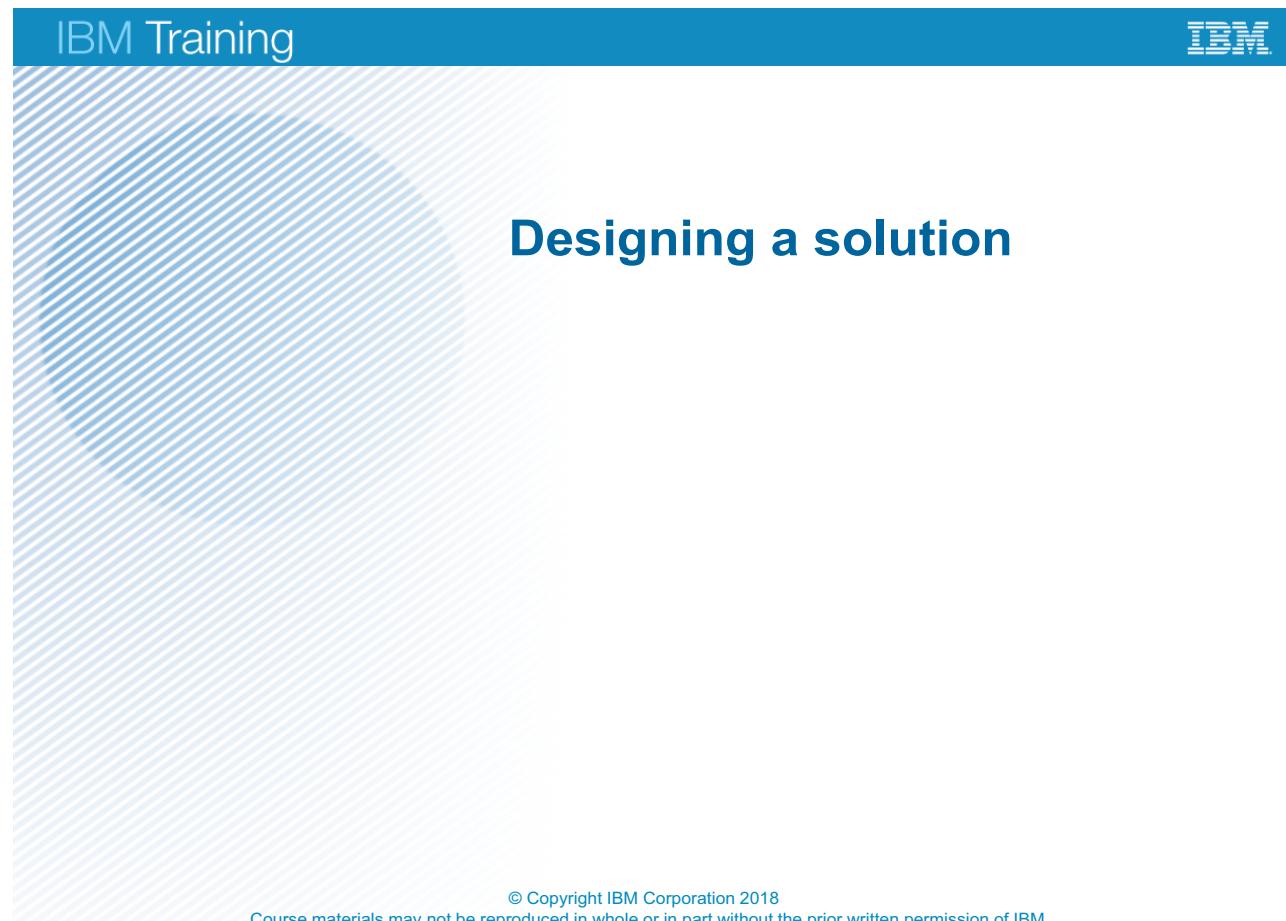


Figure 2-3. Designing a solution

Steps to developing a solution

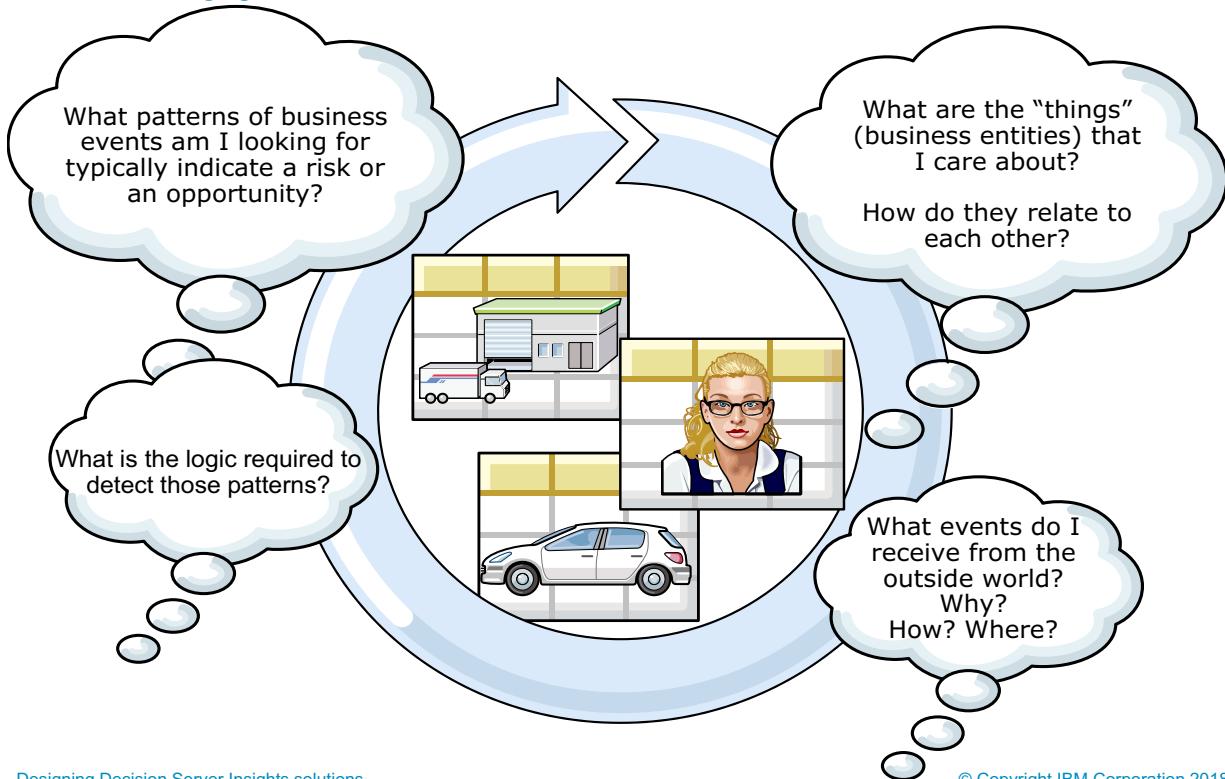
1. Identify your situation
2. Model the entities and events
3. Create agents
4. Detect your situation
5. Write rules

Figure 2-4. Steps to developing a solution

To ensure that the solution correctly addresses your needs, so it is important to take the right approach and analyze your business situation thoroughly before you start your project.



1. Identify your situation



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Figure 2-5. 1. Identify your situation

To get started on a project, you begin by documenting the business struggles that you want to respond to, and what situations you are already using to affect your business results, internal productivity, efficiency, and agility. Clarify which business events or transactions you can analyze over time to detect patterns, trends, or interactions that the business is currently missing. Then, analyze what the business already knows about the events that you want to detect, and which rules or predictive models are used to detect them.

Before you implement a Decision Server Insights solution, the architect and modeler should sketch out an outline of the entities, events, and relationships that must be accounted for in the solution. You must consider which entities are relevant. These entities are the things that have a long lifecycle within the business domain. The events and event patterns are interesting typically have some lifecycle implication on the entity.

Based on that type of information, you can determine the lifecycle for your entities, which types of agents should be bound to those entities, and how the agent should update the entity.

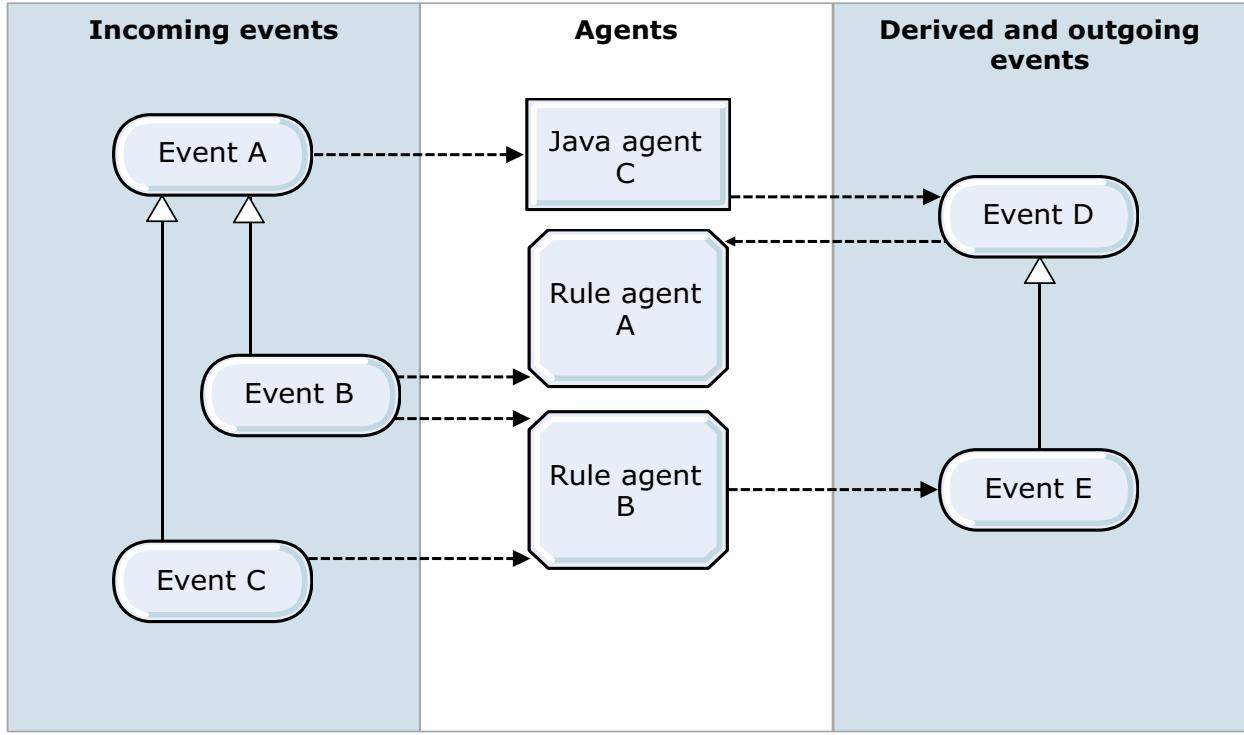
To model this type of information, you can use solution diagrams, as described next.

Instructor

- A developer, architect, or modeler starts in Insights Designer, Insights perspective
- Modeling your entities (the long-lived business things that you care about)

- Modeling your events (typically, these events have some lifecycle implication on the entity), for example, customer entity, might model a change of address event
- Agents are groups of business logic; they are the glue between entity and event
- When an event is received, it gets analyzed by an agent, agent can optionally update the state of an entity
- Multiple agents for an entity for different purposes but subscribing and receive the same events

2. Model entities and events: Solution diagrams



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Figure 2-6. 2. Model entities and events: Solution diagrams

You might have existing models, such as class diagrams or schema files, for your domain. Or, you can use modeling tools, such as UML diagrams to model the entities, events, relationships, and temporal and spatial logic.

This slide shows an example of the notation that you can use to model agents, events, and their relationships within a solution.

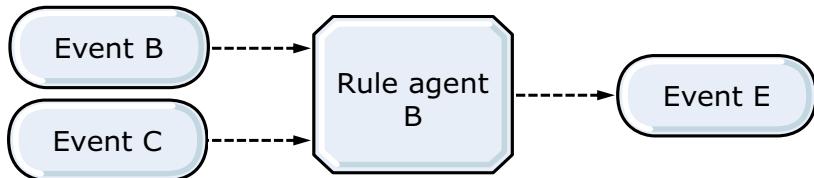
Notice the various elements that are used as notation in the diagram. These elements include the columns, or swimlanes, to distinguish between incoming events, agents, and outbound events.

The elements also include various shapes that are used to differentiate between rule agents or Java agents.

Also, notice that solid lines with arrows represent inheritance relationships, while dashed lines show which events the agents are listening to and which events the agents emit.

This type of overview diagram is to show just the logical view of event processing without physical information about the inbound and outbound endpoints.

Agent diagrams



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Figure 2-7. Agent diagrams

This slide shows an example of an agent diagram that you can use to focus on a single agent, including the events that it subscribes to, and the events that it emits.

The events that the agent is subscribed to are on the left. Emitted events are on the right.

Because the purpose of this type of diagram is to focus on the agent, you don't depict inheritance relationships between the events.

By modeling your agents, you can target which events trigger updates to the entity that this agent is bound to.

As a good practice, when you name your agents, include the name of the bound entity in the agent name.

For example, an agent that is bound to a client entity might include "Client Agent" as part of the name. Multiple agents can be bound to the same entity, so use meaningful names for your agents.

3. Create agents

- Agents update entities when events or event patterns are detected
 - One agent can process multiple events
 - Multiple agents can be bound to a single entity
- Rule agents are the default choice of agent
 - Store state in the bound entity
 - Keep event history
- Java agents do not keep event history
 - To maintain state in a Java agent, add attributes to the bound entity
- General guidelines can also be used to make your choice of agent:
 - Use rule agents when business users need to understand the situation detection and decision logic
 - If you need event aggregation in your solution, use a rule agent because the business rule language makes these operations much simpler
 - Use a Java agent when you integrate with an external service

Figure 2-8. 3. Create agents

In a common business situation, you are likely to need one or more event types, aggregates over time, and an update of the entity state when the situation occurs. When you identify which entities require updates when an event or event pattern occurs, you know that an agent is needed to process the events. An agent can process one or more event types. You can also have multiple agents that act on a single entity, but for different purposes.

When choosing an agent type, in most cases, a rule agent is likely to be your first choice of agent. In a rule agent, you can express rule-based logic in a high-level rule language. You use rule agents for decisions that are based on the business logic that you want to expose to business users. Because the logic is subject to frequent changes, you want the business stakeholders to validate the changes and even make the changes themselves.

Possible reasons for using a Java agent instead of a rule agent:

- To access the system in some way that is not possible in rules. For example, if you want to call a web service. (You can also use an OSGi service for this purpose.) Notice that introducing latency in this way might have severe performance impacts on high-throughput systems.
- To calculate some complex computation (complicated loops, data handling, Java library calls), which is difficult to implement in rules.
- To do something simple, and you are more comfortable writing Java code.

- To write some logic that does not change often and this logic exists in Java.
- For preprocessing or post-processing. For example, converting an inbound event that has some mismatch between the real world and your model by implementing Java code. An example of post-processing is to translate a displayed message to another language before sending the message to the outside world.

How do you choose which type of agent to use in your solution?

You can use all three types of agents together in a solution. Each agent can monitor different entities or the same entity, subscribe to events and emit events.

By default, you **want** to use rule agents. These agents make the decisions. Rule agents express the business logic according to the rules that the business stakeholders write.

For example, you can use a rule agent to respond to the arrival of a new event, such as an ATM withdrawal in New York. You can apply business rules to recognize particular combinations of events and entity states, such as a sequence of withdrawals in different cities, but on the same day.

The business logic is subject to frequent changes, so it must be exposed to the business stakeholders for them to validate the implementation, and even make changes themselves.

Rule agents use the ODM rule authoring technology so that the business language is expressed in high-level natural language.

If you need to write some code to do additional processing, such as data enrichment, you can use Java agents. It is important to note that all decision making should be done by the rule agents. Do not include business logic within the Java agents.

4. Detect your situation

- Consider the sequences of events and the state of entities to test correct pattern or situation detection
 - Use cases
 - Insight Designer test tools

Figure 2-9. 4. Detect your situation

5. Write rules

- Rules define what action to take when an agent receives an event
- Rule vocabulary comes from the elements that are defined in the business model and the agent descriptor
- As you develop your business logic, you might discover ambiguities in the definition of the situation
 - Ongoing collaboration between project stakeholders required
- Consider these questions and how they would be implemented in the rules:
 - What happens when the situation is moved to a different time zone like EST, GMT, CET?
 - What time zone does your solution work in?
 - What happens when you receive an event that is late?
 - What if an event never receives the stop event for a start event that is received?
 - What can you do when you receive events out of logical order?

Figure 2-10. 5. Write rules

Rules define the action to be taken when an agent receives an event. The vocabulary available in the rules comes from the elements that are defined in the business model and the agent descriptor. A rule can be expressed by using business terms, variables, operators, and values.

As you develop your business logic, it is not unusual that you discover hidden ambiguities in the definition of the situation and these tests need to be implemented in rules. As you seek answers to the following questions, the number of rules are likely to increase and provoke further conversations with the stakeholders.

Planning for event delivery

- Model connectivity for how the events are delivered to and from the solution
 - Where will the events come from?
 - What integration and connectivity infrastructure is required to receive the incoming events?
 - Will the incoming events need to be modified or transformed so that the Insight Server runtime can understand them?
 - What about outbound events?
 - What external systems need to be notified by agents?
- Solution gateway API
- Connectivity
 - Inbound
 - Outbound

Figure 2-11. Planning for event delivery

When you design your solution, you must also model connectivity for how the events are delivered to and from the solution.

- Where will the events come from?
- What integration and connectivity infrastructure is required to receive the incoming events?
- Will the incoming events need to be modified or transformed so that the Insight Server runtime can understand them?
- What about outbound events? What external systems need to be notified by agents?

You need to plan for these questions during the design phase.



Understanding “time” in Decision Server Insights

- In Decision Server Insights, every event is assigned a time stamp
- Be familiar with these concepts of time

Time units	Seconds, minutes, hours, days, weeks, months, years
Time scales	Sequence of time points that are defined by time units
Time points	An instant of time that is measured in a time scale where the smallest unit is the second
Time zones	Decision Server Insights uses time operations that are based on the Gregorian calendar Time points for the same event at the same instance but in different time zones are different time points By default, the Decision Server Insights solution uses the time zone of the server where it is deployed
Durations	The distance between two time points Example: 5 years (start point: December 3, 2014, 1:30:00 PM; end point: December 2, 2019, 1:30:00 PM)
Time periods	An interval that is defined by a start time and an end time Examples: today, this month, 2 hours before departure, the year period between the start of 2000 and the start of 2010

Designing Decision Server Insights solutions

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Figure 2-12. Understanding “time” in Decision Server Insights

The concept of time is paramount to the behavior and operations of Decision Server Insights. You must understand the units of time, what a time point is, and how you can use periods and durations to refine which events you act upon.



Location-based reasoning

- Evaluate geographical locations or measure distances
- Static geometries
 - The location of an entity or an event that does not move over time
- Moving geometries
 - The location of an entity that moves over time and has a location at a specific time
- Objects that define geographic locations are represented by these spatial geometries:
 - Geometry
 - Point
 - Line string
 - Linear ring
 - Vertex
 - Polygon
- Composed geometries
 - A group of one or more geometries

Figure 2-13. Location-based reasoning

Decision Server Insights supports the handling of geographic, geometric, and topological data.

In an agent, you can write operations on entities and events that have geographic locations. For example, you can update the location information of an entity, calculate the distance between two points, or send alerts based on the location of an entity.

Before you use geospatial computations in your solution, you must be aware that in special cases the results might be imprecise. Imprecisions in geospatial positioning are caused by the following factors.

- Shape of the Earth
- Computation of floating points

2.2. Planning for development and test environments

Planning for development and test environments

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Figure 2-14. Planning for development and test environments

Setting up the development and test environments

- Decision Server Insights relies upon WebSphere Liberty profile and WebSphere eXtreme Scale for its runtime environment
 - WebSphere eXtreme Scale configuration is paramount to the overall performance and ability to scale
 - Become familiar with WebSphere eXtreme Scale configuration settings that affect capacity and performance
- During the design phase:
 - Document the solution architecture and the functional specification that is related to the data level
 - Define the integration points of your solution
 - Determine security requirements and how to achieve security goals
 - Include anticipated metrics to assess the performance goals

Figure 2-15. Setting up the development and test environments

Before you start developing a solution, you want to make sure that you set up your development and testing environments properly to ensure productivity and mitigate risk.

In the design phase, you need to define the integration points of your solution, document the solution architecture, and functional specifications, along with metrics to assess performance goals.

For example, the design might include metrics for transaction speed performance requirements before deployment, and the architecture might be a series of block diagrams that show networks, service components, and network connection elements.

You should also become familiar with the extreme scale configuration settings that might affect capacity and performance.

Then, you can set up the hardware and other infrastructure resources that are required for development and testing activities.

Design concerns

- Data capacity
 - Entity-offloading can significantly reduce RAM requirements
 - Ensure that the database is adequately sized
 - Consider High availability and replication requirements
- Caching and Persistence
 - Data persistence can be configured to write system data to a back-end database, either synchronously or asynchronously
- Connectivity
 - All inbound and outbound binding is defined in the solution connectivity definition so you must know all of the sending and receiving endpoints and the type of binding that the messages require
- Aggregation
 - Some aggregates may require large amounts of memory and computer processing capacity

Figure 2-16. Design concerns

Before you begin the development of your solution, you want to set up your development and testing environments. Having these environments properly setup can maximize team productivity and mitigate risk.

Establishing a development environment involves setting up hardware and other infrastructure resources, such as the project structure, that the development activities require. Similar to the development environment, the testing environment must be designed to emulate the production environment as closely as possible.

This slide lists some points to consider during the design phase.

For example, when you plan data capacity, consider how many physical machines and processors you need and how much data you plan to store.

For caching topologies, you need to decide whether data should be written to a backend data store synchronously or asynchronously.

For connectivity, what are all the endpoints that you need to receive and send events to? Will you use both JMS and HTTP for inbound and outbound events, or which endpoints require which type of binding?

Global aggregation can require large amounts of memory and computer processing capacity, so the frequency of global aggregate calculation needs to be considered as part of the design.

Planning development and production environments

- Developers use single JVM environments (cisDev)
- Test environments, on the other hand, should ideally emulate your production environment



Figure 2-17. Planning development and production environments

A Decision Server Insights configuration consists of one or more servers that are connected by LAN and WAN network links.

For development, you can set up a single-server topology on a single computer. However, development and test environments should emulate your production environment.

For early development work, you might need to use a Java test client to submit events and test the execution of your solution. However, the final testing environment must use the message providers that you are going to use in production.

For example, you can use both HTTP and JMS for both inbound and outbound events. But, if in production, you expect to receive inbound events over HTTP and JMS, and you choose to use only HTTP to emit outbound events, then your development environment should reflect that.

Planning development and production environments

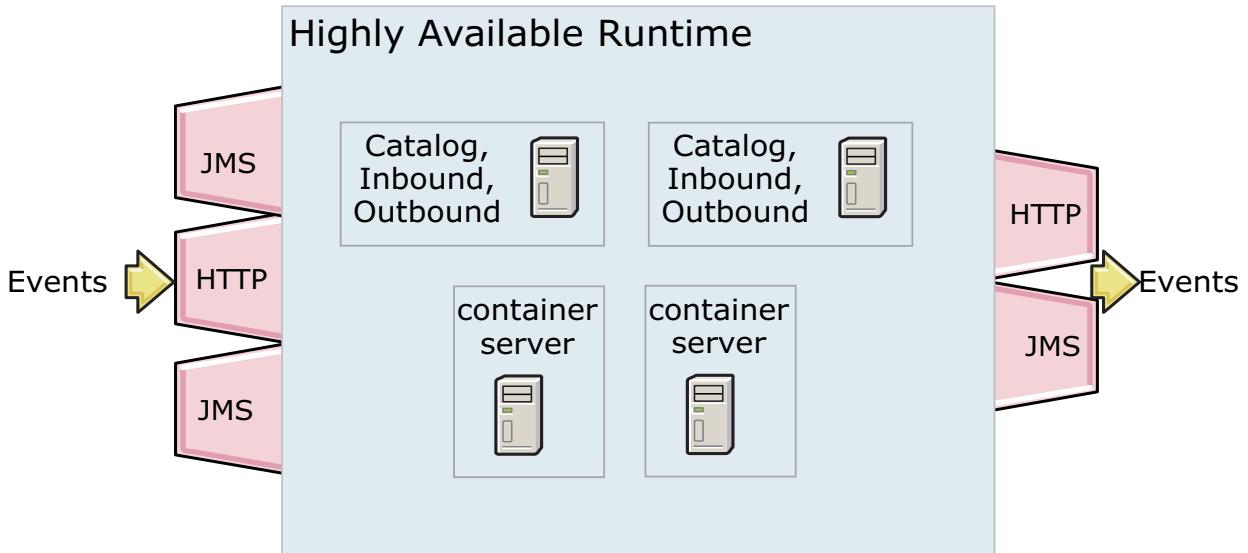


Figure 2-18. Planning development and production environments

Multiple server topology for production is designed to meet availability needs and to ensure minimal downtime if you have a disruption in the IT system. You can also use this topology to add more servers when you need more memory to store the entities.

You use the provided server templates to create the appropriate number of server types with synchronization and backup replicas. Availability and performance can be scaled up horizontally by adding more servers.

For more information about topologies, see the product documentation.

2.3. Creating solutions



Figure 2-19. Creating solutions

Steps of building a Decision Server Insights solution

- To build your solution:
 1. Create a solution project
 2. Create or import business model definitions (BMD)
 3. Set relationships between the objects of the model
 4. Create a rule agent project
 5. Write rule agent business logic
 6. Define connectivity (or use the Java API to send an event)
 7. Create or reuse a cisDev server
 8. Deploy the solution and connectivity
 9. Run the application to submit events and see the agents execute

Figure 2-20. Steps of building a Decision Server Insights solution

To start building a Decision Server Insights solution, you work in Insight Design and create a solution project. After you have a solution project, you define your business model in a business model definitions file. In this definition file, you model your entities, events, other concepts, and the relationships between them.

If you already have an XML model for your domain, you can import your event and entity types from that XSD.

The model determines the vocabulary for you to start creating rule agents, and implementing the business logic in rules.

If you are not using the sample cisDev server, you also create an Insight Server. To test your solution, you deploy the solution to the server, and create and initialize your entities. Finally, you submit events to test the agent execution. You use a Java test client or define connectivity to submit events.

You walk through these steps during the labs.

Getting started on an Insights solution

- The solution project is the starting point for adding rules to agents, adding agents to solutions, and adding solutions to the enterprise-wide runtime
- The solution project is the main project of the solution
- The BOM, rules, and other artifacts are stored separately in referenced projects

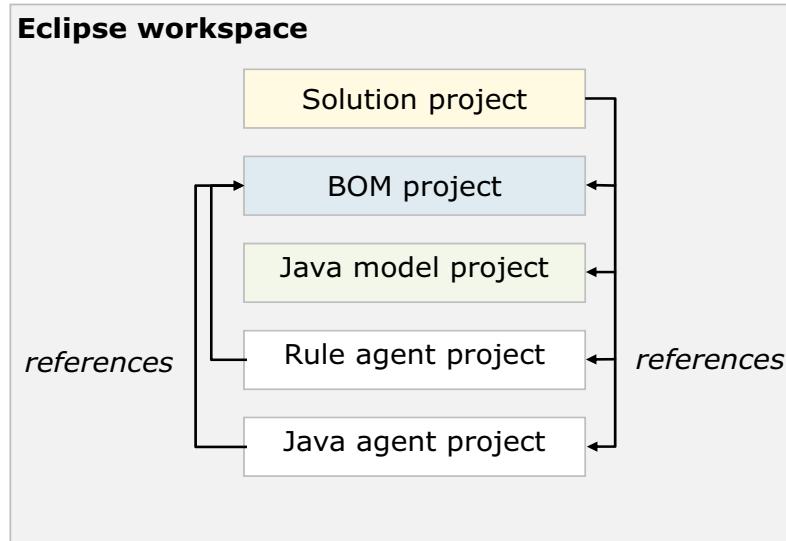


Figure 2-21. Getting started on an Insights solution

If you are familiar with ODM Rules, you know that the rule project is the container for all rule artifacts in a rule solution. With Decision Server Insights, the solution project contains many, but not all solution artifacts. An insight solution involves several projects that reference each other. This type of container organization makes it easier to manage artifacts.

A complete solution contains the projects that you listed here. The solution project is the main project. When you create a solution, you start off with the solution project, BOM project, and Java model project, which are all generated by default.

The BOM project contains your business model definitions. The Java Model project is a container for the executable object model that is generated from the business object model.

After you add entity and event definitions to the BOM model, you can start creating agent projects. Each agent is stored in a separate project.

Rule agent projects contain the rules that define the business logic. The agent project also contains a descriptor that you must complete to define which entity the agent should monitor and what events the agent should listen for or subscribe to. Both rule agents and Java agents use descriptors for this purpose.

The **Java agent project** contains Java code.

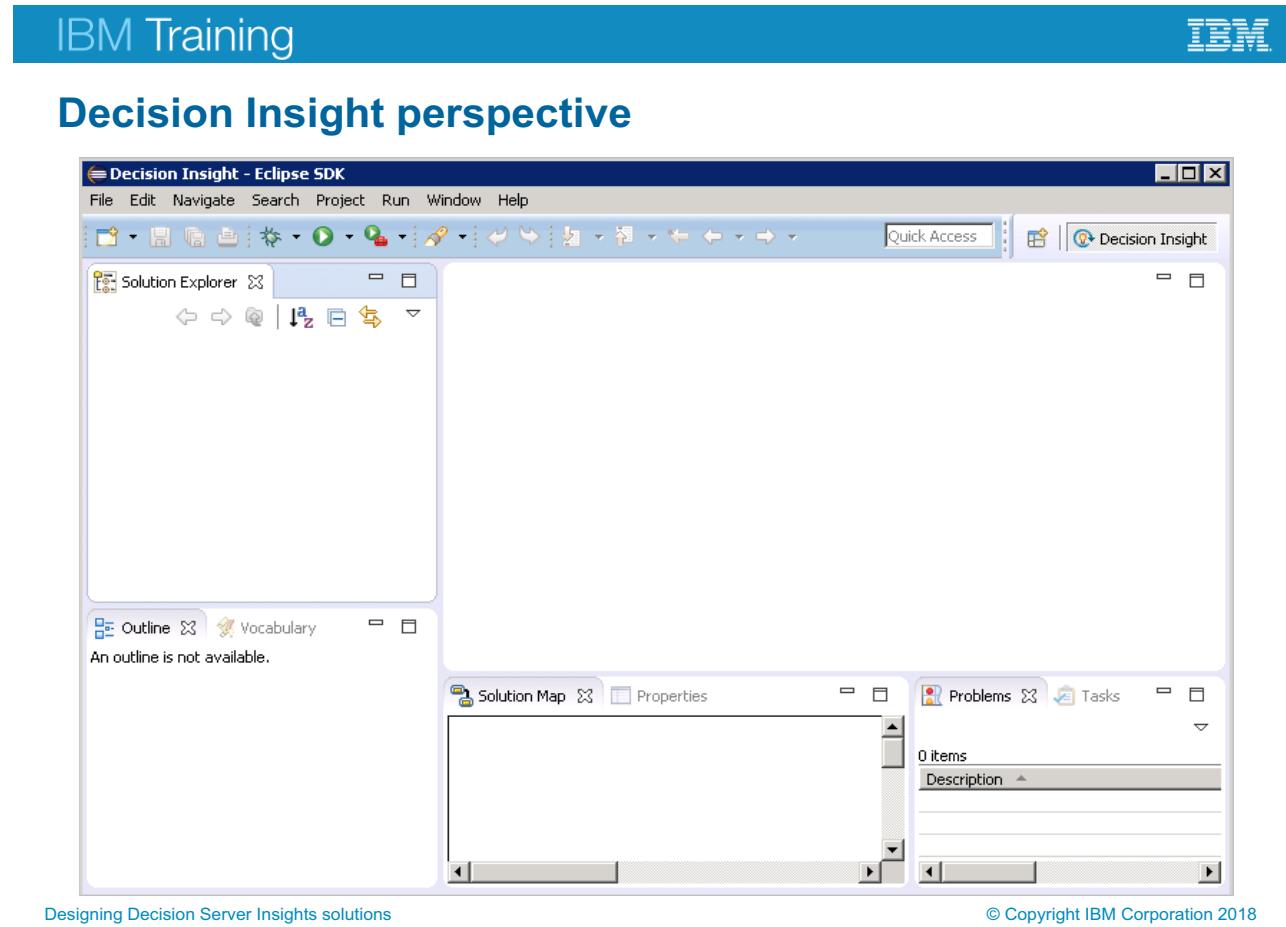


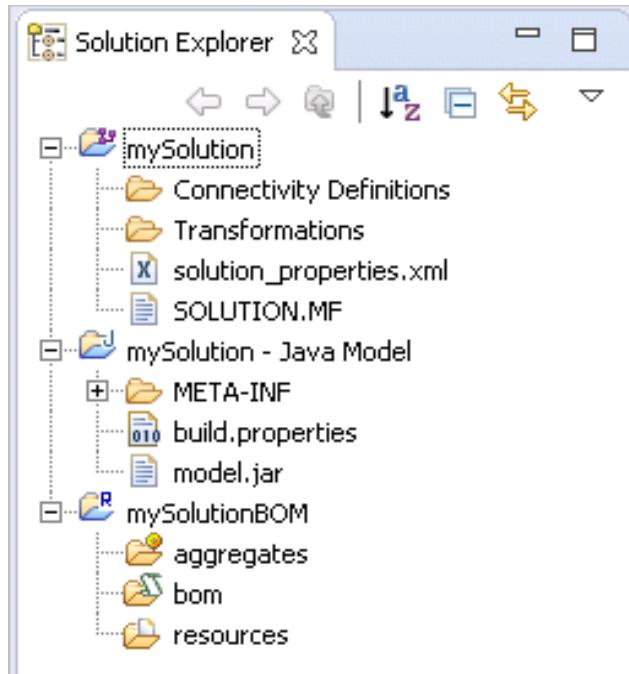
Figure 2-22. *Decision Insight perspective*

When you create your solution in Insight Designer, you work in the Decision Insight perspective, as you see here.

This perspective contains the menus and tools that you need to create the solution, including the Solution Explorer, which lists any projects that are referenced for the solution.

Solution project folders and files

- When you create a solution, three projects are automatically generated:
 - Solution project
 - BOM project
 - Java Model project



Designing Decision Server Insights solutions

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Figure 2-23. Solution project folders and files

As you see in the example, when you create a solution, three projects are generated: the solution project, the BOM project, and the Java model project.

The BOM project that contains the following artifacts:

- bom** folder: Stores the business model definition files (**.bmd**) where you define in plain English the entities, events, concepts, and others
- aggregates** folder: Stores the global aggregate definitions (**.agg**)

The solution project folder contains these folders and files:

- Connectivity Definitions** folder: Stores the connectivity definition (**.cdef**) files that define the inbound and outbound bindings and endpoints for the solution.
- Transformations** folder: Stores XSL transformation files for converting unrecognized inbound messages.
- solution_properties.xml** file: Contains the custom properties of the solution project.
- SOLUTION.MF** file: Contains the version information of the solution, and the solution symbolic name.



Note

You learn more about the business model and aggregates in later units.



Setting up the workspace

- To compile Java code for Java agents in Insight solutions, you must set Insight Server as the target platform

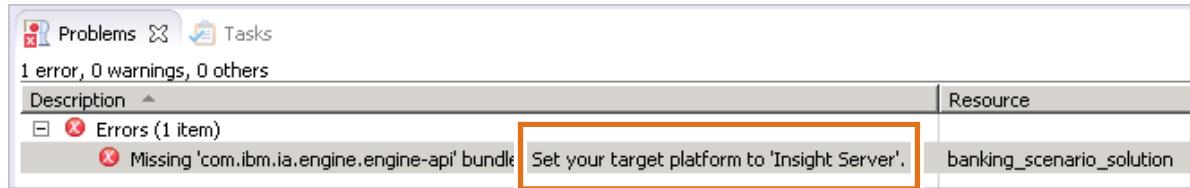
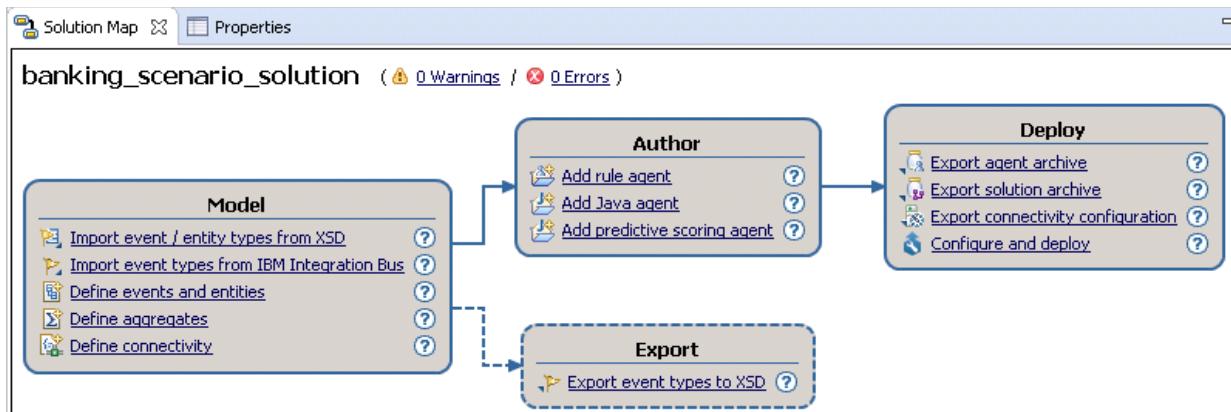


Figure 2-24. Setting up the workspace

When you develop an Insights solution, you need to set the target platform to use the Insight Server. Java agents are plug-in projects, so to compile the Java code for these plug-in projects, you must set the Insight Server target platform, which is a set of OSGi bundles.

Solution Map view in Decision Insight perspective

- Use the Solution Map to guide you through development tasks
- Solution Map tasks are grouped in boxes in the map by their overall goal: Model, Author, Export, and Deploy



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Figure 2-25. Solution Map view in Decision Insight perspective

The Decision Insight perspective also includes the Solution Map, which guides you through the tasks of developing a solution.

You start with modeling, which includes the business model, aggregates, and connectivity definitions. You learn more about the Model task later.

The solution map is context-sensitive to each solution that you have in your workspace.

The map displays the solution project name and an accumulated count of the warnings and errors from all of the projects that are referenced by the solution.

When you click a task in the map, Insight Designer opens the relevant dialog box or wizard to start that task. Tasks that appear in gray in the map are disabled because they are not currently applicable to the status of the selected solution.

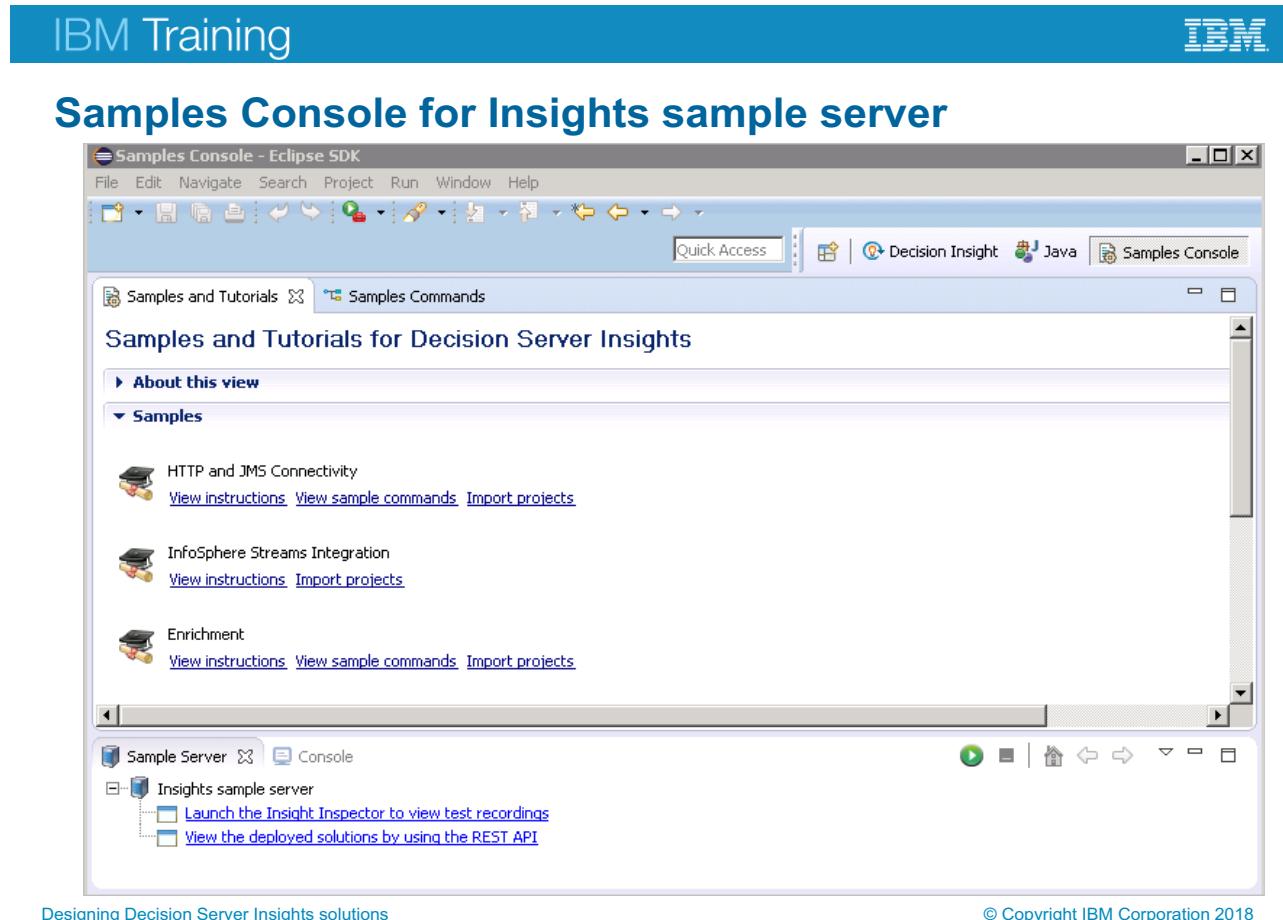


Figure 2-26. Samples Console for Insights sample server

While most of the solution development tasks are done in the Decision Insight Perspective, you also work in the Java perspective and the Samples Console perspective.

For example, to work with the sample server and other tools that are provided by Decision Server Insights, you can use the menus and tools in the Samples console perspective. You can start and stop the Insights sample server from a command prompt window or from the Samples Console. The Insights sample server is called cisDev.

Unit summary

- Model a solution
- Outline design factors
- Describe the solution project

Figure 2-27. Unit summary

Review questions

1. True or false: An outbound event from one agent cannot be an inbound event for another agent.
2. True or false: The spatial geometries feature is built in Decision Server Insights.
3. Solution projects are an Eclipse project that includes references to which of these projects? Select all that apply.
 - a. Agent projects
 - b. Java test client projects
 - c. Business object model project

Figure 2-28. Review questions

Write your answers here:

- 1.
- 2.
- 3.

Review answers

1. True or false: An outbound event from one agent cannot be an inbound event for another agent.
Answer: False. An agent can consume events that were emitted by other agents.
2. True or false: The spatial geometries feature is built in Decision Server Insights.
Answer: True.
3. Solution projects are an Eclipse project that includes references to which of these projects? Select all that apply.
 - a. Agent projects
 - b. Java test client projects
 - c. Business object model project

Answer: a (agent projects) and c (business object model projects).

Figure 2-29. Review answers

Exercise: Creating a rule agent

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Figure 2-30. Exercise:

Exercise introduction

- Create a rule agent
- Write an agent descriptor
- Write a rule that emits an event
- Create a Java agent



Figure 2-31. Exercise introduction

Unit 3. Creating the business model

Estimated time

01:00

Overview

This unit teaches you how to create the business model definition file.

How you will check your progress

- Review
- Exercise

Unit objectives

- Describe the elements of a business model
- Translate a UML diagram into a business model definition

Figure 3-1. Unit objectives

Topics

- Overview of the business model
- Writing the business model

Creating the business model

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Figure 3-2. Topics

3.1. Overview of the business model

Overview of the business model

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Figure 3-3. Overview of the business model

Modeling for a Decision Server Insights solution

- Before you implement the business logic, you must build the business model
 - Business model definitions determine agent and rule vocabulary
 - Despite the name, DSI business models are not enterprise business models. They are specific to the solution.
- A business model includes definitions for:
 - Entity types
 - Event types
 - Attributes
 - Relationships
 - Global aggregates
 - Shared aggregates and entity initialization (in the Statements tab)
- You can use modeling tools, such as UML diagrams to visualize entities, events and relationships between them

Figure 3-4. Modeling for a Decision Server Insights solution

Modeling the entities and events in your business domain is the first step of developing an insight solution.

The business model includes definitions for entity types, event types, attributes, relationships, global aggregates, and others.

If you used modeling tools, such as UML diagrams to model your entities, events, relationships, or temporal logic, you can use those diagrams as a starting point for your model.

The language that is used in the business model definition is natural language not code. It integrates well with source code control. All the vocabulary that is used by your agents and your business rules comes from the business model definition file.

Elements of a business model

- **Concepts:** A simple data structure, such as an address
- **Entities:** Concepts that have an identifier and a lifecycle
- **Events:** Concepts that have a time stamp and can relate to one or more entities
- **Relationships:** Defines the inheritance or reference to other entities, events, and concepts
- **Enumerations:** Concepts that include a list of possible values
- **Attributes:** An attribute is a characteristic of an entity, event, or concept
- **Derived attributes:** Value is calculated from the value of another attribute
- **Enriched attributes:** Value is supplied by a data provider
- **Data providers:** A service that accepts inputs and that returns outputs
- **Facets:** Location or time attributes that can be added to a concept

Figure 3-5. Elements of a business model

Here you see a list of elements that you can define in your business model.

For example, a concept is the most basic data structure that you can include in your business model.

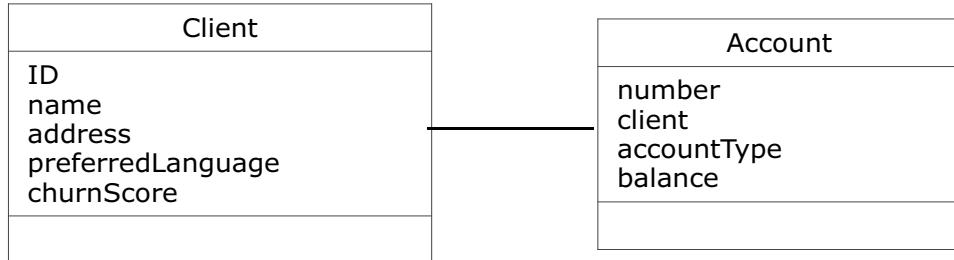
Next, you see entities, which are also considered concepts, but they have an identifier and lifecycle. As discussed earlier, they are the things that are important or relevant to your business domain. The events that occur in your domain happen to these entities or affect the entities.

Events are also considered concepts, but they are concepts with a time stamp and they can relate to one or more entities.

For more information about other elements of a business model, see the product documentation for Decision Server Insights.

Example entity model

- UML class diagram for an entity of type Client and of type Account



- Business model definition

a client is a **business entity identified by an ID.**

a client **has a name, an address, a preferred language, a churnScore.**

an account is a **business entity identified by a number.**

an account **is related to a client.**

an account **has an account type, a balance.**

Figure 3-6. Example entity model

Here you see a UML class diagram that is used to model an entity of type *client* and an entity of type *account*.

The entity type is composed of a set of attributes and relationships to other entity types. Each entity has an attribute that acts as an identifier for entity instances.

In this example, as you can see by the business model definition, the identifier for client is the *ID*. The identifier for the account is *number*.

Also, in the business model definition, you see that to define the relationship between entities by using the “is related to” construct. In this example for account, an account is related to a client.

Example event model with relationships

- UML diagram of event inheritance relationships

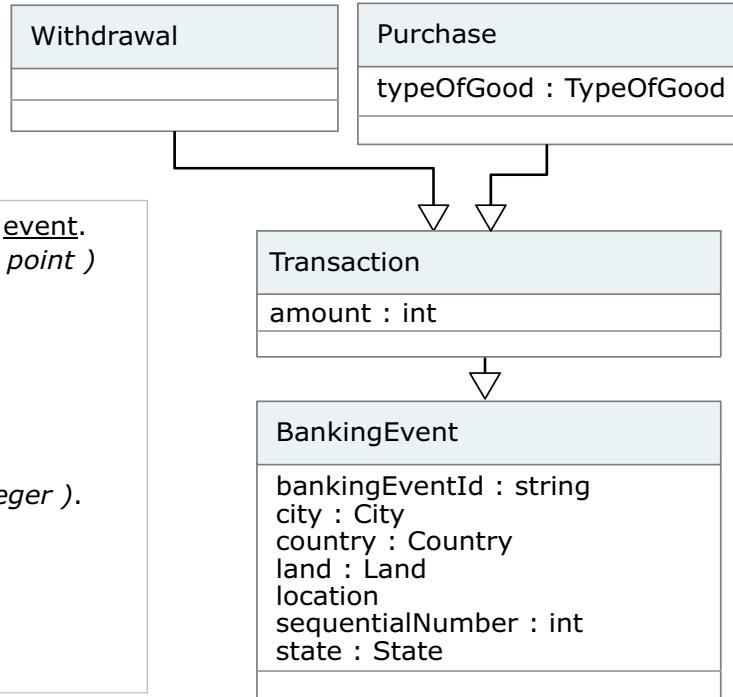
- Business model definition

a banking event is a client related event.
a banking event has a location (a point) used as the default geometry
a banking event has a country.
a banking event has a state.
a banking event has a city.

a transaction is a banking event.
a transaction has an amount (integer).

a withdrawal is a transaction.

a purchase is a transaction.
a purchase has a type of good.



Creating the business model

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Figure 3-7. Example event model with relationships

Here, you see a UML diagram of events in the inheritance relationships between events.

An event type describes the shape of an event. It is also composed of a set of attributes, and a set of relationships to other entity types. An event has a time stamp attribute that represents a date and time. An event can also have a location, such as the location of a withdrawal. Decision Server Insights provides special constructs in the rule language to facilitate the handling of location.

As you see in the model definition, you can model relationships between event types. The type of construct that you use determines the type of relationship. For example, the business model defines a **banking event** with its attributes, and the definition for **transaction** is that the transaction is a banking event, and it also has an amount. Also, transaction is in the definition for **withdrawal**: a withdrawal is a transaction.

So here, you see the inheritance relationships that are depicted in the UML diagram, which are translated into the business model definition.

Example enumerations

- Enumerations define a list of possible values

<enumeration>
AccountType
Savings: Account
Checking: Account
High_Interest: Account

<enumeration>
City
Beijing: City
Kuala_Lumpur: City
New_York: City
Paris: City
San_Francisco: City

<enumeration>
TypeOfGood
COMPUTING: TypeOfGood
TRAVEL: TypeOfGood
MUSICAL: TypeOfGood

Figure 3-8. Example enumerations

On this slide, you see examples of enumerations. Enumerations define a list of possible values.

An entity type like account might have an attribute account type, which is an enumeration and limits the list of possible values.

Facets

- Add a location or time facet to a concept to facilitate time-based or location-based reasoning in your rules
 - Example: Use “*flight is before...*” rather than “*the timestamp of the flight is before...*”
- Location facets
 - Location facets are used for space-driven logic
 - Example:
a banking event **has a** location (a point) **used as the default** geometry.
- Time facets
 - In Decision Server Insights, every event is assigned a time stamp, or time **facet** of type date and time
 - Time facets are used for time-based reasoning
 - Example:
a client related event **has a** transaction time (a time) **used as the default** time stamp.

[Creating the business model](#)

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Figure 3-9. Facets

In Decision Server Insights, facets are used when you work with location-based or time-based reasoning.

The term “facet” refers to an aspect or element of something. A “location facet” means an element of location, such as a geometrical point. Or, with the time facet, it refers to an element of time, such as the date or an exact time.

When you define facets in your model, these facets can help you streamline your rules so that the rules are easier to write and read.

For example, consider the banking event definition on this slide, which has “a point” defined as the default geometry. This point is the location facet. With this facet, you can compare the distance between geometrical points where banking events occur.

So when you write the rule about banking events, you do not need to write out the full term:

the distance between the location point of a BankingEvent1 compared to the location pointed BankingEvent2

You can write a simpler rule that tests:

the distance between BankingEvent1 and BankingEvent2 in miles

The rule language automatically implies a test between geometrical points for these events.

The same principal applies to the time facet that is defined for client-related event definition that is shown here. You can write a rule that tests:

```
if ClientRelatedEvent1 is before ClientRelatedEvent2
```

The language implies that the times for these events are to be compared.

So, the facets are a powerful tool for implied business logic and also improve readability.

3.2. Writing the business model

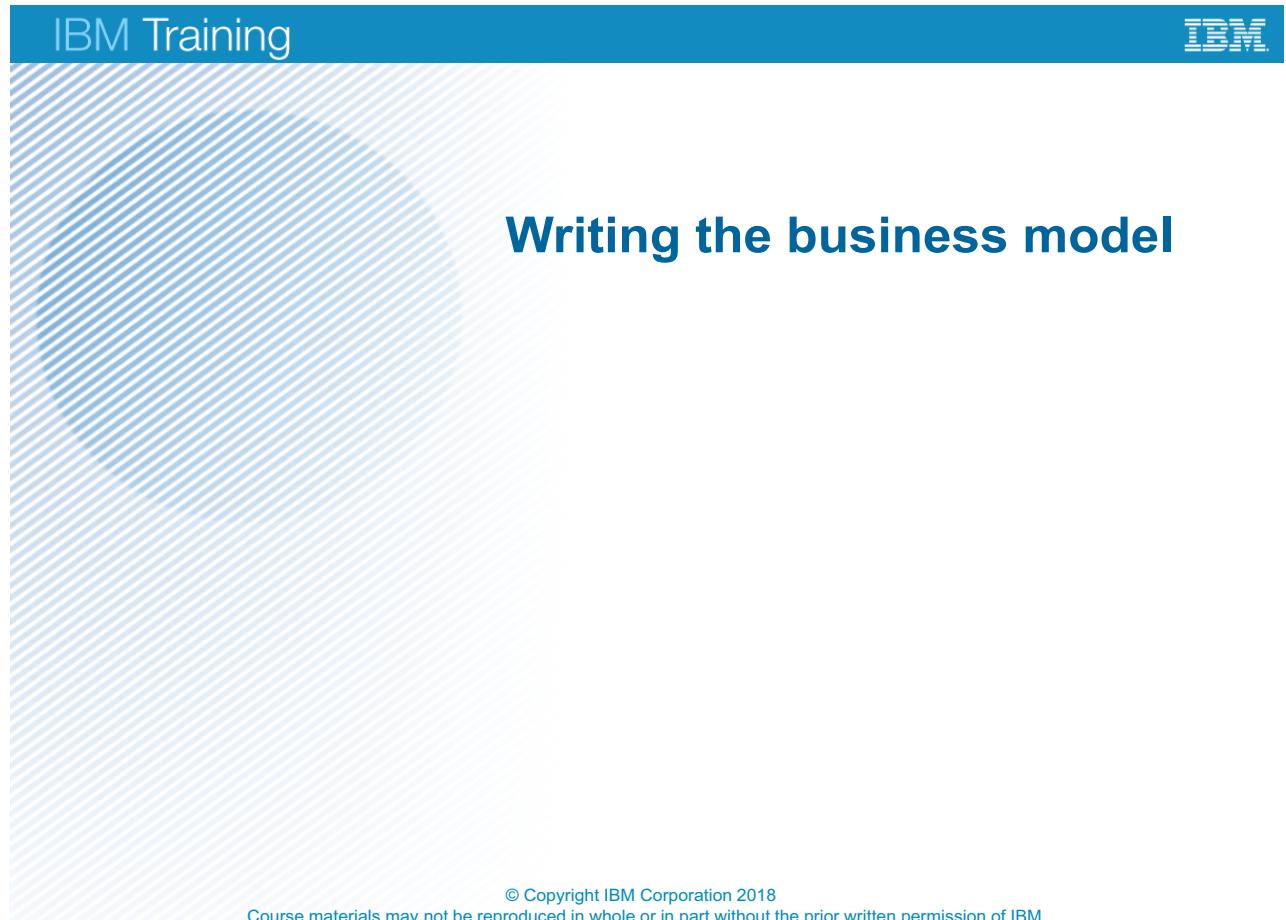


Figure 3-10. Writing the business model

Definition structure

- A definition contains one or more phrases
 - First phrase defines the nature of the concept as an entity, event, or simple concept
 - Phrases that follow specify the attributes and relationships to other concepts
 - Each phrase starts with the name of the concept and ends with a period (.)

- Example definition for a ticket entity
 - Identifier: ***ticket number***
 - Attribute: ***price***, which is a number
 - Relationships to: ***trip*** and ***customer*** entities, ***seating category***, and ***status*** enumerations

```
a ticket is a business entity
identified by a ticket number.

a ticket has a price (numeric).

a ticket is related to a trip.

a ticket is related to a customer.

a ticket has a seating category.

a ticket has a status.
```

Figure 3-11. Definition structure

So how do you start writing the definition? When you open the editor, you see an empty page. But as you start typing, the completion menu prompts you with a list of possible syntax options or constructs that are listed in a Content Assist box. You can either choose an option from the Content Assist box, or you can type freely, or even copy and paste from another file. As you add more entity and event definitions, these terms are added to the vocabulary, and also become available in the Content Assist box. So later definitions in that file allow you to choose from earlier definitions, which is useful when you want to define a relationship for example.

As you write your first definition, keep in mind the syntax. A definition contains one or more phrases to identify the type of concept, either an entity, an event, or just a simple concept. You also include phrases to specify attributes, and phrases to identify relationships to other concepts. Each phrase starts with the name of the concept (including the article, “a” or “an”) and ends with a period.

On this slide, you see the definition for a ticket entity. Each phrase starts with lowercase “a ticket” and ends with a period. The ticket definition also includes an identifier: ***ticket number***

So, the first line of this definition is:

a ticket is a business entity identified by a ticket number

The definition also includes attributes, which are identified by the ***has a*** construct. So a ticket ***has a*** price, and in brackets, price is of type ***numeric***. Also, a ticket ***has a*** seating category and a ticket

has a status. Seating category and status might be defined as enumerations, which would limit the possible values for this attribute.

The ticket definition also includes phrases to identify the relationships. A ticket *is related* to a trip and a ticket *is related* to a customer.

So the **trip** entity type, the **customer** entity type, the **seating category**, and **status** enumerations all need to be defined in this file so that the ticket entity type definition has no errors.

Defining attributes

- Keywords to define attributes:
 - with**
 - has**
 - can be**

an address **is a concept with** a street, a town, a zip code **and** a country.

a customer **is a business entity identified by** an email **with** a first name, a last name, and an address.

a customer **has** a mobile number.

a customer **has** a gender.

a customer **has** several different payment methods.

- Attributes

- Must have a type, and the instance of this type belongs to the instance of the object
- Attributes must be separated by commas, except for the last attribute in the list, which is preceded by the **and** connector
- Introduced by an indefinite article: **a**, **an**, **some** and “**several different**”

Figure 3-12. Defining attributes

Entities, concepts, and events can have attributes.

On this slide you see the keywords that are part of the predefined syntax to define attributes you use the words: **with**, **has**, or **can be**.

For example, in this snippet from a business model definition, an **address** is defined with four attributes that addresses the concept. It is defined with the following attributes: **street**, **town**, **zip code**, and **country**. Notice that you do not need to have a separate phrase for every attribute; you can use a comma-separated list.

The next example is the **customer**, which is a business entity that is identified by an email with a first name, a last name, and an address. The additional attributes **mobile number** and **gender** are also included for the customer by using the **has** keyword.

When you define an attribute, it must have a type. For example, a first name and a last name would be of type **string** or gender would be an enumerated list. Also, notice that the attributes were introduced by an indefinite article you can use: **a**, **an**, or **some**.

Entity definition

- Entities have an identifier and their own lifecycle

a car **is a business entity identified by** a vin **with** a make, a model,
a year (integer).

a car **is related to** a policy.

a policy **is a business entity identified by** an id.
a policy **has** a start (date & time).
a policy **has** an end (date & time).
a policy **is related to** a car.
a policy **is related to** a customer.
a policy **has** a fraud status.

Figure 3-13. Entity definition

This slide shows two more examples of entity type definitions.

All the entity types that you defined for your domain have a lifecycle, which means that when you have an entity of that type it is created with a certain set of initial values. As events arrive in the Insights runtime, those events have some impact on the lifecycle of the entities.

In general, you define entities that have a long lifespan within your domain. On this slide, if your domain is car insurance and your car entity has a lifecycle that begins when the car is first insured. That lifecycle lasts for the duration of the policy. The policy also is an entity with a lifecycle. In the business model definition snippet here, the lifecycle of the policy entity is defined by the start and end date.

Event definition

- An event is a concept with a time stamp
 - Define events to represent the things that happen in your business
- Each event has a time of occurrence

a client related event **is a business event time-stamped by a timestamp.**

a client related event **is related to** a client.

Figure 3-14. Event definition

Here, you see an example of an event type definition.

The definition uses the predefined syntax term: **a business event time-stamped by a timestamp**

Every event that arrives in the Decision Server Insights runtime receives a time stamp to determine how it is processed.

As you can see from the definition, this event type is related to a client entity type so that relationship is defined by the **is related to** construct.



Business model editor (1 of 3)

- **Definitions tab**
- Model is written with natural language in the BMD

```

BusinessModel.bmd
21 a client is a business entity identified by a name .
22 a client has a segment .
23 a client has a churn score ( numeric ) .
24 a client has a monthly profitability ( numeric ) .
25 a client has a propensity to buy BROADWAY SHOW TICKETS ( numeric ) .
26 a client has a preferred language ( a language ) .
27 a client has a average withdrawal ( numeric ) .
28
29 -----
30 -- Events --
31 -----
32
33 a client related event is a business event time-stamped by a timestamp .
34 a client related event is related to a client .
35
36 a confirmation from client is a client related event .
37
38 a banking event is a client related event .
39 a banking event has a banking event id .
40 a banking event has a location ( a point ) used as the default geometry .
41 a banking event has a country .
42 a banking event has a Land .
43 a banking event has a state .
44 a banking event has a county .
45 a banking event has a city .
46
47 a check account event is a banking event .
48 <

```

Definitions | Statements | BOM

Creating the business model

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Figure 3-15. Business model editor (1 of 3)

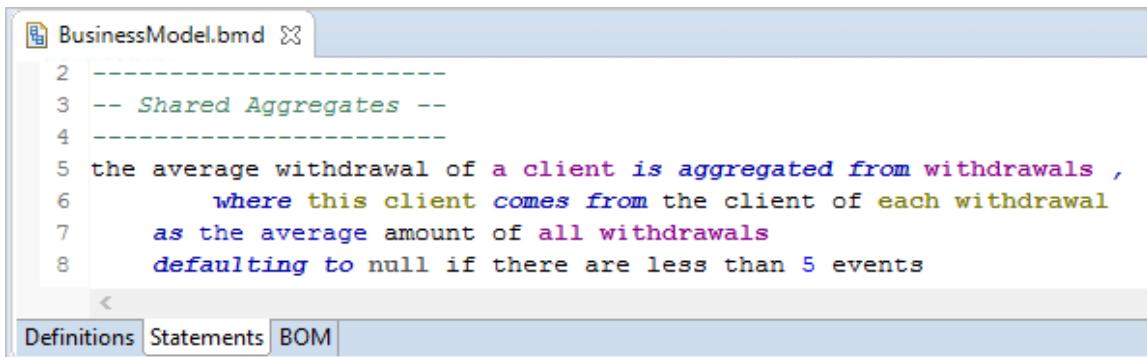
Here, you see a screen capture of the business model definition in the business model editor.

The predefined constructs that are provided as part of the model definition language are italicized and in bold. Notice that the end of every phrase has a period.

On the **Definitions** tab of the editor, you can type freestyle. You can also press Ctrl+Space to use the editor and see the list of syntax options that are available in the Content Assist box. You can even copy and paste definitions from another file.

Business model editor (2 of 3)

- Use **Statements** tab: In the Statements editor, you write behaviors for your business model definitions
 - Initialize entities from an event
 - Enrich attributes
 - Derive attributes
- Example: Definition of a shared aggregate



```

BusinessModel.bmd
-----
2 -----
3 -- Shared Aggregates --
4 -----
5 the average withdrawal of a client is aggregated from withdrawals ,
6     where this client comes from the client of each withdrawal
7     as the average amount of all withdrawals
8     defaulting to null if there are less than 5 events

```

The screenshot shows a software interface titled "BusinessModel.bmd". The main window displays a block of text in a code editor, specifically defining a "Shared Aggregates" section. The text describes how to calculate the average withdrawal of a client by aggregating from multiple withdrawal events, taking the average of all withdrawals, and defaulting to null if there are fewer than 5 events. Below the code editor, there is a navigation bar with three tabs: "Definitions", "Statements" (which is currently selected), and "BOM".

Figure 3-16. Business model editor (2 of 3)

A data provider is a piece of Java code that calculates the value of an entity's attribute at runtime. A data provider typically fetches data in a database or calls a web service.

The screen capture on the slide shows the **Statements** editor. On the **Definitions** tab, if you define a type of entity that requires methods, you use the **Statements** tab to complete those methods.

For example, on the **Definitions** tab, if you define a language provider, then, on the **Statements** tab you define how that language provider should behave.



IBM

Business model editor (3 of 3)

- Use **BOM** tab to view and verify code implementation

The screenshot shows the IBM Business Model editor interface. The title bar says "BusinessModel.bmd". The main area displays the following Java-like code:

```

property bdl_generated "true"
package banking_scenario;

public class BankingEvent
    extends banking_scenario.ClientRelatedEvent
    property "brl.facets" "com.ibm.geolib.geom.Geometry:location"
    property "de.generated" "true"
    property "xsd.definedNamespaces" "xmlns:geom=\\"http://www.ibm.com/geolib/geom\\" "
    property "xsd.eventElementName" "BankingEvent"
    property "xsd.fileName" "model.xsd"
    property "xsd.support" "true"
    property "xsd.targetNamespace" "http://www.ibm.com/ia/xmlns/default/banking_scenario_bom/model"
{
    public string bankingEventId
        property "xsd.name" "bankingEventId"
        property "xsd.optional" "true"
        property "xsd.order" "0";
    public banking_scenario.City city
        property "xsd.name" "city"
        property "xsd.optional" "true"
}
  
```

At the bottom of the editor window, there are three tabs: "Definitions", "Statements", and "BOM". The "BOM" tab is currently selected.

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Figure 3-17. Business model editor (3 of 3)

As a developer, you might find the format of your model definitions easier to read and review in the BOM view of the editor. By clicking the **BOM** tab, you can see the implementation of your model.

Unit summary

- Describe the elements of a business model
- Translate a UML diagram into a business model definition

Figure 3-18. Unit summary

Review questions

1. True or False: Entity and event types are defined in UML.
2. True or False: BMD supports inheritance for entity types and for event types.
3. True or False: Every entity has a unique identifier.
4. True or False: Every event has a timestamp.

Figure 3-19. Review questions

Write your answers here:

- 1.
- 2.
- 3.
- 4.

Review answers

1. True or False: Entity and event types are defined in UML.

Answer: False: Entity and event types are defined in the BMD.

2. True or False: BMD supports inheritance for entity types and for event types.

Answer: True. The BMD supports inheritance for entity types and for event types through the “is a” construct.

3. True or False: Every entity has a unique identifier.

Answer: True.

4. True or False: Every event has a timestamp.

Answer: True.

Figure 3-20. Review answers

Exercise: Defining the business model

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Figure 3-21. Exercise:

Exercise introduction

- Create a business model definition file



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Figure 3-22. Exercise introduction

Unit 4. Authoring the business logic

Estimated time

01:30

Overview

This unit teaches you how to implement the business logic with rule agents.

How you will check your progress

- Review
- Exercises

Unit objectives

- Describe the structure of rule agents and Java agents
- Implement business logic with rules
- Explain how to implement time-based reasoning
- Describe location-based tests

Figure 4-1. Unit objectives

Topics

- Implementing business logic with agents
- Rule agents
- Java agents

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Figure 4-2. Topics

4.1. Implementing business logic with agents

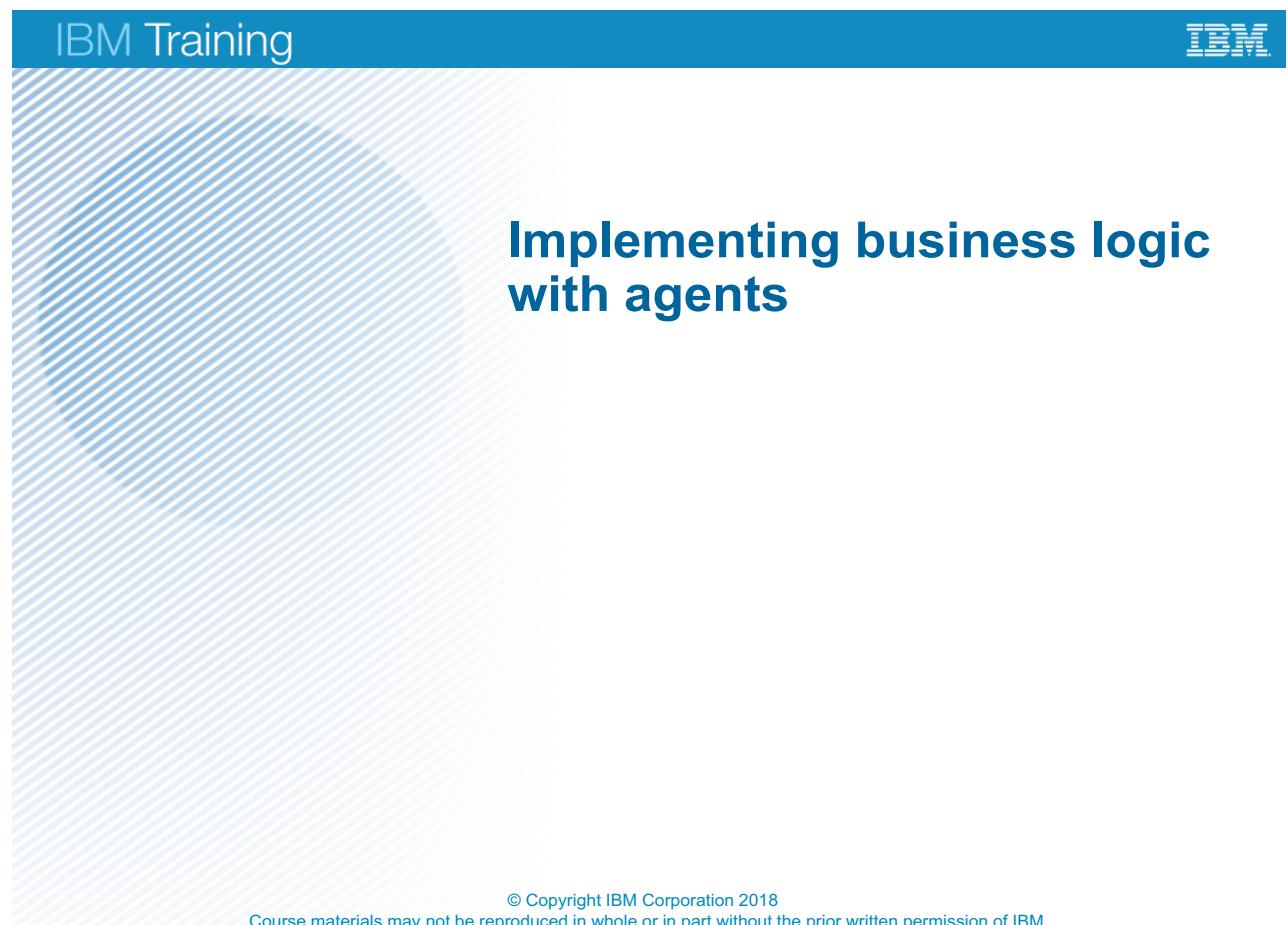
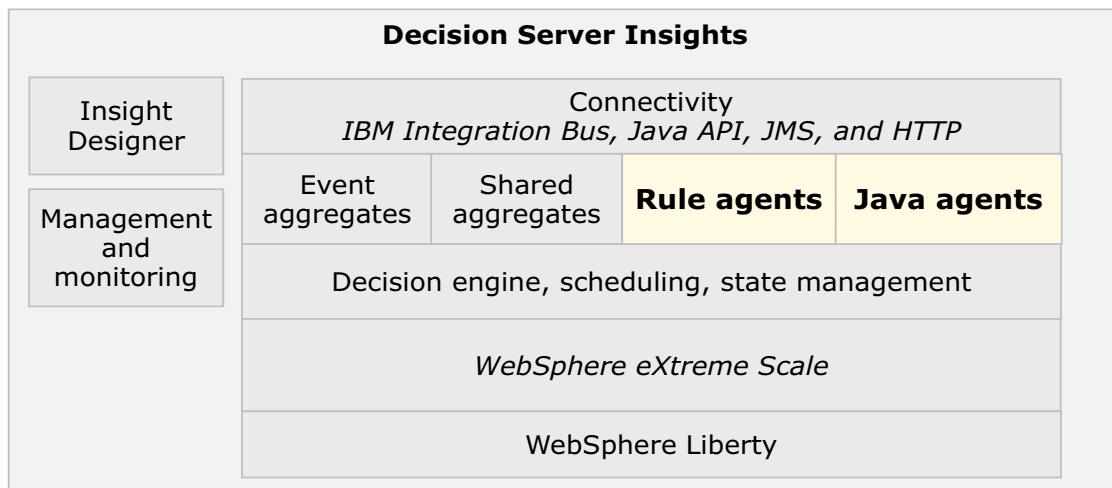


Figure 4-3. Implementing business logic with agents



Runtime architecture: Agents

- Two types:
 - Rule agents
 - Java agents



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Figure 4-4. Runtime architecture: Agents

Decision Server Insights uses two types of agents: rule agents and Java agents.

The agents are managed in the runtime tier, where they have direct access to the entities that they monitor.

As events arrive through the connectivity tier, they are routed to the agents that are listening for or subscribed to those events. The agents are bound to an entity, and when the event arrives, the agent processes the event for that entity. So if an event affects that entity, the agent handles it.

The Decision Server Insights runtime automatically and transparently maintains the state that is required for temporal and stateful computations by the agent.

Agents

- Use agents to define the business logic that binds incoming events to entities
 - Define routing logic between events and entities
 - Define function logic that defines how to process the event
- An agent detects incoming events, and can also generate new events
- Agents can either be triggered by the arrival of events or be scheduled for execution

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Figure 4-5. Agents

Agents define the routing logic between events and entities. The agent also defines the binding logic that determines which entity to monitor and they define the function logic that determines how to process the event.

You use your agents to detect incoming events or event patterns and also to emit new events. Agents can be triggered by the arrival of events or you can schedule them for execution.

Agents and entities

- An agent is bound to only one entity but can listen to several events
- Several agents can be bound to the same entity
- The binding to the entity is defined at the agent level, in an agent descriptor
- If an event is dispatched to several agents that target the same entity, you can define priority for the agent to determine the runtime invocation order

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Figure 4-6. Agents and entities

An agent can be bound to only one entity but it can listen to several events and it can emit new events. An agent can create, update, or remove its bound entity. Agents also have read-only access to other non-bound entities.

You can have multiple agents that are bound to the same entity. The binding is defined at the agent level in agent descriptor. In the descriptor, you can also define a priority for the agent to determine the runtime invocation order. So if multiple agents subscribe to the same event and are bound to the same entity the priority determines which agent processes the event first.

Instructor

Agents can update their internal state, update the state of their bound entity, or emit new events.

An agent can create, update, or remove its bound entity. An agent has read-only access to other non-bound entities.

The business logic for an agent can include the following operations, which can be combined:

- Emit a derived event that is based on the data in the incoming event.
- Emit a derived event that is based on events that are already received.
- Emit a derived event that is based on the state of the entity, or state accessible from the entity, which can include some temporal filtering of the attributes of the entity.

- Update the attributes of the bound entity.
- Read attributes of an entity that is resolved through a relationship from the bound entity or event.
- Create the bound entity of the agent from data in the incoming event.
- Remove the entity that is bound to the agent.

Agent types (1 of 2)

- Create a rule agent to define the business logic that binds incoming events to entities
- Rule agents act on entities and event history through rules
- Rules can generate events and emit them into and out of the system
- Rule agents have the following access rights:
 - Read and write on all attributes of the bound entity
 - Read-only on attributes of entities that are referenced through relationships (remote entities)
 - Read-only on event attributes

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Figure 4-7. Agent types (1 of 2)

The rule agent is the agent that makes the decisions, so this agent is where you implement your business logic.

Agents access their bound entity in various ways. The rule agents act on entities through rules. The rules are written in natural language by your business experts, who can read, review, and even update themselves.

Agent types (2 of 2)

Java agent:

- Create a Java agent to process events by using Java code
 - Examples: To calculate complex computations, to call a web service, or to write some logic that is not likely to change
- A Java agent has access to the entity model and can establish a Java coded logic
- A Java agent does not have to be bound to an entity

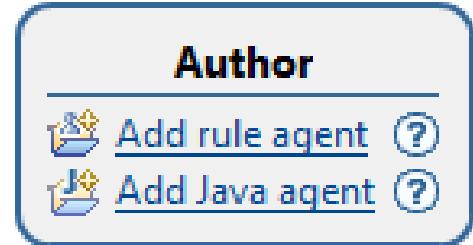
Figure 4-8. Agent types (2 of 2)

Java agents process events by using Java code. Because Java agents can be developed to do many things that do not require access to a particular entity, you can create a Java agent with no bound entity.

In the descriptor, you omit the clauses that bind the agent to an entity.

Creating rule agents

- After you create a solution project and business model, you create agents
- Agents describe the bound entity and subscribe to events of interest
- To develop an agent:
 1. Create the agent project
 2. Write the descriptor
 3. Write the rules
- You can use the links in the **Author** goal of the **Solution Map** to create agents



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Figure 4-9. Creating rule agents

Before you can create an agent that is bound to an entity or that subscribes to an event, those entities and events need to be defined in your business model.

To create an agent, you can use the links in the Solution Map of the Decision Insight perspective. For example, to create a rule agent, click the **Add rule agent** link to open the wizard, which guides you through the steps of creating the agent.

Agent projects

- Agents are represented as:
 - Rule agent projects
 - Java agent projects
- An agent project contains an agent descriptor and the business logic

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Figure 4-10. Agent projects

All the agents are represented as agent projects so each rule agent is stored in a separate project and the project contains the agent descriptor and the business logic or code.

The agent signature also defines the applicability condition. Decision Server Insights routes events to specific agents, and loads the data to execute the business logic.

Agent descriptors

- Descriptors define the agent signature, which includes:
 - The event types that the agent wants to process
 - The event field that is the key for the entity
 - The event horizon for each event type
 - The routing logic (how the event is correlated to the entity)
- The information contained in the agent descriptor determines the authoring context for rules or Java code contained in that agent.

Figure 4-11. Agent descriptors

Agent descriptors were mentioned earlier. The agent descriptor is what defines the agent signature, including which events the agent wants to listen to or subscribe to, which event field is used as the key for the entity, and the routing logic. This agent signature determines the authoring context to help rule authors write the rules and it defines the applicability condition.



Writing an agent descriptor

- Descriptor is stored in the `.adsc` file
- When you create the agent project, the `.adsc` file automatically opens in the editor

```

agent.adsc
1 'banking_scenario_agent_fraud_detection' is an agent related to a client ,
2 processing events :
3   - banking event , where this client comes from the client of this
4     banking event , with a horizon of 50 days

```

- As a good practice, always define an **event horizon** for each event
 - For example:

- banking event . where this client comes from the client of this
banking event with a horizon of 50 days
- All agents are written with business vocabulary
 - Before you can define an agent, you must define the entities and events in the business model (`.bmd` file)
 - Vocabulary to build the agent comes from the `.bmd` file

Figure 4-12. Writing an agent descriptor

A descriptor is written and stored in a `.adsc` file. When you create an agent project, a descriptor file is automatically generated and opens in the editor. Some initial text is already in place, including the name of your agent. You need to choose which entity to bind the agent to and which events to subscribe to.

Example descriptor

- In this example, the agent is bound to “a client” entity and is subscribed to banking events

```
'banking_fraud_detection' is an agent related to a client ,  
processing events :  
    - banking event , where this client comes from the client  
    of this banking event, with a horizon of 7 days
```

Figure 4-13. Example descriptor

In this example, you see a rule agent that is named **banking fraud detection**, which is related to a client entity type. This agent processes all banking events that affect its client entity to detect fraud patterns. The rules that are attached to the agent implement the business logic for fraud detection.

Relationship between events and entities

- Relationships that are defined in the business model are used in the descriptor to determine how the entity is retrieved from the event

Business model

```
a client related event is a business event time-stamped by a timestamp .
a client related event is related to a client .

a banking event is a client related event .
a banking event has a banking event id .
```

Descriptor

```
'banking_fraud_detection' is an agent related to a client ,
processing events :
    - banking event where this client comes from the
client of this banking event
```

Figure 4-14. Relationship between events and entities

When you complete your descriptor file, the completion editor prompts you with a list of possible options. But where do those options come from? They come from your business model.

You cannot define the banking fraud detection agent that is being bound to a client entity unless you have a client entity that is already defined in the model. Nor can you listen to a banking event unless the banking event is also defined in your model.

As you see on this slide, the vocabulary that was used to build the descriptor comes directly from your business model definition.

You also see the significance of inheritance relationships. According to the business model definition, a banking event **is** a client-related event, and a client-related event **is related to** a client. Therefore, a banking event is automatically related through inheritance to a client.

When your agent subscribes to a banking event, that banking event is automatically routed to the correct agent, the one monitoring the client entity that is related to this banking event.

Relationship between events and entities

- Relationships that are defined in the business model are used in the descriptor to determine how the entity is retrieved from the event

Business model

```
a client related event is a business event time-stamped by a timestamp .
a client related event is related to a client .

a banking event is a client related event .
a banking event has a banking event id .
```

Descriptor

```
'banking_fraud_detection' is an agent related to a client ,
processing events :
    - banking event where this client comes from the
client of this banking event
```

Figure 4-15. Relationship between events and entities

When you complete your descriptor file, the completion editor prompts you with a list of possible options. But where do those options come from? They come from your business model.

You cannot define the banking fraud detection agent that is being bound to a client entity unless you have a client entity that is already defined in the model. Nor can you listen to a banking event unless the banking event is also defined in your model.

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When your agent subscribes to a banking event, that banking event is automatically routed to the correct agent, the one monitoring the client entity that is related to this banking event.

4.2. Rule agents

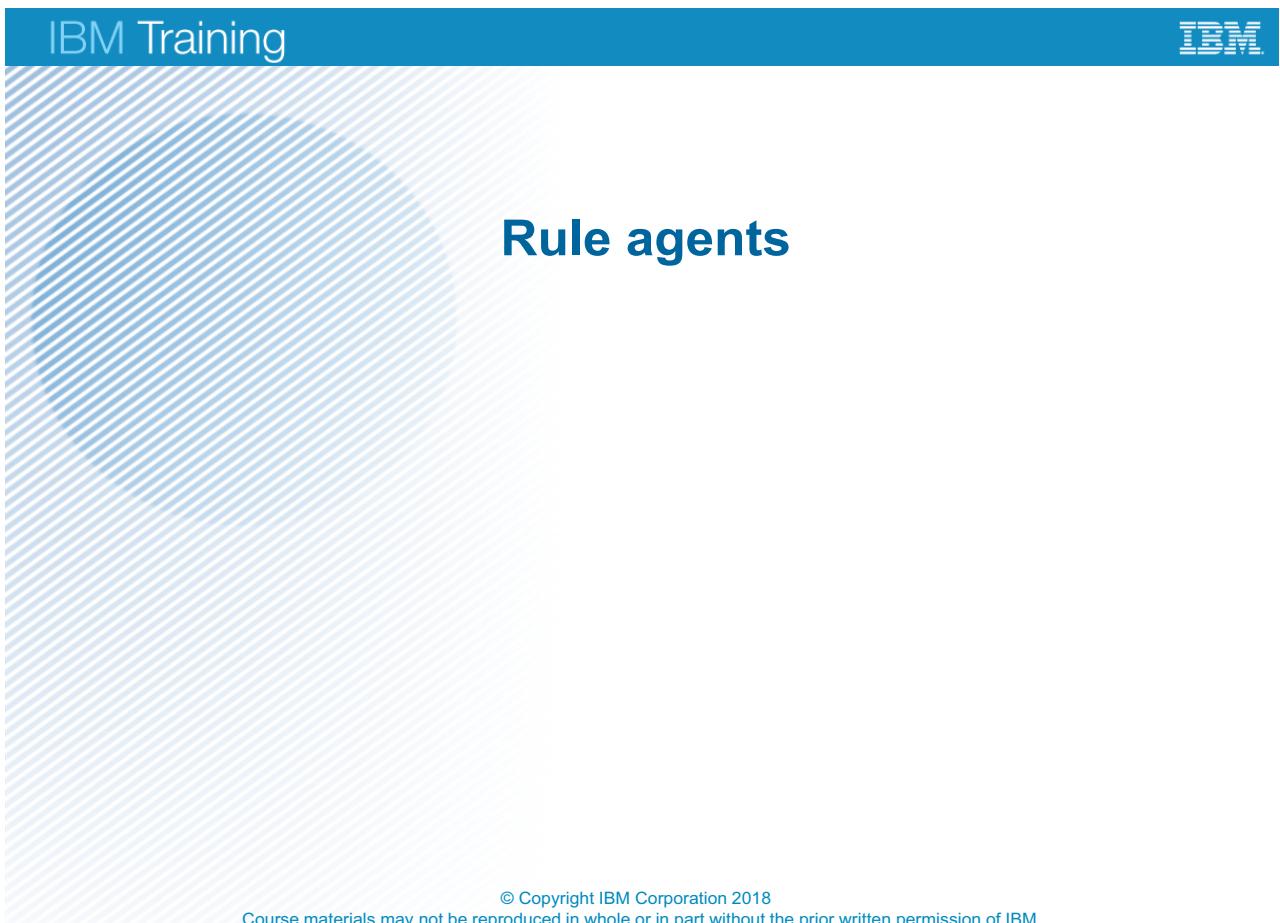


Figure 4-16. Rule agents

Creating rule agents

- A rule agent encapsulates the business logic that updates the state of its bound entity or that emits events
- You write rules to define the business logic of the agent
- The rules define the action to be taken when an agent receives an event
- An agent can listen to several events, but is always associated with a bound entity
 - The binding to the entity is defined at the agent level
 - At authoring time, the rule references the entity through the authoring context that is defined by the agent descriptor
- By using the rules, rule agents can emit new events

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Figure 4-17. Creating rule agents

You create a rule agent to make decisions within the insights solution.

The rule agent acts as a container for the rules that implement the business logic that is required by that agent.



Note

Rule agents do not include decision tables, decision trees, or ruleflows.

Structure of an action rule

- A rule can comprise some or all of the following parts

when	The <i>when</i> part defines the processing of an event
definitions	The <i>definitions</i> part defines variables that can be used within the rule
if	The <i>if</i> part defines the condition upon which an action is executed
then	The <i>then</i> part defines the action to be taken if the condition is true
else	The <i>else</i> part defines the action to be taken if the condition is false

Figure 4-18. Structure of an action rule

A rule defines the specific actions to take when certain conditions are met. A rule is composed of several parts, as you see here, that define the conditions and actions.

A basic rule associates a condition with an action. If the condition tests true, take a particular action. The vocabulary available in the rules comes from the elements that are defined in the business model and the agent descriptor. The agent descriptor provides the context for your rule authoring because it limits which vocabulary is available to you as you write the rule.

As outlined in this table, a rule can comprise some or all of the following parts. The parts that you include depend on the type of rule that you want to write.

The **when** part defines the processing of an event. For rules that are used to apply logic to event processing, you always include the **when** part.

The **definitions** part is where you can define variables that are used in the rule. If you define a variable in the **definitions** part, the scope of that variable is the rule itself. That variable is not visible or accessible outside the rule.

In the **if** part, the **if** part of the rule defines the condition tests. When you define a condition, the action is only executed when the condition tests true.

The **then** part of the rule defines the action to take when the condition tests true. The **else** part can also be used to define what action to take when the condition tests false.

All these parts of the rule are optional except the **then** part. You can have a rule that includes only an action, in which case, that rule would always execute every time that it is invoked because it is not dependent on a condition.

Defining the “when” part of a rule

- To process an event immediately when it arrives in the agent, use:
`when <event> occurs`
- When an event is received, the rule is instantiated for this event
 - The rule instance is applicable only when this event is processed and is no longer applicable when later events arrive
- You can add filters to the **when** part by adding a **where** clause
`when a banking event occurs`
`where the state of this banking event is CA`

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Figure 4-19. Defining the “when” part of a rule

Rules that are used to process events start with the **when** part.

The **when** part and the **then** part are mandatory.

The **when** part can be written to execute a rule as soon as the event arrives or it can be written to wait or postpone the event processing. You learn more about postponing event processing in the next slide.

To process an event as soon as the agent receives it, use the clause: **when event occurs**

When the event that is specified in this clause is received, a rule is instantiated for this event. How does that work?

If you are familiar with Decision Server Rules, you know how the rule engine and working memory are used to manage from instances. For Decision Server Insights, the rule agent has a working memory. When a rule agent receives a new event, the agent tests the event against all its rules and sees whether the event matches the when clause for any of the rules. If it makes a match between an event and a rule, the agent creates a rule instance for every match.

The next step is for the agent to select a rule instance from the list, based on some specific criteria such as priority, and then execute that rule.

To execute a rule instance, means to apply the action statement. The execution can modify the state of the entity that the agent is monitoring and might affect the results the next time that rule

agent tries to match events to rules. After a rule instance is executed, the rule instance is deleted so that it does not execute anymore. So a rule instance applies only while it's being evaluated to events that it matched.

You can write rules that do not have a ***when*** part. Those rules would be evaluated either every time a new event arrives or by an internal scheduling mechanism. An instance of rule without a when part might be applied several times.

Using “when” to postpone event processing

- To postpone processing an event, use:

when <event> has occurred, after a delay of <delay period>

- To indicate the delay period, you use a time expression with an implicit reference to now

- 1 day
- 2 hours

- Use postponed processing if:

- An event depends on other events
- The order in which the events are processed is important
- An action must happen after a certain duration
- You want to test the presence or absence of events

Figure 4-20. Using “when” to postpone event processing

To postpone the processing of an event, you use the phrase: **when event has occurred**

To indicate how long the delay period should be, you use a time expression such as **1 day ago**, or **2 hours ago**. This expression implicitly compares the delay to “now” which represents the time stamp of the event.

This type of construct to postpone or schedule an event is useful when you have an event that depends on other events. It is also useful in the following situations:

- When the order in which events are processed is important
- When an action must happen after a certain duration
- When you want to test for the presence or absence of events

Example: Testing for the absence of an event

- This rule postpones processing by 30 minutes:

```

when a fraud alert has occurred, after a delay of 30
minutes
if
    there is no confirmation from client
        where this confirmation from client is after this
        fraud alert ,
then
    emit a new notification to client where
        the client is the client of this fraud alert ,
        the code is CALL_BANK_30 ;

```

Figure 4-21. Example: Testing for the absence of an event

This example shows how to postpone event processing, and how to test for the absence of an event.

The **when** clause says, “when a fraud alert has occurred 30 minutes ago” (meaning 30 minutes before now, which represents the time stamp of the event).

To test for the absence of an event, the **if** statement says “if there is no confirmation from the client.” This statement means that if no notification was received within that 30-minute delay period, then the action emits a new notification event.

Defining rule variables

- Define the variable in the ***definitions*** part of a rule
 - Variables can be set to:
 - An expression
 - An event type
 - A constant
 - A collection of values
 - Example: 'RECENT TRANSACTIONS' is set to a collection of withdrawals
- definitions**
- ```
set 'RECENT TRANSACTIONS' to all withdrawals during
the last period of 50 days ;
```

Figure 4-22. Defining rule variables

To implement the business logic, you might need to define variables. The variables that you define in the ***definitions*** part of the rule are only accessible or visible within the scope of the rule.

A variable can be set to an expression, an event type, a constant, or a collection.

For example, you might define a variable called ***recent transactions***, which is sent to a collection of withdrawal transaction events.

As you see in this example, the syntax to define the variable is:

```
set recent transactions to all withdrawals during the last period of 50 days
```

## Calling global aggregate variables in rules

- Use global aggregates in your rules in the same way that you use other rule variables
- Example: Set a variable to the value of a global event aggregate definitions

```
set AVG_CHURN to 'Average churn for GOLD' ;
if
 the churn score of 'the client' is at least 1.5 *
AVG_CHURN
then
 emit a new gift where
 the code is COUPON 100 USD ;
```

*Figure 4-23. Calling global aggregate variables in rules*

Within your rules, you can also refer to global aggregates in the same way that you would use other variables.

The scope of global aggregates makes them accessible to all agents within your solution.

So in the example that is shown here, a local rule variable is set to the value of a global entity aggregate. The definition says:

**set AVG\_CHURN to Average churn for GOLD**

Where **Average churn for GOLD** is the name of your global entity aggregate.

You learn more about global aggregates later in this unit but for now it's important to know that you can use the global aggregates throughout your rule.

However, because global aggregates are defined and calculated by different process than rule variables, you cannot create a global aggregate within a rule. The scope of the global aggregate is the entire solution, whereas the scope of rule variable is just the rule.

## Defining conditions

- Use the ***if*** part to state under which conditions to carry out the rule actions that are defined in the ***then*** and ***else*** parts
- Use condition tests to:
  - Compare statements
  - Test for a number
  - Test if an object belongs to a set
- Negate conditions
  - it is not true that
  - none of the following conditions are true:

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Figure 4-24. Defining conditions

The ***if*** part of the rule is used to state the conditions under which to complete the rule actions that were defined in the ***then*** or in the ***else*** parts of the rule.

Earlier, you saw that the rule agent performs a pattern matching, where it tests the events against all the rules to see whether the event matches any of the ***when*** clauses in any of the rules. The agent also tests the event against the ***definitions*** part and the ***if*** parts of the rule, looking for a match.

Even if the rule does not have a ***when*** part, the rule agent still creates a rule instance when an event matches the ***definitions*** or the ***if*** parts of the rule.

In the ***if*** part, you create your condition tests to compare statements, to test for a number, or test whether an object belongs to a set.

You can also use negative statements to negate conditions, such as: “if it is not true that” or “none of the following conditions are true.”

Remember that conditions are not mandatory in a rule. If you have a rule with no conditions, that rule always executes, which can be useful when you need a rule to always be evaluated.

## Defining actions

- Rule actions have at least one action phrase in the ***then*** part of the rule that executes when the ***if*** part of the rule test true
  - Optionally, you can include ***else*** statements to execute when the ***if*** part of the rule is false but using 2 mutually exclusive rules is preferred
- You can use action phrases to create bound entities
  - Set the rule to the highest priority and test for null entities and create them before other rules in the agent execute
  - Example: Create an account from event data

```
when a new account event occurs, called 'the event'
if
 'the account' is null
then
 set 'the account' to a new account where
 the customer is the customer of 'the event',
 the opening date is 'the event',
 the status is NEW;
```

Figure 4-25. Defining actions

The final part of the rule structure to discuss is the actions part of the rule.

Actions can be defined in the ***then*** part of the rule, and optionally in the ***else*** part.

The ***then*** part is mandatory for all your rules, and they must have at least one action phrase.

If your rule has condition statements, and the condition tests true, the action phrases in the ***then*** part are executed. If you have an ***else*** part in your rule and the conditions test false, then the action statements in the ***else*** part are executed.

Generally, it is not as easy to maintain rules that have an ***else*** statement. For more guidelines on when to use an ***else*** statement, see the product documentation.

The action statements that you define in the ***then*** part of the rule can be used to modify entity data or to even create an entity.

For example, if you need to initialize entities with values, you can set a rule with the highest priority to test for all null entities and create them before other rules in the agent execute. By initializing entities, you ensure that you do not cause null pointer errors.

In the example that is shown here, you see that the action statement creates an account with initial values. After testing whether the account is null, the then statement says:

**set the account to a new account where ...**

Then, it provides some initial values for the account entity.

## Time-related tests (1 of 2)

- Time operators can be used to calculate useful values, such as:
  - An elapsed time
  - A time window
  - A window of opportunity
- To use the time of the current event or identify when events arrive out of sequence, you can use the time reference: `now`
  - The `now` value is set from the time stamp of the latest event received by the entity instance
  - Example: Compare the calendar date to `now` as set by the banking event time stamp
 

```
when a banking event occurs
 If now is after 1/1/2018
 then
 print "A banking event occurred after 1/1/2018"
```
- When possible use a reference to the event, rather than 'now'. For example: if this banking event is after 1/1/2018...

*Figure 4-26. Time-related tests (1 of 2)*

For event processing logic, time-related tests are essential.

Time operators can be used to calculate values, such as an elapsed time, a time window, or a window of opportunity.

To use the time of a current event, or identify when events arrive even when they are out of sequence, you can use the time reference: **now**

Events have a time stamp that is defined by the event source. In most cases, you see a delay between the time stamp of the event and the moment when the event arrives into the system to be processed by the agent.

An event that happened first might be processed *after* another event that happened later. When an event is processed out-of-order, its time stamp is considered before **now**.

In this example, you can compare the calendar date to **now** as set by the banking event time stamp. So in the condition test, "if **now** is after January 1, 2018" means if the time stamp of the banking event is after January 1, 2018, then apply the action.

## Time-related tests (2 of 2)

- Time points
  - An instant of time that is measured in a time scale of a specific time zone
  - Can be specified by a date, an event, or an attribute of type date or time
- Operators to compare time points:
  - is after and is after or the same as
  - is before and is before or the same as
  - is at the same time as
- Operators to compare a time point and a duration:
  - <duration> before <date> | <duration> after <date>
- Operators to compare a time point and a time period:
  - before | after
  - during
  - includes
  - starts at | ends at

Figure 4-27. Time-related tests (2 of 2)

## Location-related tests

- You can write rules to reason over location-aware entities or events and perform the following operations:
  - Detect whether some locations contain or are contained by other locations
  - Calculate the distance between two locations
  - Define a perimeter in which locations are contained
  - Check whether a location intersects a path or an area
  - Find the nearest location to another location
  - Add a location to a path or route
- Use <a geometry> to reference any type of geometry that is defined in the business model, such as a point

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Figure 4-28. Location-related tests

Objects that have a geographic location must define a spatial geometry. A spatial geometry can be static or moving.

## Static and moving geometry types

- Static geometries
  - Represent the location of an entity or an event that does not move over time
- Moving geometries
  - Represent the location of an entity that moves over time
  - A moving geometry has a location at a specific time
- Use a static geometry to model location-related objects, such as a building, a field, a county, or a state
  - Example: Business office location (static)
 

a business has a location (a geometry) used as the default geometry.
- Use a moving geometry to model an entity whose location changes over time
  - Example: Car location (moving)
 

a car has a location ( a moving geometry ) used as the default moving geometry .

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Figure 4-29. Static and moving geometry types

Objects that have a geographic location must define a spatial geometry. A spatial geometry can be static or moving.

You use a **static** geometry to model location-related objects, such as a building. You use a **moving** geometry to model an entity whose location changes over time. The time that is needed to access the value of a moving geometry and the memory that is required depend on the size of the history limit that you define.

## Geospatial attributes and operators

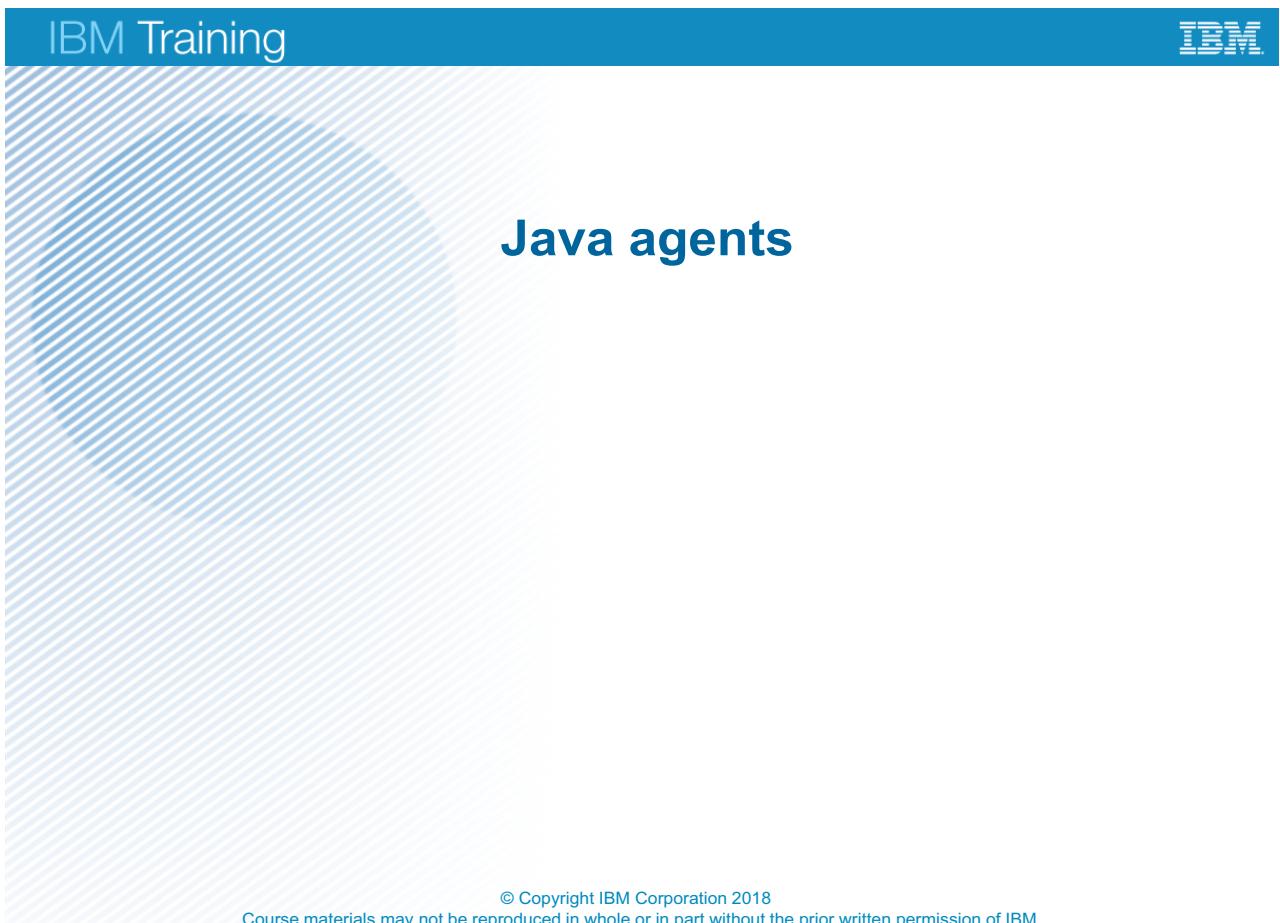
- You can define how long to track movement when you initialize the location of a moving entity
  - set <attribute> of [attribute of]\* <entity> to a new moving geometry [tracked for <calendar period>]
  - Default history limit is 24 hours
  
- Geospatial operators for moving geometries include:
  - the maximal | minimal | average speed of <moving geometry> in <speed unit> over <time period>
  - <moving geometry> is leaving <geometry> observed location at timestamp
  - <moving geometry> is approaching <geometry>
  - <moving geometry> is accelerating
  - <moving geometry> has been located in <a polygon> during <time period>

*Figure 4-30. Geospatial attributes and operators*

You define geometries and moving geometries as attribute types in your model. Static geometries are defined as “a geometry” and moving geometries are defined as “a moving geometry.”

Geospatial operators for moving geometries include calculations of the maximal, minimal, or average speed of a moving geometry over a time period. Or you can check a moving geometry’s location at a specified time point. You can also check whether the distance between entities is decreasing or increasing, such as when two objects are approaching or leaving.

## 4.3. Java agents



*Figure 4-31. Java agents*

## Setting the target platform in Insight Designer

- In the Decision Insight perspective, set the target platform to Insight Server before creating Java agents or predictive scoring agents
  1. In Insight Designer, use the **Window > Preferences** menu
  2. Select **Plug-in Development > Target Platform**
  3. Add the Insight Server template
  4. Select the Insight Server template as the target

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*Figure 4-32. Setting the target platform in Insight Designer*

When you develop Java agents in Insight Designer, you must first set the target platform to build the Java code.

If the target platform is not set, you see errors on the agent projects.

During the lab, you see how to do this task.

## Java agents

- Use Java agents for complex computations or to call a web service
- The Java agent project contains the descriptor and a .java class file
- To process an event in a Java Agent override the following method:  

```
public void process(Event event) throws AgentException { }
```
- Get a Java Agent's bound entity like this:  

```
Order order = (Order) getBoundEntity();
```
- Update the bound entity in the following way:  

```
order.setStatus("NEW");
updateBoundEntity(order);
```
- You can schedule Java agents to run at a specific time by using the com.ibm.ia.agent.Agent API  

```
public String schedule(int delay, TimeUnit unit, String cookie)
```

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*Figure 4-33. Java agents*

You can use Java agents any time you need to write code, for example, for complex computations, or to call a web service, or to create some type of data provider. The reasons for using Java code are innumerable.

One thing to keep in mind is that the Java agent is not designed to make the decision. All business logic should be handled by the rule agent.

Like a rule agent, a Java agent contains a descriptor that binds it to an entity. However, you can also create Java agents that are not bound to an entity.

When you create a Java agent, a Java class file is automatically generated that you need to complete.

Java agents can also be scheduled to run at a specific time by using the agent API that is provided with Decision Server Insights.

## Unit summary

- Describe the structure of rule agents and Java agents
- Implement business logic with rules
- Explain how to implement time-based reasoning
- Describe location-based tests

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*Figure 4-34. Unit summary*

## Review questions

1. True or false: An agent is bound to only one entity, and several agents can be bound to the same entity.
  
2. The rule agent can postpone processing an event by using which construct?
  - a. Postpone <event> for <time duration>
  - b. When <event> has occurred
  - c. When <event> occurs

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*Figure 4-35. Review questions*

Write your answers here:

1.

2.

## Review answers

1. True or false: An agent is bound to only one entity and several agents can be bound to the same entity

**Answer: True**

2. The rule agent can postpone processing an event by using which construct?

- a. Postpone <event> for <time duration>
- b. When <event> has occurred
- c. When <event> occurs

**Answer: b. When <event> has occurred**

Figure 4-36. Review answers

## Exercise: Writing and testing rules

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*Figure 4-37. Exercise:*

## Exercise introduction

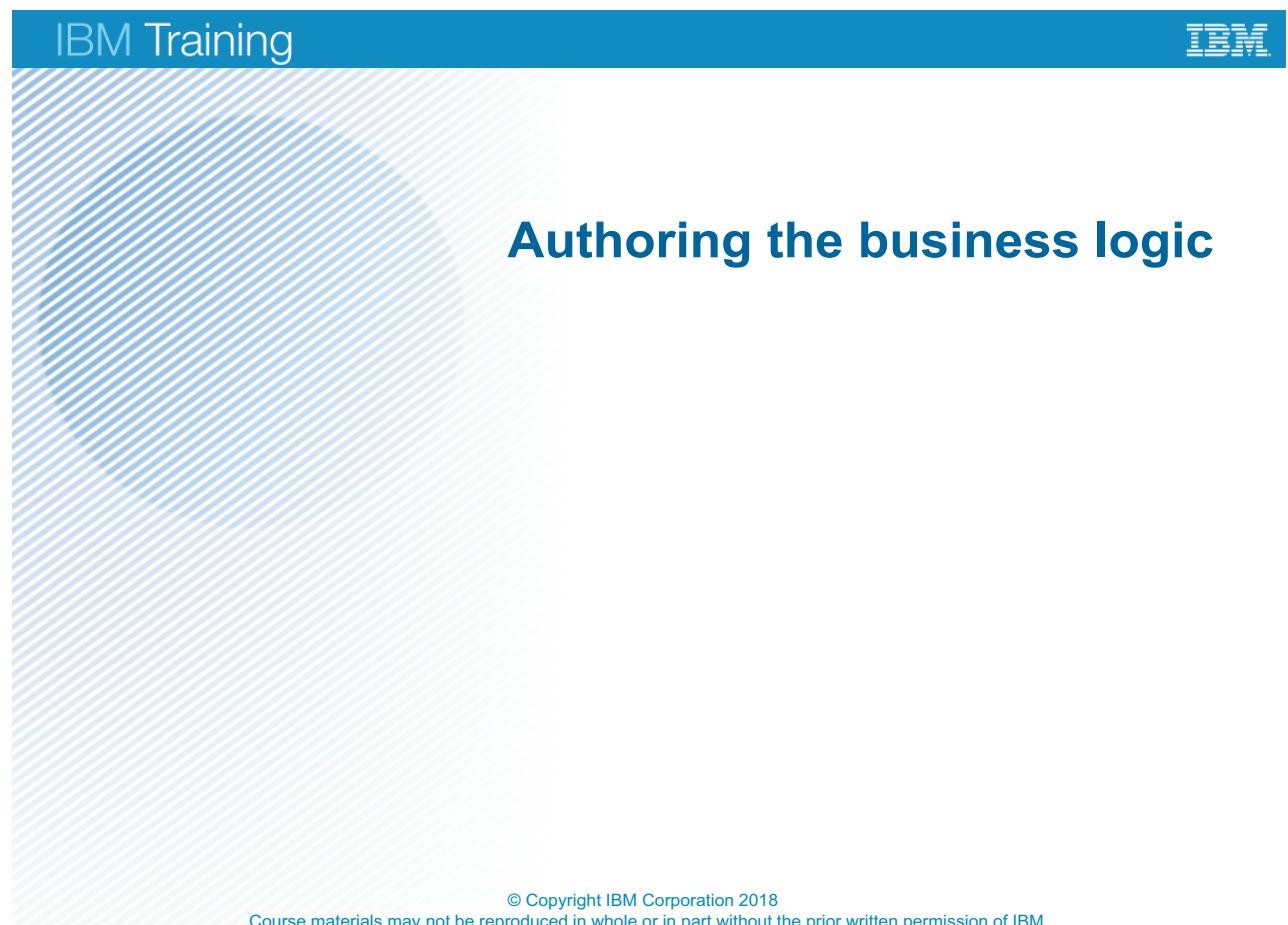
- Add a rule to a rule agent
- Deploy a solution
- Submit events through a test client to test rule behavior



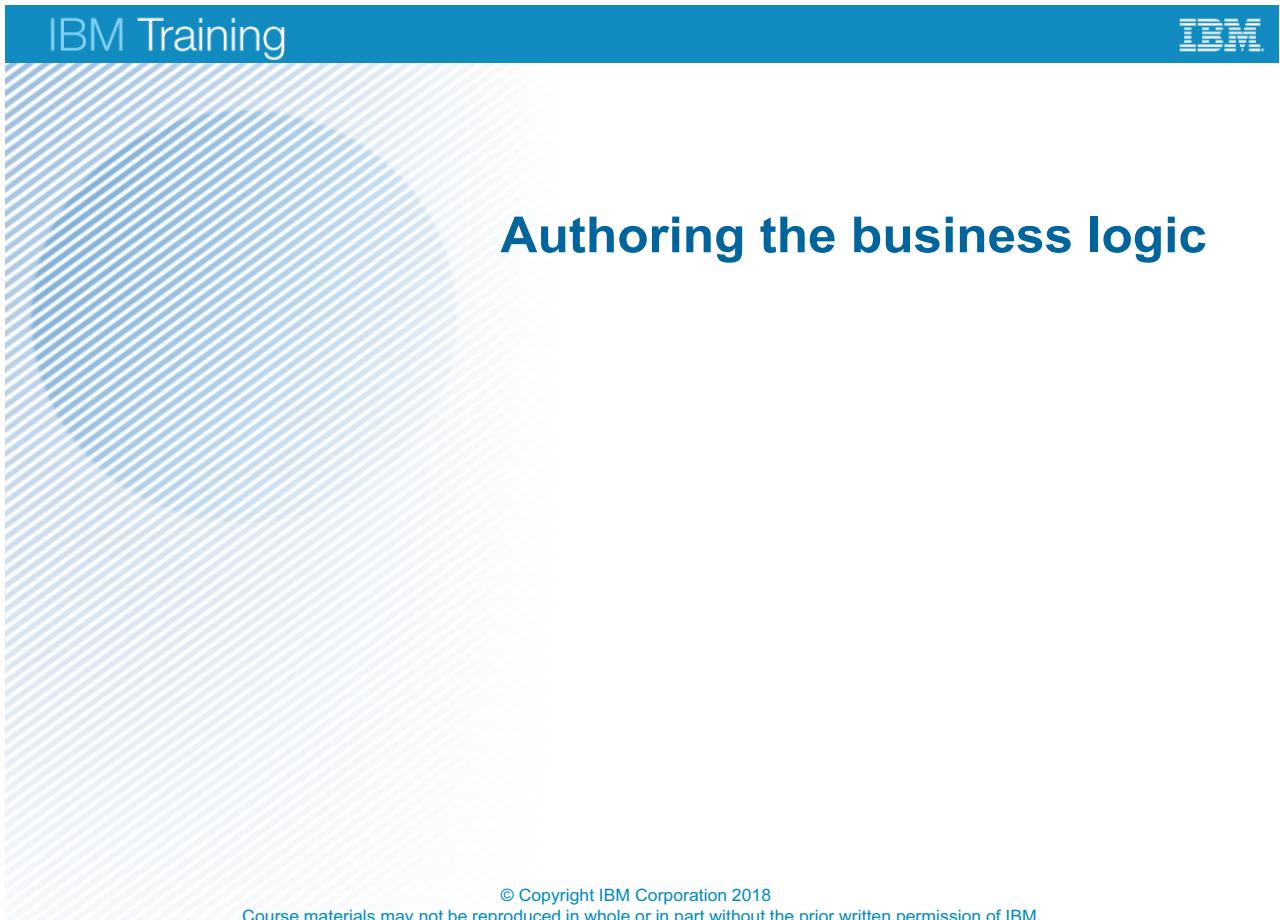
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*Figure 4-38. Exercise introduction*



*Figure 4-39. Exercise:*



*Figure 4-40. Exercise introduction*

---

# Unit 5. Working with aggregates

## Estimated time

00:45

## Overview

This unit teaches you how to implement analytics in your business logic by using local, global, and shared aggregates.

## How you will check your progress

- Review
- Exercises

## Unit objectives

- Define global event aggregates
- Define shared aggregates

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*Figure 5-1. Unit objectives*

## Topics

- Global event aggregates
- Shared aggregates

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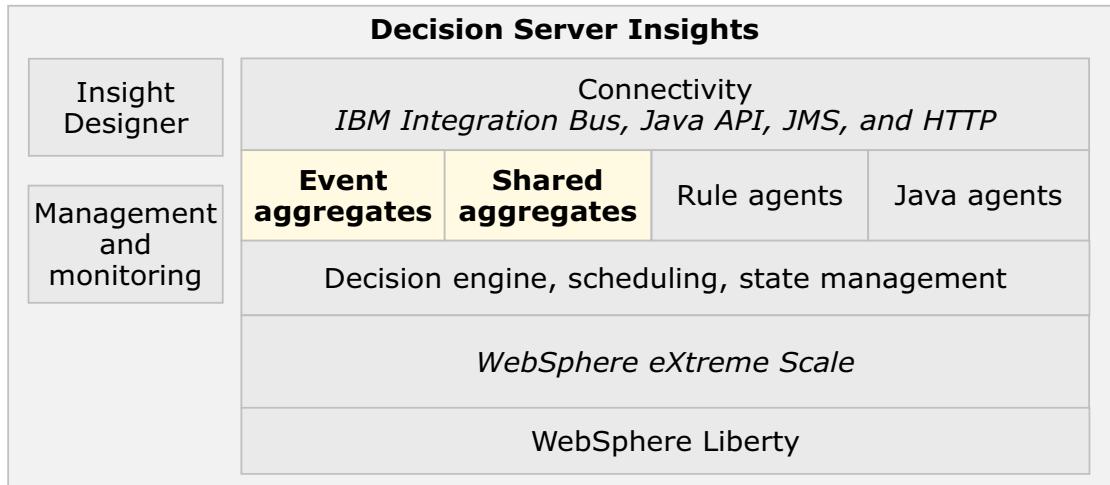
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*Figure 5-2. Topics*



## Runtime architecture: Aggregates

- Global event aggregates
- Shared aggregates



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Figure 5-3. Runtime architecture: Aggregates

Decision Server Insights includes both a **local** and a **global** programming model for entities and events that allows for global calculations and analysis of all events and all entities in the solution.

Global aggregates are defined as part of a solution in Insights Designer. After deployment, the runtime manages the aggregates.

## 5.1. Global aggregates



*Figure 5-4. Global aggregates*

## What is a global aggregate?

- Globally calculated values that are derived from a population of events
  - Not about an individual event or entity
- Event aggregates
  - A global event aggregation is evaluated automatically when a new event of that type occurs
  - Calculate the total, minimum, maximum, or average value for a collection of events
- Scalar values
  - What is the average age of all customers?
  - How many accounts were opened last year?

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*Figure 5-5. What is a global aggregate?*

What is a global aggregate? Global aggregates are globally calculated values that are derived from a population of events.

## Aggregates in the programming model

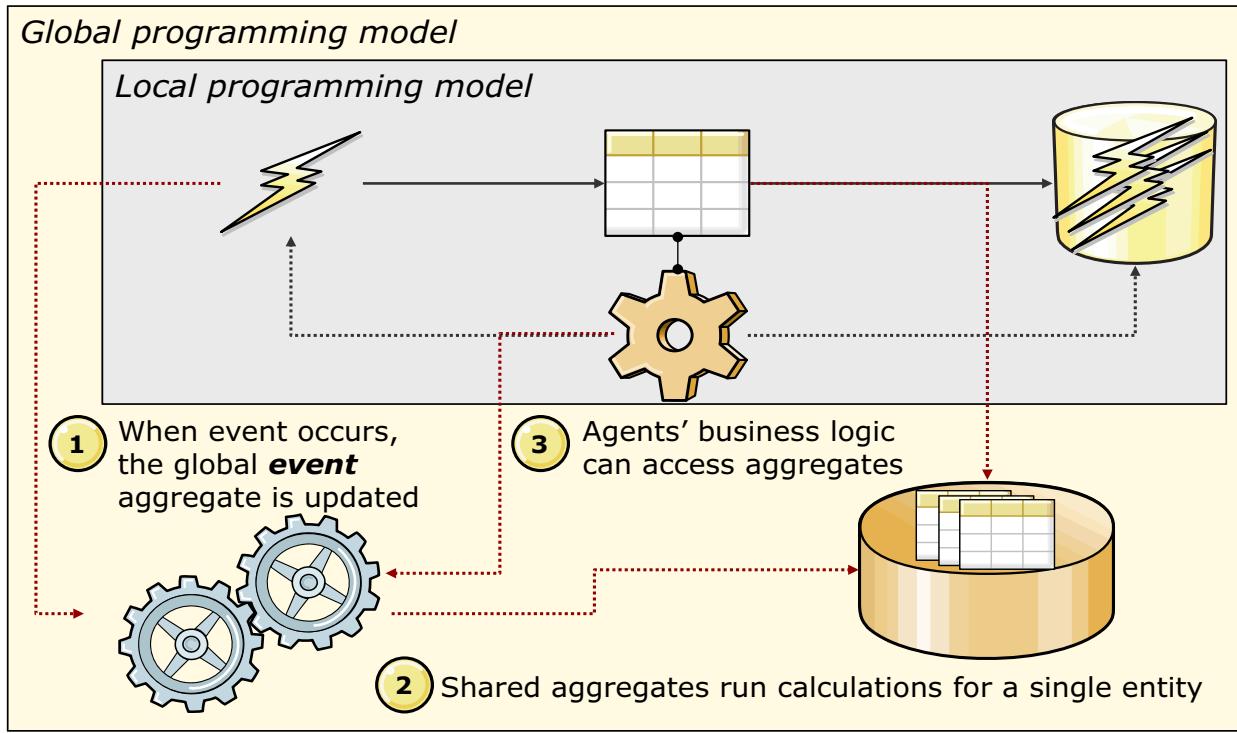


Figure 5-6. Aggregates in the programming model

Global event aggregates run continuously as part of a deployed solution. The graphic depicts both the local and global programming model. For example, in the local programming model, you can aggregate event information for all events that are delivered to a particular entity (as opposed to all entities). So a local aggregate can calculate the 30-day average transactions for an account entity. However, a global aggregate can calculate the 30-day average transactions of all accounts.

The first step of calculating an event aggregate is that when an event occurs, the global event aggregate is updated. A global event aggregate is calculated every time that an event occurs. So if you have an event aggregate defined for all banking transactions, every time a banking transaction occurs, that banking transaction aggregate is recalculated, and its stored value is updated.

In point number two, shared aggregates compute the value of an entity attribute by aggregating values from events that are associated with this entity. Shared aggregates can be more efficient than aggregates that are defined in rules to calculate a value from the history of past events because they can be used by multiple agents and applied to multiple time periods and time points.

Global aggregate values are accessible to all agents in your solution.

## Global event aggregates

- You define a global event aggregate by specifying an aggregate expression, an optional time filter, and an optional default value
  - Can find **total**, **minimum**, **maximum**, or **average** value of a collection of events, or the number of events
- Global events run continuously as part of a deployed solution
  - Continuously performs calculations on incoming events
  - Calculated every time one of the events occurs
- To define the event aggregate, specify:
  - The aggregation operator or *the number of* construct
  - The attribute of an event
  - Example:  
`define 'average_delay' as the average delay of all flight_delay events, where the delay of each flight_delay event is more than 10`

*Figure 5-7. Global event aggregates*

To define a global event aggregate, you specify the aggregate expression and an optional time filter. The aggregate can calculate totals, minimums, maximums, or average values of a collection of events or a specific number of events.

Global event aggregates run continuously to perform calculations on incoming events. The value is recalculated every time one of the specified events occurs.

During the lab, you see how to define an event aggregate by following the syntax that you see here.

In this example, the average delay aggregate is calculated as:

the average delay of all flight delay events where the delay is more than 10

So the events that are calculated are filtered according to the delay attribute

## Global aggregate functions

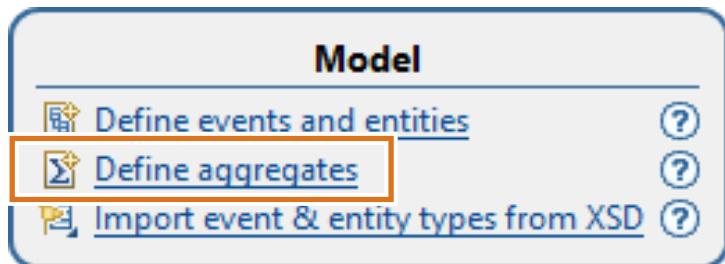
- **Count**
  - Define '*transaction count*' as the **number** of Transactions
- **Sum**
  - Define '*transactions total*' as the **total** amount of all Transactions
- **Average**
  - Define '*average transaction amount*' as the **average** amount of all Transactions
- **Min**
  - Define '*min amount of all transactions*' as the **minimum** amount of all Transactions
- **Max**
  - Define '*max amount of all transactions*' as the **maximum** amount of all Transactions

Figure 5-8. Global aggregate functions

Here, you see the predefined aggregate functions that you can use when defining your global aggregates.

## Defining aggregates

- You create global aggregate definition (.agg) files to define how the aggregate should work
- The name of the aggregate is the same as the name of the .agg file
- Aggregate files are created in the **aggregates** folder of the BOM project
- Use the link in the **Model** goal of the **Solution Map** to create an aggregate



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Figure 5-9. Defining aggregates

You define a global event aggregate by composing an expression in the .agg file that has the following syntax:

```
define '<same_name_as_file>' as <expr>
```

If events occurred for too short a time, a global event aggregate might not have a meaningful value. Therefore, you can specify a default value and the condition for when the default applies. The default value applies unless enough event history exists for the aggregate calculations, and any rules that are based on them, to have meaningful results. You might need to test and experiment with the default value and the condition to obtain optimal results for your particular solution.

The event history is the elapsed time after the first event of any type occurs in a deployed solution. If you change the definition of the global event aggregate and deploy a new version of the solution, the elapsed time is reset to zero and restarts after the first event of any type occurs.

To create a global aggregate, you can use the **Define aggregates** link in the Model goal of the Solution Map.

When you create a global aggregate, an .agg file is generated for you in the **aggregates** folder of the BOM project. The name of the aggregate is the same as the name of the .agg file.

## Retrieving global aggregate value

- Accessible from rules

```
definitions
 set AVG_CHURN to 'Average churn for GOLD' ;
 if
 the churn score of 'the client' is at least 1.5 * AVG_CHURN
```

- Accessible from Java agents through the Java agent API

```
getGlobalValue(aggregateName)
```

- Accessible from REST

- To display all aggregates:

```
https://<host>:<port>/ibm/ia/rest/solutions/<solution>/aggregate
```

- To display a particular aggregate:

```
https://<host>:<port>/ibm/ia/rest/solutions/<solution>/aggregate/<aggName>
```

Figure 5-10. Retrieving global aggregate value

Aggregate names are in the BOM project. You can also open the **globalQueries** variable set in the **aggregates** folder to see the list.

Your global aggregate values are visible to all the agents in the solution, so you can access the aggregate values in your rules. You can also access the aggregate in a Java agent by using the Java agent API. In addition, you can use the REST API to view your aggregates and their values.

## 5.2. Shared aggregates

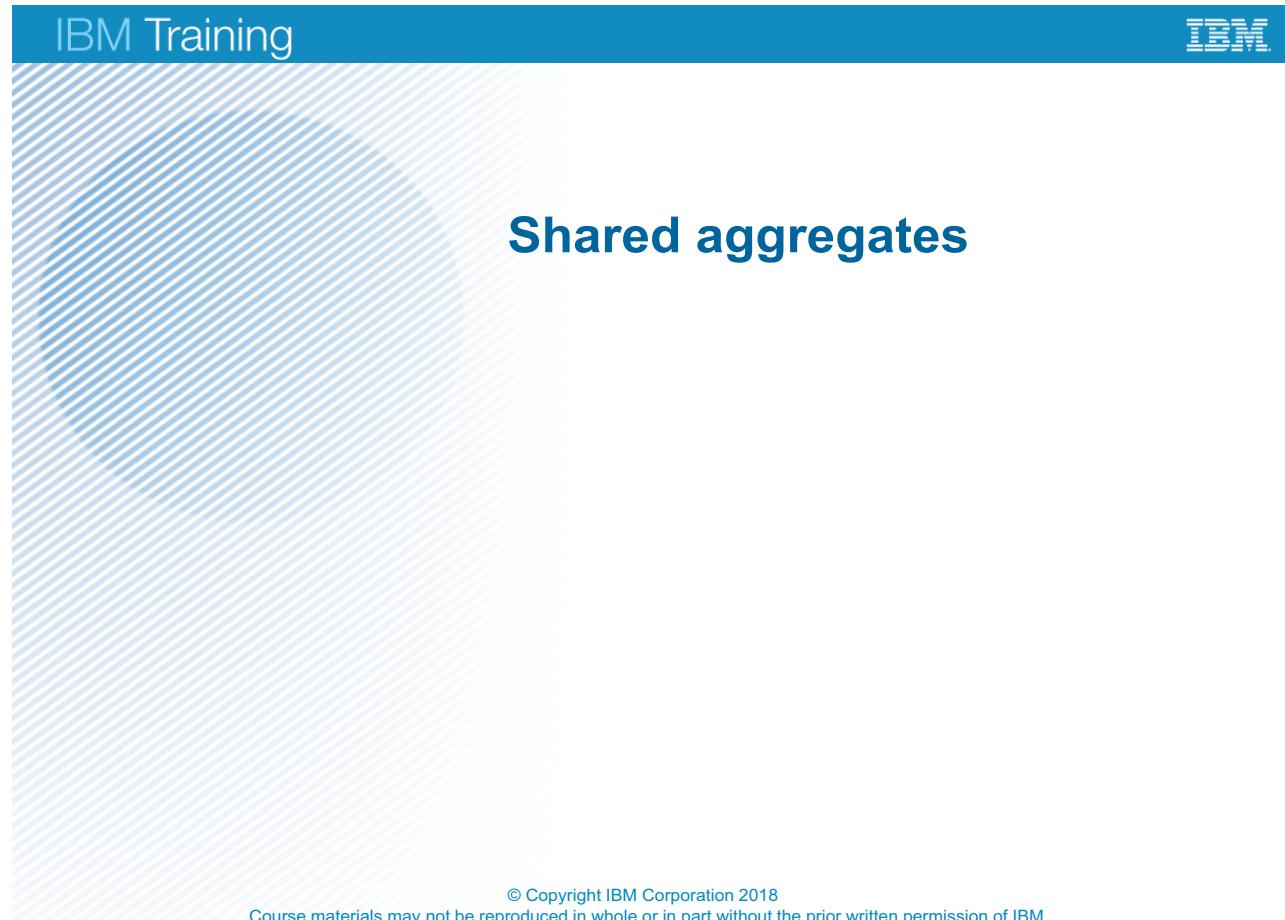
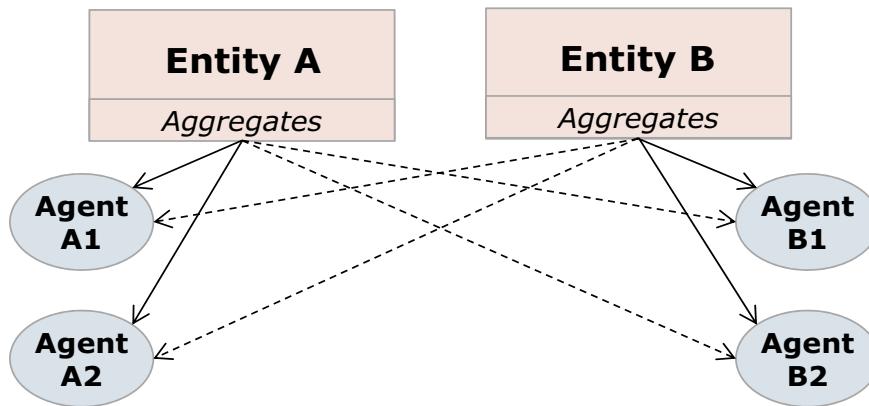


Figure 5-11. Shared aggregates

## What is a shared aggregate?

- Used to count the historical occurrence of events that meet some criteria
  - Can be defined in different ways allowing aggregated values to be queried for time points or time periods
- Enables smaller event histories
- Usable from any agent, local or remote to the entity instance
- Sharing results in increased performance and code reuse



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Figure 5-12. What is a shared aggregate?

Shared aggregates are used to aggregate events that are associated with a particular entity.

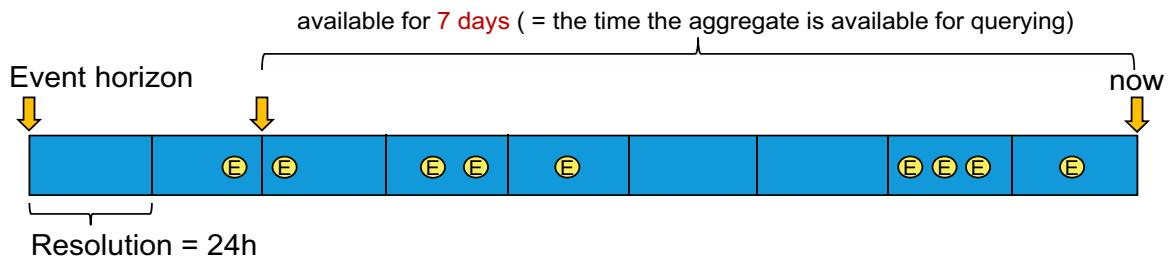
You define a shared aggregate in the business model as a normal entity attribute. You use the business model statements to define how the aggregation should be evaluated.

The aggregate is generated and shared with any agent, either local or remote to that entity. As shown in the graphic, Agents A1 and A2 are defined for Entity A. Agents A1 and A2 can access the shared aggregates that are defined on both Entity A and Entity B. The agents are also defined for Entity B as long as they have a reference to Entity B.

A shared aggregate is somewhat like an index of a database; it can be used to access quickly any value within the range of the horizon. Getting a value at a specified moment in time (not necessarily the current moment) can be used to detect when a change in the value occurs over time.

## Shared aggregates: ‘available for’ and ‘resolution’

- The available for <time duration> construct determines for how long event data is available for aggregation
- The resolution combines the data of multiple events over its specified period
- Example of an event history timeline
  - Aggregate declared:  
available for 7 days with a resolution of 24 hours
  - Timeline is divided into 9 “buckets” corresponding to a 24-hour resolution over 9 days
  - Each bucket contains the value of the aggregate for the time interval delimited by that bucket



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Figure 5-13. Shared aggregates: ‘available for’ and ‘resolution’

The value of a shared aggregate can be queried, typically by a rule, at the present moment (now) or at some time in the past within an ‘available for’ period. The number of values of the aggregate that are available for querying within the ‘available for’ period are determined by the *resolution* of the shared aggregate.

The diagram shows an event history timeline where an aggregate has been declared to be available for 7 days with a resolution of 24 hours. The timeline is divided into 9 ‘buckets’ corresponding to a 24 hour resolution over 9 days. Each bucket contains the value of the aggregate for the time interval delimited by that bucket.

## Referenced with an argument

- Uses a time argument when referenced in a rule
- Eliminates the need for separate aggregates for each time frame
- Allows for comparisons across time frames
- Argument can be a time point or time period
- Time periods cannot be used in aggregates with time filtering
- Time points default to "now" of the agent

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*Figure 5-14. Referenced with an argument*

Unlike other aggregate types, shared aggregates are referenced with a time argument when they are used in a rule. The argument can be either a time point or a time period. By default, if no time point is specified, the time point defaults to “now”.

The ability to use a single-shared aggregate for multiple time frames eliminates the need to define aggregates for each time frame. You can easily use the aggregate to compare values from different time frames, for example, comparing a total from “last month” to the same month from the previous year.

## Defining shared aggregates

- Declared as an attribute of an entity in the business model
  - Example:  
a train has a *total seven day delay* (numeric).
- Can aggregate average-of, maximum-of, minimum-of, number-of, and total-of
- Defined in statements on **Statements** tab of editor
  - Example:

the total seven day delay of a train is aggregated from train delays,  
 where this train comes from the train of each train delay as  
 the total delay of all train delays during the last period of 7  
 days  
 available for 1 month.

*Figure 5-15. Defining shared aggregates*

Here you see an example of how to work with shared aggregates.

First, the shared aggregate is defined in the same way that you define any attribute on an entity. In this example, the train entity has the shared aggregate: *total seven day delay*

This value is aggregated from all *train delay* events. The *total* operation sums the *delay* attribute values.

The argument that is passed to the aggregate is the time point “now” and the value is calculated from the 7 days previous to the time point.

The system keeps the data for this aggregate available for one month.

## Time filtering

- Any explicit or implicit reference to "now" is time filtering

- With time filtering:

the longest monthly delay of a train is aggregated from train delays,

where this train comes from the train of each train delay as the maximum delay of all train delays during the current month

available for 1 year.

- Without time filtering

the average weekday delay of a train is aggregated from train delays,

where this train comes from the train of each train delay as the average delay of all train delays,

where the day of week of each train delay is not one of { Saturday, Sunday }

available for 1 year.

*Figure 5-16. Time filtering*

Time filtering is an implicit or explicit reference to "now" in the definition of the aggregate.

In the first example, the term "during the current month" is an implicit reference to now. According to the rule language, "the current month" is the month that contains "now".

A time period argument cannot be used with time filtering.

The second example does not have time filtering. The term "where the day of week" is a reference to the time of the event. The rule is looking for an event on a weekday, which is not based on "now".

The use of time is not equivalent to time filtering, which is always in reference to "now". The time period that is passed as an argument replaces time filtering.

## Rules with time points

- Use “at” to specify the query time point
- The query time point defaults to "now" in the rule
  - "Now" in the aggregate definition is the query time point

```

when a train delay occurs
if
 the total seven day delay of 'the train' is more than
 the total seven day delay of the train at the time of 1 day
before the departure time of the train
then
 emit a new alert where
 the message is "The delays are trending the wrong way!" ;

```

*Figure 5-17. Rules with time points*

Here, you see how to the aggregate is referenced in a rule.

This rule references the aggregate twice. No time reference is passed to the first reference, which means the aggregate calculation is based on the default time point, “now”.

In the second reference, the time period “1 day before the departure time of the train” is passed as the time argument.

## Flexibility with time periods

- Use “over” to specify a time period
  - "Now" does not apply to time period queries

```

when a ticket purchase occurs
definitions
 set 'average delay last month' to the average weekday delay of 'the train'
 over the calendar month of 1 month before now;
 set 'average delay last year' to the average weekday delay of 'the train'
 over the calendar year of 1 year before now;
 set improvement to (1 - ('average delay last year'
 / 'average delay last month')) * 100);
if
 'average delay last month' is less than 'average delay last year'
then
 emit a new email where the message is "Thank you for your purchase. We're
 proud to have achieved " + 'improvement' + "% improvement in commuter
 service over last year.";
else
 emit a new email where the message is "Thank you for your purchase.";
```

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Figure 5-18. Flexibility with time periods

Time period arguments replace time filtering.

In the example here, the same aggregate is used over two different time periods to compare the last calendar month to last calendar year.

## Default values

- If you do not specify a default value, the default value of shared aggregates is null
  - If there are fewer than the minimum quantity data points at the requested time parameter, a null value is returned
  - For number-of operations, an actual numeric value is returned even if empty (0)
- When the oldest point of an aggregate query is older than the horizon, the value returned is null
- Null values can cause rules that use the shared aggregate to not fire
- Specify a default value to avoid null pointer errors
  - Example: Default is 5

```

the longest monthly delay of a train is aggregated from train
delays,
 where this train comes from the train of each train delay
 as the maximum delay of all train delays during the current
month
 defaulting to 5 if there are less than 3 events
 available for 1 year.

```

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*Figure 5-19. Default values*

If you do not specify a default value for the shared aggregate, the default value is null. When the oldest point of an aggregate query is older than the horizon, the value returned is null. Null values can cause rules that use the shared aggregate to not fire, so to avoid null pointer errors, a good practice is to specify a default value.

In this example, the longest monthly delay aggregate is set to 5.

## Resolution

- Defines the length of the interval (or “bucket”) between pre-aggregations
  - Main purpose is to enable smaller event histories
  - Improves performance
  - As a good practice, keep the number of buckets under 300
- Result is approximate
  - Precision is determined in large part by the resolution
- If the aggregate definition uses time filtering then you may not use resolution

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*Figure 5-20. Resolution*

Resolutions are defined in the `available-for` statement and cause the system to internally bundle aggregate data. By bundling the data, the system maintains much less data.

Including a resolution clause is useful when the aggregate runs over long time periods. Resolutions are a tradeoff between performance and accuracy.

In this example, the aggregate runs over a period of several weeks. The `available-for` period includes a 24-hour resolution. The resolution causes the system to bundle all the events in the past 24 hours, so the bundling means that the accuracy is plus or minus a day.

## Resolution: Memory gain and precision

- Resolution (pre-aggregation at regular intervals)
  - Reduces memory requirements and aggregate computation time
  - Reduces precision
- Given the event frequency and the resolution, you can estimate the gain in memory compared to not using the resolution
- Given a resolution and the size of the time period, you can get an estimation of the precision

| Resolution | Frequency<br>(events per hour) | Gain vs no resolution |
|------------|--------------------------------|-----------------------|
| 1 hour     | 1                              | none                  |
|            | 60                             | 60                    |
|            | 3600 (1 per sec)               | 3600                  |

| Resolution | Time period | Precision<br>TP/(TP+FP) |
|------------|-------------|-------------------------|
| 12 days    | 1 year      | 98%                     |
| 1 day      | 1 month     | 96%                     |
| 4h40mn     | 7 days      | 97%                     |
| 40mn       | 1 day       | 97%                     |
| 20mn       | 12 hours    | 97%                     |
| 2mn        | 1h          | 96%                     |

Figure 5-21. Resolution: Memory gain and precision

The first table shows that given the same resolution, higher event frequencies result in savings in memory and processing requirements. Setting an appropriate resolution is highly recommended especially when the event rate is high.

The second table shows how you can estimate the precision of the aggregate. You can see that the smaller the precision interval relative to the time period (as specified in the ‘available for’ clause), the greater the precision. A higher precision typically results in greater accuracy, but for high event rates this can lead to memory and CPU overhead.

## Example: Time point queries (1 of 2)

- Shared aggregate definition (in the BMD statements tab)
 

the coffee cups count of **an employee is aggregated from coffee consumption events**,  
**where this employee comes from the employee id of each coffee consumption event**  
**as the number of coffee consumption events available for 5 days with a resolution of 24 hours.**
- Rule queries the value of the aggregate at different time points

```

if now is at the same time as 6/10/2018
then
 print "DSI_AGG - consumption on 4th: " + the coffee cups count of 'the
employee' at the time of 6/4/2018;
 print "DSI_AGG - consumption on 5th: " + the coffee cups count of 'the
employee' at the time of 6/5/2018;
 print "DSI_AGG - consumption on 5th, 2 AM: " + the coffee cups count of 'the
employee' at the time
 of 6/5/2018 2:00:00 AM +0100;
...
etc.

```

Working with aggregates

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Figure 5-22. Example: Time point queries (1 of 3)

Here you see an example of a shared aggregate definition. In this example, the coffee cups count shared aggregate tracks the number of cups an employee consumes. This count is signalled by each coffee consumption event.

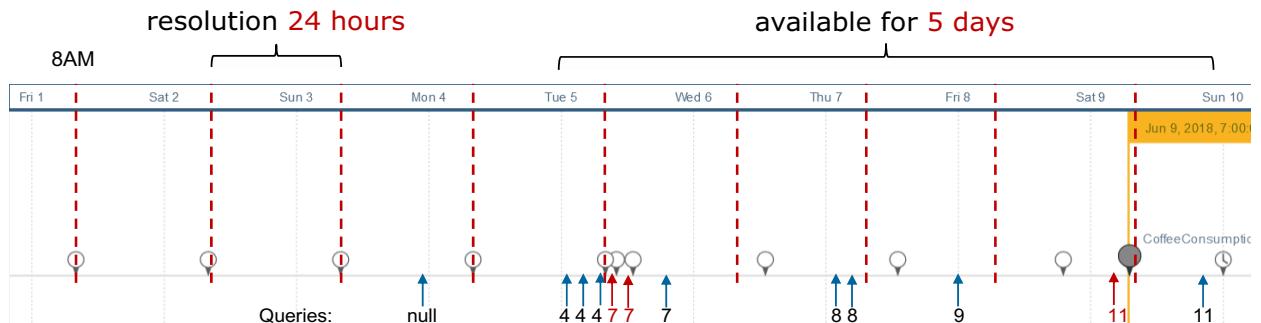
The available for 5 days clause means that you can query what the consumption count was up to 5 days ago.

The resolution of 24 hours clause means that you trade off accuracy for not having to record the value of the aggregate every time a new coffee consumption event arrives (assuming an employee has more than one cup of coffee in a 24hour period). The rule queries the value of the aggregate at different time points in the past.

The diagram in the next slide shows the impact of 'available for' and resolution on time point queries.

## Example: Time point queries (2 of 2)

*-- Bucket boundary*



### Observations:

- Queries outside the available for period return null
- Queries include all events to the right of a bucket boundary, including those on the boundary but excluding any events on or beyond the next boundary.
- Queries at the timepoints indicated by the red arrows have a 'precision error' which is a consequence of the resolution.

Figure 5-23. Example: Time point queries (2 of 3)

In this graphic, the vertical dotted lines represent resolution interval or “bucket” boundaries, which occur every 24 hours at 8 AM. The circles are coffee consumption events, and the vertical arrows are time point queries.

The ‘available for’ clause is a sliding window relative to the value of `now`. Any time point query outside this window returns null.

You can see in the diagram that, depending on the distribution of the events, some queries might return an accurate result (the exact event count up to that point), while others may represent the value that corresponds to the aggregation performed at the end of the time interval (or bucket). This illustrates the loss of accuracy due to the resolution.

## Example: Time period queries

### Time Period query for the same aggregate

- Queries include all events in all the buckets that the query period “touches”
- If one of the dates falls outside the available for period, the query returns **null**

if now is at the same time as 6/10/2018

then

```
print "Q1 - over last 4 days: " + the coffee cups count of 'the employee' over the last period of 4 days;
print "Q2 - over current week: " + the coffee cups count of 'the employee' over the current week ;
print "Q3 - over 2 dates in av p: " + the coffee cups count of 'the employee' over the period between 6/5/2018
and 6/9/2018;
print "Q4 - between 2 dates outside av p: " + the coffee cups count of 'the employee' over the period between
6/1/2018 and 6/7/2018;
print "Q5 - over last 2 hours: " + the coffee cups count of 'the employee' over the last period of 2 hours;
```

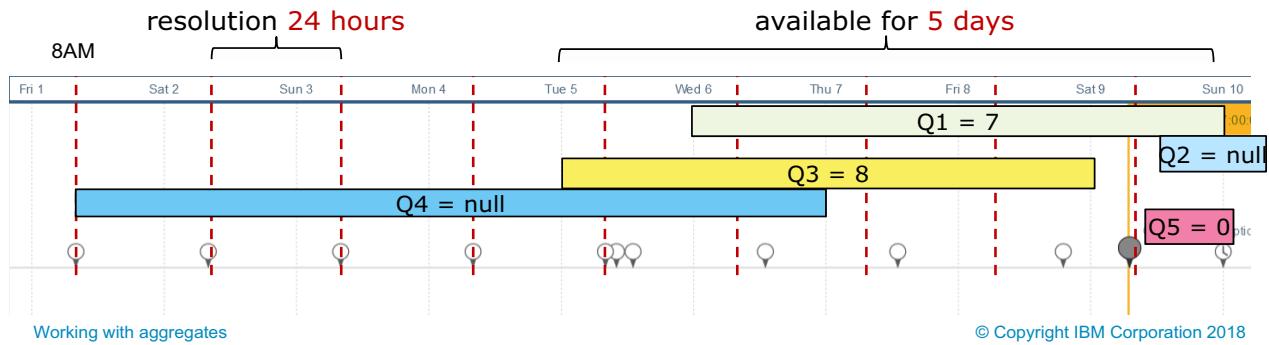


Figure 5-24. Example: Time point queries (3 of 3)

Here we see 5 examples of time period queries. Notice that the query result includes all events for the query period but also includes those events that fall outside the period as long as they are in a bucket that is “touched” by the query period.

Q2 and Q4 exemplify queries where one of the delimiters are outside the ‘available for’ period. Q5 returns 0 because, although the query period is valid, there are no events in the bucket that the query period touches.

## Unit summary

- Define global event aggregates
- Define shared aggregates

[Working with aggregates](#)

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*Figure 5-25. Unit summary*

## Review questions

- 1. True or False:** Java agents have an API to access aggregates.
  
- 2. True or False:** A global event aggregate can perform calculations across entire populations of events.

Working with aggregates

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*Figure 5-26. Review questions*

Write your answers here:

- 1.
  
- 2.

## Review answers

1. Java agents have an API to access aggregates.  
**Answer: true.**
  
2. A global event aggregate can perform calculations across entire populations of events.  
**Answer: True.**

Figure 5-27. Review answers

## Exercise: Using event and shared aggregates in rules

Working with aggregates

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Figure 5-28. Exercise: Using event and shared aggregates in rules

## Exercise introduction

- Use event aggregates and shared aggregates in rules



[Working with aggregates](#)

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*Figure 5-29. Exercise introduction*

# Unit 6. Testing solutions

## Estimated time

01:00

## Overview

This unit teaches you how to test the implementation of your business logic.

## How you will check your progress

- Checkpoint

## Unit objectives

- Test solutions with the TestDriver API
- Test solutions with the Test Client
- Work with the REST API
- Analyze event processing with Insight Inspector

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*Figure 6-1. Unit objectives*

## Topics

- TestDriver API
- Test Client
- REST API
- Insight Inspector

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*Figure 6-2. Topics*

## 6.1. TestDriver API

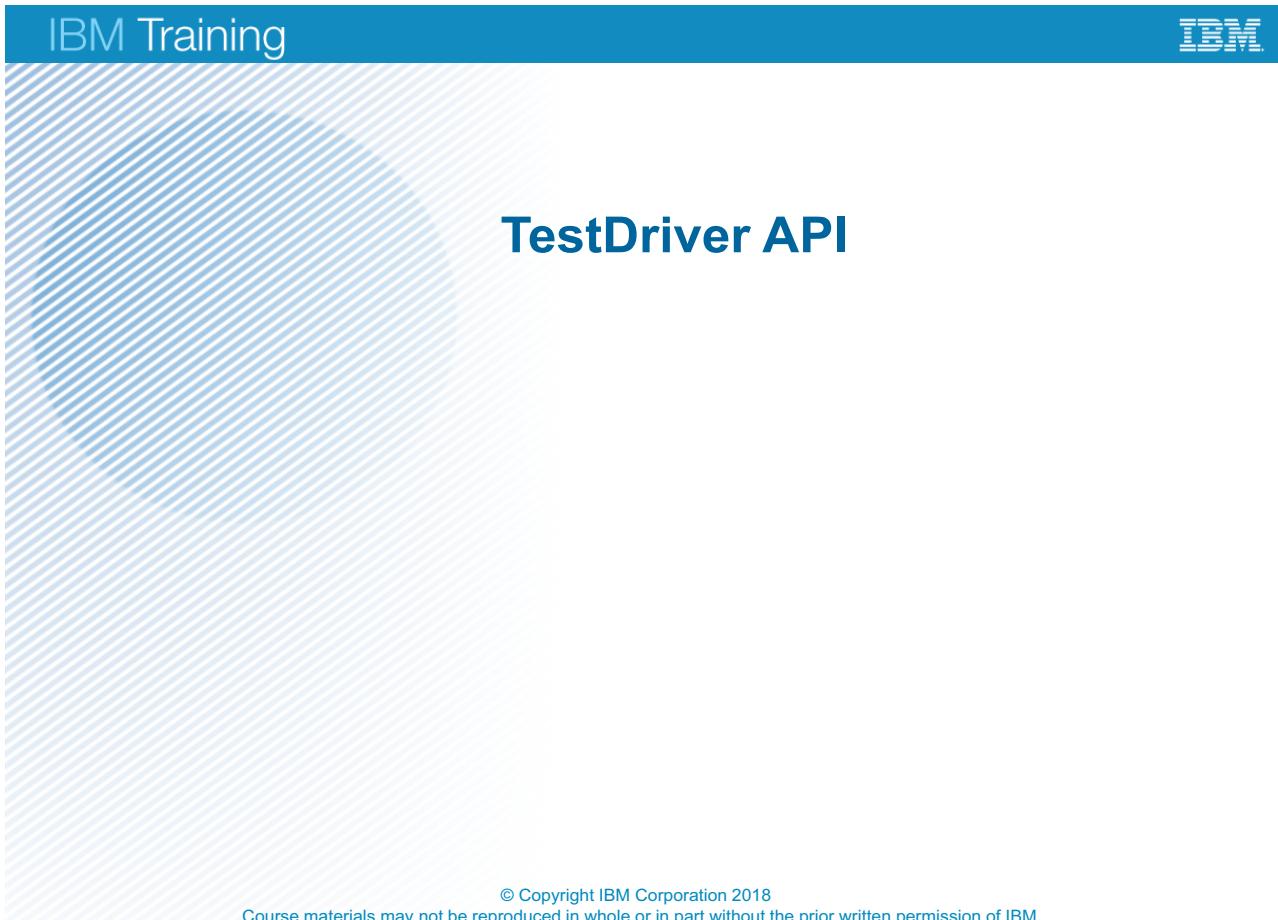


Figure 6-3. TestDriver API

## TestDriver API

- Java TestDriver API provides all methods that are required to test a solution
  - Test and debug solutions
  - Manage entities
  - Determine the system and solution status
  - Create and submit events to Insight Server
- The TestDriver class is the main entry point for testing a solution
- Use model factory methods such as `getConceptFactory` and `getEventFactory` to create events, entities, and concepts
- Use TestDriver API to capture events for debugging and problem determination

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Figure 6-4. TestDriver API

You can test your Insights solutions in several ways, such as by using the TestDriver API to load test entities into the grid and submit test events for processing.

A test driver helps you run solution tests and debugging, manage entities, determine the system and solution status, and create and submit events to Insight Server. TestDriver provides model factory methods, such as `getConceptFactory` and `getEventFactory` to create events, entities, and concepts.

The TestDriver API provides the `DebugReceiver` interface to help you capture outbound information from test events for debugging and problem determination.

## TestDriver properties

- Configured within a Java Properties object that contains property/value pairs for the various properties
- Use a `testdriver.properties` file to
  - Connect the test driver instance to a server
  - Create and add properties to modify the behavior of the test driver

Figure 6-5. TestDriver properties

To use TestDriver, you create a Java project and a test driver instance.

To ensure that a test driver instance can connect to a server, you create a `testdriver.properties` file and add properties to configure the behavior of the test driver.

The `testdriver.properties` file contains connectivity and server properties to set up and run the test driver.

The `testdriver.properties` file must be located either in the directory where the Java application starts, or in a location that is defined by the `TESTDRIVER_HOME` environment variable.

## Example testdriver.properties

```
solutionname=MyTestDriverProject
catalogServerEndpoints=localhost:2809
host=localhost
port=9443
debugServers=localhost:6543
username=tester
password=tester
trustStoreLocation=<InstallDir>\\runtime\\wlp\\usr\\servers\\\\
cisDev\\resources\\security\\key.jks
trustStorePassword=tester
disableSSLHostnameVerification=true
```

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Figure 6-6. Example testdriver.properties

Here, you see the testdriver properties and some example values.

The **solutionName** property is a required property and specifies the solution where the test driver instance runs. The other properties are optional or use default values.

The **username** and **password** properties must match the **username** and **password** properties in the **server.xml** file.

The **trustStoreLocation** property uses the default installation path for the keystore location. If you share projects and test drivers with users on other computers, they might need to modify this property to match their installation path.

## Insert entities and submit events (1 of 2)

- In your class, create a TestDriver instance and code a connection to your solution

```
TestDriver testDriver = null;
testDriver = new TestDriver();
testDriver.connect();
```

- Define a method to insert your entities to the grid

```
private void loadCustomer() throws Exception {
Customer customer =
testDriver.getConceptFactory(ConceptFactory.class).createCustomer
("Smith");
customer.setFirstName("Jack");
customer.setLastName("Smith");
customer.setLoyaltyCardOwner(true);
testDriver.loadEntity(customer);
}
```

*Figure 6-7. Insert entities and submit events (1 of 2)*

To insert entities and submit events to your solution, you first create a TestDriver instance and define a connection to your solution by using the code that you see here.

Next, you define a method to insert your entities to the grid and this method would create the entity and initialize it with some values.

## Insert entities and submit events (2 of 2)

- Create an event by using the EventFactory API

```
CreateCartEvent createCartEvent =
testDriver.getEventFactory().createEvent(CreateCartEvent.class);
createCartEvent.setShoppingCartId(shoppingCartId);

Relationship<Customer> customerRel =
testDriver.getEventFactory().createRelationship(Customer.class,
customerId);

createCartEvent.setCustomer(customerRel);
```

- Send the event in a TestDriver.submitEvent method

```
testDriver.submitEvent(createCartEvent);
```

Figure 6-8. Insert entities and submit events (2 of 2)

The next step is to create an event by using the EventFactory API. Finally, you submit the event by using the TestDriver `submitEvent` method.

## Receiving and storing debug information (1 of 2)

- Run the `propertyManager set` command to configure the server debug port property, or range of ports
  - For example:

```
propertyManager set --username=admin --password=admin
debugPort=6543
```
- Use the `DebugReceiver` interface to create a debug receiver instance
  - The interface defines an entry point for `DebugInfo` by using the `addDebugInfo` method
  - The `addDebugInfo` method is called when the server sends debug information to the test driver client
  - For example:

```
addDebugInfo(DebugInfo info, String sourceAgent)
```

  - In the example, the `info` parameter represents the debug information and `sourceAgent` is the name of the agent that generated the information

*Figure 6-9. Receiving and storing debug information (1 of 2)*

After testing event processing by submitting events, the TestDriver API also helps you monitor and capture event debug information. You can use the TestDriver to collect the debug information from the server in memory or write it to a file.

As you saw earlier, the `testdriver.properties` file contains connectivity and several properties to set up the TestDriver instance and control solutions and information. You can also identify which agents should send information by using the debug agent list property. You set this property to a comma-separated list of your agent names. By default, you get debug information from all the agents in the solution.

During the first lab of this course, you set the debug port as described on the slide. The TestDriver uses the host port value to receive the debug information.

In your TestDriver instance, you use the debug receiver interface to capture outbound information from the events for debugging and problem determination.

## Receiving and storing debug information (2 of 2)

- Start with the sample implementation `IADebugReceiver` and then customize the debug receiver to work in your environment
- Add the debug receiver instance to the test driver client by calling the `addDebugReceiver` method in the client
- For example:

```
TestDriver testDriver = null;
testDriver = new TestDriver();
DebugReceiver r = new IADebugReceiver();
testDriver.addDebugReceiver(r);
testDriver.connect();
```

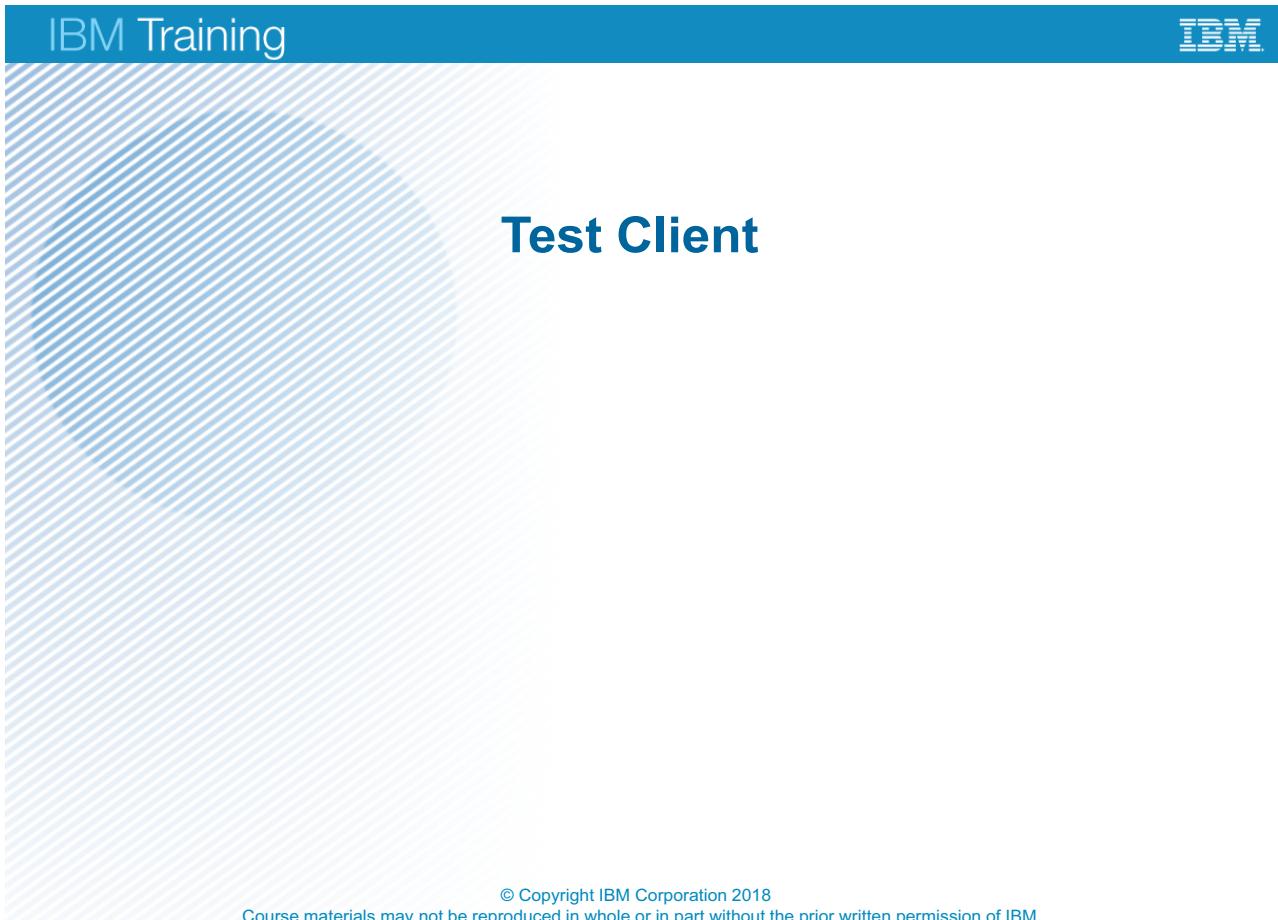
*Figure 6-10. Receiving and storing debug information (2 of 2)*

When the connection to the server is established, the server detects all events that are emitted by specific solutions and agents that match the `solutionname` and `debugagentlist` properties in the `testdriver.properties` file.

The server then sends debug information from the events to the `TestDriver` instance. The `TestDriver` instance calls the debug receiver, which captures the information and caches it in memory or stores it in a file.

You can start with a sample implementation of the `IADebugReceiver` and then customize the receiver for your environment. To add the debug receiver instance to a `TestDriver` client you call the `addDebugReceiver` method in the client, as you see in this example.

## 6.2. Test Client



*Figure 6-11. Test Client*

## Using a test client

- Use test clients to:
  - Define and load entities
  - Create and submit a sequence of events
  - Write and run assertions about the state of the entities
- No Java required

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*Figure 6-12. Using a test client*

The test client provides solution developers with simplified tools to verify the behavior of their solution.

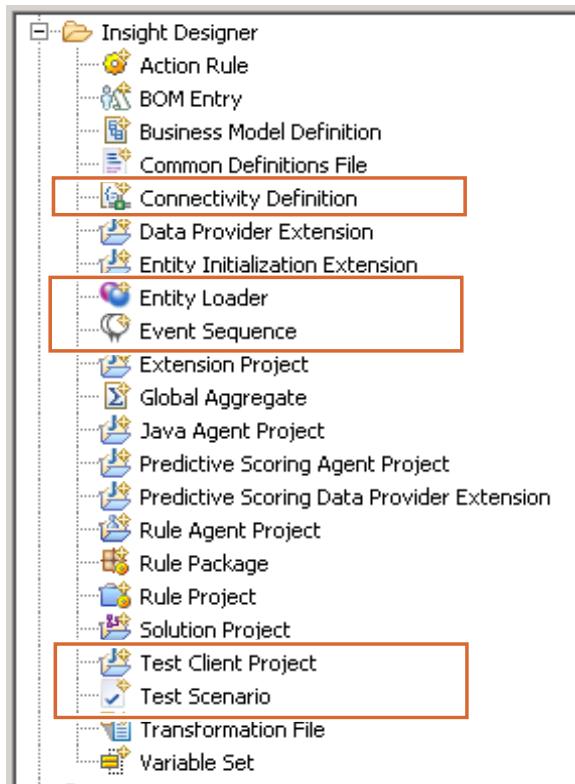
Writing test cases with Java and XML provides power and flexibility, but can be difficult for quick experimentation for non-technical users.

The test client provides an easy way to quickly load entities and submit some events. You can then use the test client to verify the state of your system as a result of those actions, and know whether your solution is working.



## Test Client artifacts

- Test artifacts include:
  - Common definitions
  - Entity loaders
  - Event sequences
  - Test scenarios
- Artifacts are stored in a **Test Client Project**



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Figure 6-13. Test Client artifacts

Insight Designer provides various artifacts to enable users to test their solution.

- **Entity loaders** allow the user to define entities to load.
- **Event sequences** allow the user to define an ordered sequence of events.
- **Test scenarios** allow the user to co-ordinate their entity loaders, event sequences and to write assertions about the state of their entities.
- **Common definitions files** allow the user to create definitions that can be used throughout the other testing artifacts.
  - The languages for all of these assets are based around a subset of the rule language.
  - Entity loaders, event sequence, and test scenarios can all be run on a development server, by using Eclipse run configurations, without requiring the user to write any Java code.
  - If recording is enabled in the run configuration, Insights Inspector can be used to review any submitted events. The REST API can be used to review the loaded entities.

## Creating a test client project

- All testing artifacts stored in a separate Test Client project
  - Use **File > New > Other > Insight Designer** menu
- Connection details for the server to run the test artifacts on can be found in the `testdriver.properties` file within the Test Client project
  - Modify properties to match the development server
- Run a testing artifact by right-clicking on the file or editor and select **“Run as”**
  - Modify your run configuration later by using the Run Configurations window

*Figure 6-14. Creating a test client project*

All artifacts that you need to test the solution are stored together in a separate test client project. To run test artifacts, you right-click your file and select **Run as** with the appropriate menu option.

## Entity loaders

- Use the “load” keyword to load entities into a development server.
- Define the initial attributes of the entity, so it is in the state that you require at the beginning of your test.

```
load a new customer where
 the customer id is "123" ,
 the name is "Betty" ,
 the address is a new address where the house number is "21" ,
 the street name is "Hursley Park Road" ,
 the city is "Winchester" ;
```

Figure 6-15. Entity loaders

You can load multiple entities in the loader. In the example here, the entity loader defines the customer entity and required attributes.

## Event sequences

- Use the “emit” keyword to emit events in the sequence that you would like them to be submitted to the server
- After you emit an event with a time-stamp, subsequent events can be emitted with timestamps set relative to the previous event

```
emit a new transaction where the amount is 50 , the customer is
the customer "Fred", time-stamped 10/01/2015;
```

```
emit a new transaction where the amount is 100, the customer is
the customer "Fred" , time-stamped 1 week later;
```

Figure 6-16. Event sequences

The emit keyword emits the events in the sequence you specify. You can include time stamps along with relative times set relative to the previous event.

## Test scenarios

- Coordinate loading entities and running event sequences
- Allow you to write assertions about the state of the entities in the system at various time points
- Can simulate the passing of time
  - Ask the system to continue processing until a particular point in time
  - Supports testing scheduled rules and time conditions

```

load entities from "Customers" ;
check that the customer "Fred" exists ;
check that for the customer "Fred" :
- the customer id of this customer is
 "123"
- the name of this customer is "Fred"
- the status of this customer is BRONZE ;

submit events from "Fred transactions" ;
check that for the customer "Fred" :
- the status of this customer is SILVER ;
continue processing until 1/10/2018 ;
check that for the customer "Fred" :
- the status of this customer is BRONZE ;

```

*Figure 6-17. Test scenarios*

You can use the test scenarios to coordinate the event sequences and write assertions about entities at various time points.

Test scenarios can simulate the passing of time so that you can test scheduled rules and time conditions.

## Common definitions

- Definitions that are defined in a Common Definitions file can be used in any of the other test artifacts
  - Use Common Definitions file to define complex structures, such as lists
  - Use the definitions in the entity loader, event sequence, and test scenario artifacts
  
- Access all the definitions by including this statement:  
`using definitions from <common definitions filename> ;`
  - `using definitions from "Fred definitions" ;`
  - `emit 'Fred transaction', time-stamped 10/04/2015 ;`
  - `emit 'Fred transaction', time-stamped 1 day later;`

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Figure 6-18. Common definitions

You can use a common definitions file to define IDs or complex structures that you do not want to repeatedly define, such as lists of concepts.

To include these definitions in other files, you include a statement at the beginning of your other files that makes the definitions accessible.



## Run configuration

- Define a Run Configuration of type Test Scenario

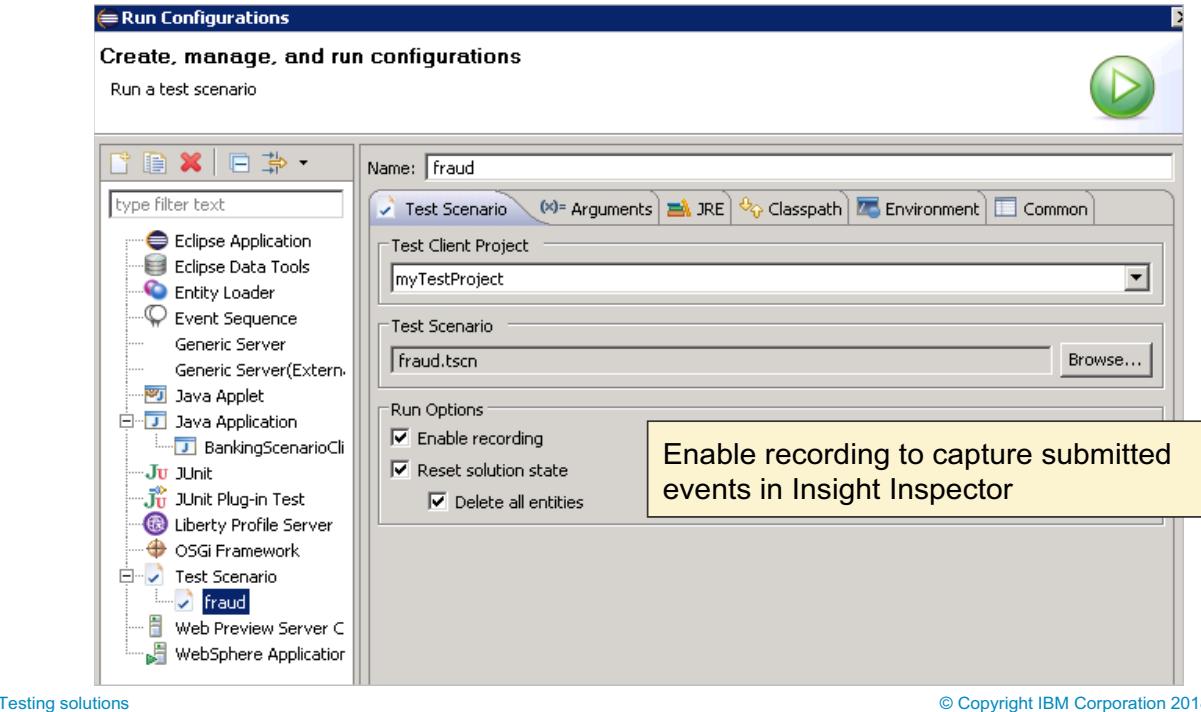
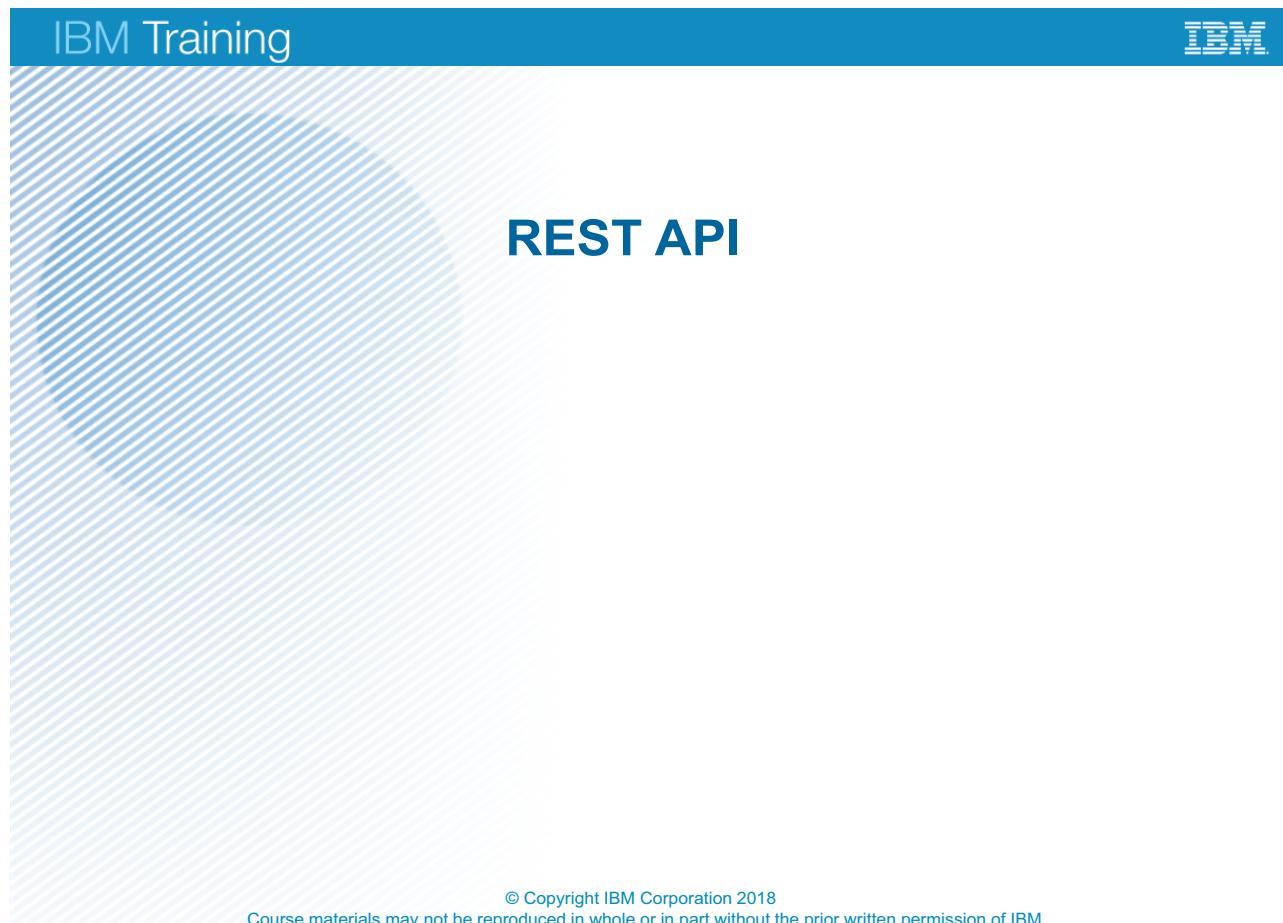


Figure 6-19. Run configuration

The testdriver.properties file within the Test Client project is used to connect to the server when you run the Test Scenario.

In the **Run Options**, you can enable a recording of the test run to analyze in Insight Inspector. The recording is automatically started and stopped for you. After the test is done, a link to the recording is provided in the console.

## 6.3. REST API



*Figure 6-20. REST API*

## Using REST API

- Use a browser to call REST API methods

- Verify connections to servers

`https://[hostname]:[port]/IBMJMXConnectorREST`

- Verify deployment of solutions to servers

`https://[hostname]:[port]/IBMJMXConnectorREST`

- Get values for testing

- Check whether an entity is created
  - Verify the current value of a global aggregate

Figure 6-21. Using REST API

You can use the REST API as a quick way to verify connections to servers, deployment of solutions, or get values, such as entity instances or aggregate values.

## Using the REST API to access deployed solutions

- List all deployed solutions:

`http://[hostname]:[port]/ibm/ia/rest/solutions`

- List all entity types that are managed by your solution:

`http://[hostname]:[port]/ibm/ia/rest/solutions/MySolution/entity-types`

- List all aggregates in your solution:

`http://[hostname]:[port]/ibm/ia/rest/solutions/MySolution/aggregate`

- Retrieve a global aggregate value:

`http://[hostname]:[port]/ibm/ia/rest/solutions/MySolution/aggregate/aggregate_name`

Figure 6-22. Using the REST API to access deployed solutions

On this slide, you see URL examples that you can use to validate that your solution is deployed and to see which entities are created. You can also check for the aggregates in your solution and their values.

The screenshot shows the Advanced Rest Client interface. On the left is a sidebar with links: Advanced Rest Client, Request, Socket, Projects, Saved History, Settings, About, Rate this application, and Donate. A 'Scroll to top' button is at the bottom of the sidebar. The main area has tabs for 'MyCreditCardSolution' and 'Get entity types'. Below is a URL input field with 'https://localhost:9443/ibm/ia/rest/solutions/MyCreditCardSolution/entity-types/creditcard.Account'. Underneath are radio buttons for various HTTP methods: GET (selected), POST, PUT, PATCH, DELETE, HEAD, OPTIONS, and Other. Below the methods are three buttons: Raw, Form, and Headers. The Headers tab is selected, showing 'Accept: application/json'. Underneath is a 'Status' section with '200 OK' and a loading time of '155 ms'. Below that are three tabs: Raw, JSON (selected), and Response. The JSON tab displays a JSON object representing a collection of creditcard.Account entities. The Response tab shows the raw JSON text.

- Use a REST client for introspection of deployed solutions, types of entities, entity instances, and global aggregate values
- To get **JSON responses**:
  - Set the "Accept:" header in the request to "get"
  - More readable than XML for debugging

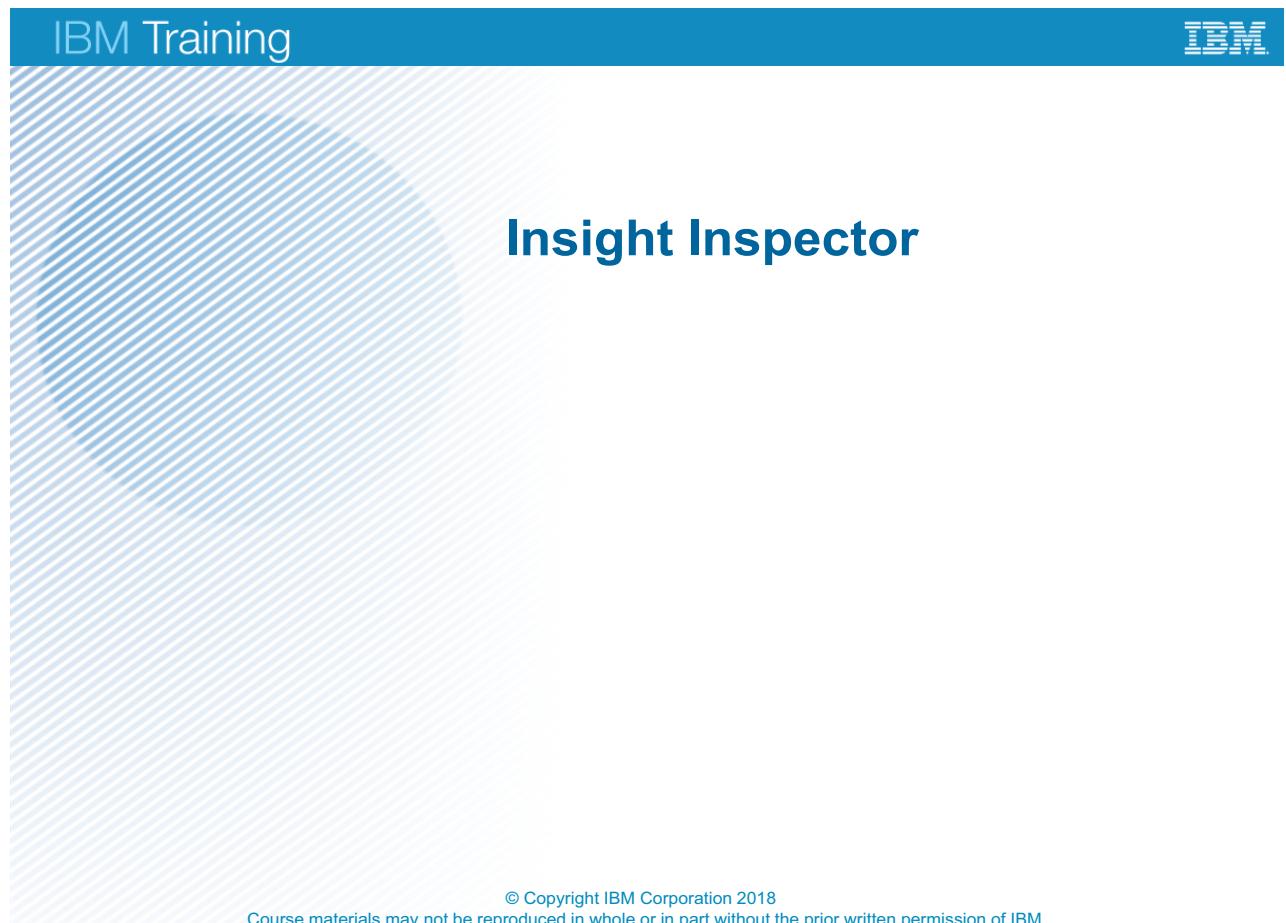
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Figure 6-23. REST methods

After you run a test project, you can use the REST API as a quick way to check that entities are inserted into the grid.

You can use a REST client to view deployed solutions, types of entities, entity instances, and global aggregate values. If you want JSON responses, you need to set the **accept-header** in the request to get. JSON is more readable than using XML for debugging.

## 6.4. Insight Inspector



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Figure 6-24. *Insight Inspector*

## Overview

- Web application to review and analyze solutions during development
- Record a test run of a solution
- Review and inspect the events and entities that are associated with each solution agent
- Troubleshoot failures and errors
  - For example: No emitted events, rules are not fired, unexpected results
- Insight Inspector is a component of the Insights Runtime feature
  - For non-production

Figure 6-25. Overview

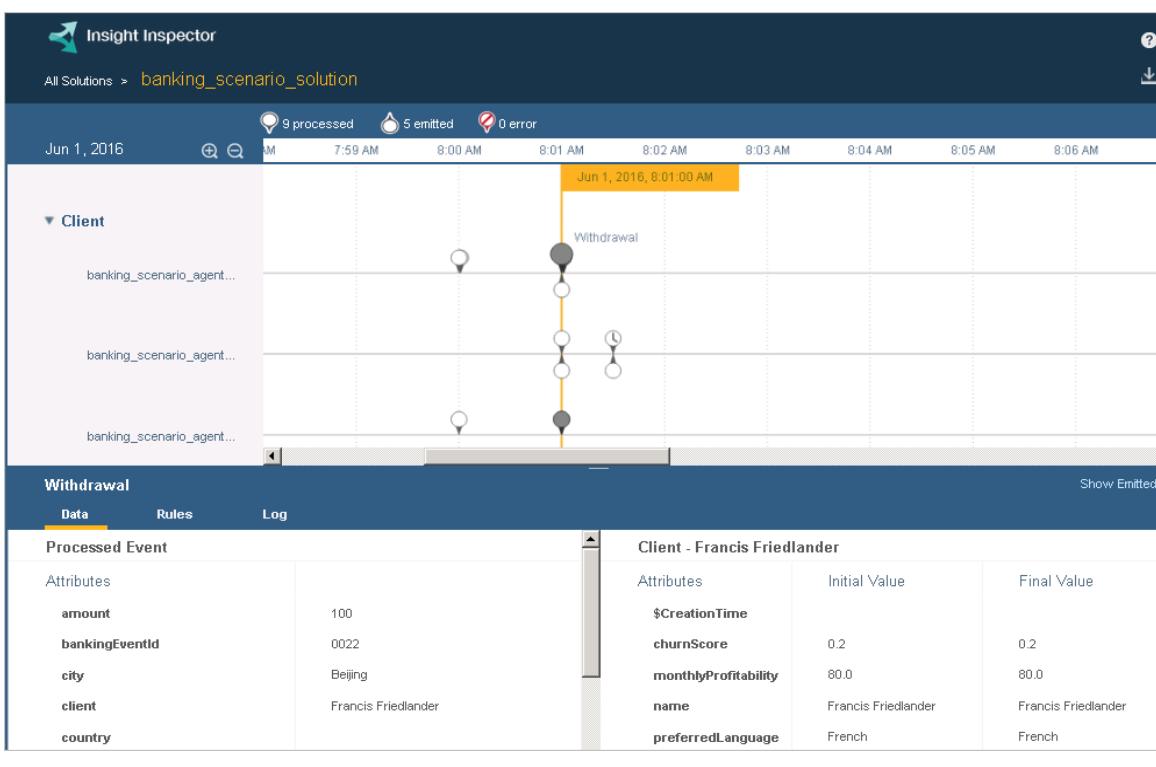
Insight Inspector is a web-based debugging tool that helps you review and analyze events, agents, and entities that are associated with a solution test.

When you open Insight Inspector, you see a list of recorded tests that are identified by solution name and time.

When you open the test, you see the solution entities, agents, and event timelines that are organized into groups according to the entity type.

Insight Inspector is intended for testing during development; it is not a production tool.

## Web interface



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*Figure 6-26. Web interface*

This slide shows an example of what you see when you open the solution to test in the inspector.

Record a test run to capture the event activity. After the test and after you stop the recording, you can open the recording in a browser.

Insight Inspector displays the event activity on a timeline. Events are represented as icons above and below the timeline.

You can zoom and scroll to get a clearer view of the agents, entities, and events, and their details.

The lower pane includes three tabs: **Data**, **Rules**, and **Log**.



## Checking event and entity data

- **Data section**
  - Lists entity and event attributes

The screenshot shows the IBM Event Explorer interface. On the left, there's a timeline with several event icons. One specific event icon, labeled 'FraudAlert', is highlighted with a red box and has a yellow vertical line pointing down to its corresponding data panel. The data panel is titled 'FraudAlert' and contains three tabs: 'Data' (which is selected and highlighted with a blue box), 'Rules', and 'Log'. Below the tabs, the panel is titled 'Emitted Event' and displays the following attributes:

| <b>client</b>       | Francis Friedlander                    |
|---------------------|----------------------------------------|
| <b>fraudEventId</b> | 0022                                   |
| <b>message</b>      | ABNORMAL COMBINATION OF BANKING EVENTS |
| <b>type</b>         | banking_scenario.FraudAlert            |

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Figure 6-27. Checking event and entity data

The **Data** section displays information about the selected event and entities that are associated with the event. To review the event and entity data, click to select an event icon in the timeline.

When an event is processed, the agent might emit zero, one or multiple related events.



## Verifying rules as fired

- **Rules section**

- Displays which rules fired and did not fire

FraudAlert

|              |              |     |
|--------------|--------------|-----|
| Data         | <b>Rules</b> | Log |
| <b>Fired</b> | Not Fired    | All |

✓ Check distance to recent events

FraudAlert

|       |                  |     |
|-------|------------------|-----|
| Data  | <b>Rules</b>     | Log |
| Fired | <b>Not Fired</b> | All |

Check amount versus historical average

Figure 6-28. Verifying rules as fired

The **Rules** section displays a list of rules that are fired as a result of processing the selected event. The rules are processed and evaluated during the recording. Use the **Fired** and **Not Fired** lists to verify that the correct rules are fired during event processing.



## Verifying results in the log

- **Log section**

- Displays messages that are captured between the start of the event processing and the end of the event processing

FraudAlert

|      |       |            |
|------|-------|------------|
| Data | Rules | <b>Log</b> |
|------|-------|------------|

Processing time was Jun 1, 2016 8:01:00 AM PDT

▼ Check distance to recent events was fired

▶ NEW was set

CLOSE ENOUGH TO DRIVE was set to false

CAN DRIVE was set to false

DISTANCE was set to 5111.573093965814

DRIVE MAX DISTANCE was set to 1.1666666666666667

CAN FLY was set to false

▶ OLD was set

MINUTES PER HOUR was set to 60

DRIVE SPEED LIMIT was set to 1.1666666666666667

FAR ENOUGH TO FLY was set to true

DURATION CHECK IN AND LANDING was set to 120

FLY MAX DISTANCE was set to -991.66666666666667

FLY DURATION was set to -119

FLY SPEED LIMIT was set to 8.33333333333334

DURATION was set to 1

FraudAlert was emitted

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Figure 6-29. Verifying results in the log

Use the **Log** section to check the log information for a selected event.

The **Log** section displays messages that are captured between the start of the event processing and the end of the event processing.

The original server log files are stored in the  
`<InstallDir>/runtime/wlp/usr/servers/<server_name>/logs` directory.

## Managing recording

- Start the recording by using `TestDriver.startRecording()` or the REST API:

```
http://[hostname]:[port]/ibm/insights/rest/recording/start/MySolution
```

- Run your solution test client to load entities and submit events for processing

- Stop the recording by using `TestDriver.stopRecording()` or the REST API:

```
http://[hostname]:[port]/ibm/insights/rest/recording/stop/MySolution
```

- View details at Insight Inspector URL:

```
http://[hostname]:[port]/ibm/insights
```

- For example: `http://localhost:9080/ibm/insights`

Figure 6-30. Managing recording

To start and stop the recording, you can use the Test driver API or you can use the REST API.

After you start the recording, then you create the entities and submit events to the runtime. When the runtime processing is done, you stop the recording and open Insight Inspector in a browser. Your recording becomes available for you to select and review.

## Unit summary

- Test solutions with the TestDriver API
- Test solutions with the Test Client
- Work with the REST API
- Analyze event processing with Insight Inspector

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*Figure 6-31. Unit summary*

## Checkpoint questions

1. True or false: The TestDriver object is provided with **Decision Server Insights** and includes methods that are required to test a solution.
2. Which of the following options is *not* a troubleshooting tool for an Insights solution?
  - a. Server trace logs
  - b. Debug mode in Insight Designer
  - c. Insight Inspector
3. True or false: To capture event activity in Insight Inspector, you must first record the activity by using REST API.

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Figure 6-32. Checkpoint questions

Write your answers here:

- 1.
- 2.
- 3.

## Checkpoint answers

1. True or false: The TestDriver object is provided with **Decision Server Insights** and includes methods that are required to test a solution.

**Answer: True**

2. Which of the following options is *not* a troubleshooting tool for an Insights solution?

- a. Server trace logs
- b. Debug mode in Insight Designer
- c. Insight Inspector

**Answer: b. Debug mode in Insight Designer**

3. True or false: To capture event activity in Insight Inspector, you must first record the activity by using REST API.

**Answer: True**

Figure 6-33. Checkpoint answers

## Exercise: Testing solutions

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*Figure 6-34. Exercise: Testing solutions*

## Exercise introduction

- Create a test client project
- Run a test scenario



Testing solutions

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*Figure 6-35. Exercise introduction*

---

# Unit 7. Modeling and defining connectivity

## Estimated time

01:00

## Overview

This unit describes how to define and manage connectivity for your solution.

## How you will check your progress

- Checkpoint
- Exercise

## Unit objectives

- Define inbound and outbound connectivity for a solution
- Configure and deploy connectivity

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*Figure 7-1. Unit objectives*

## Topics

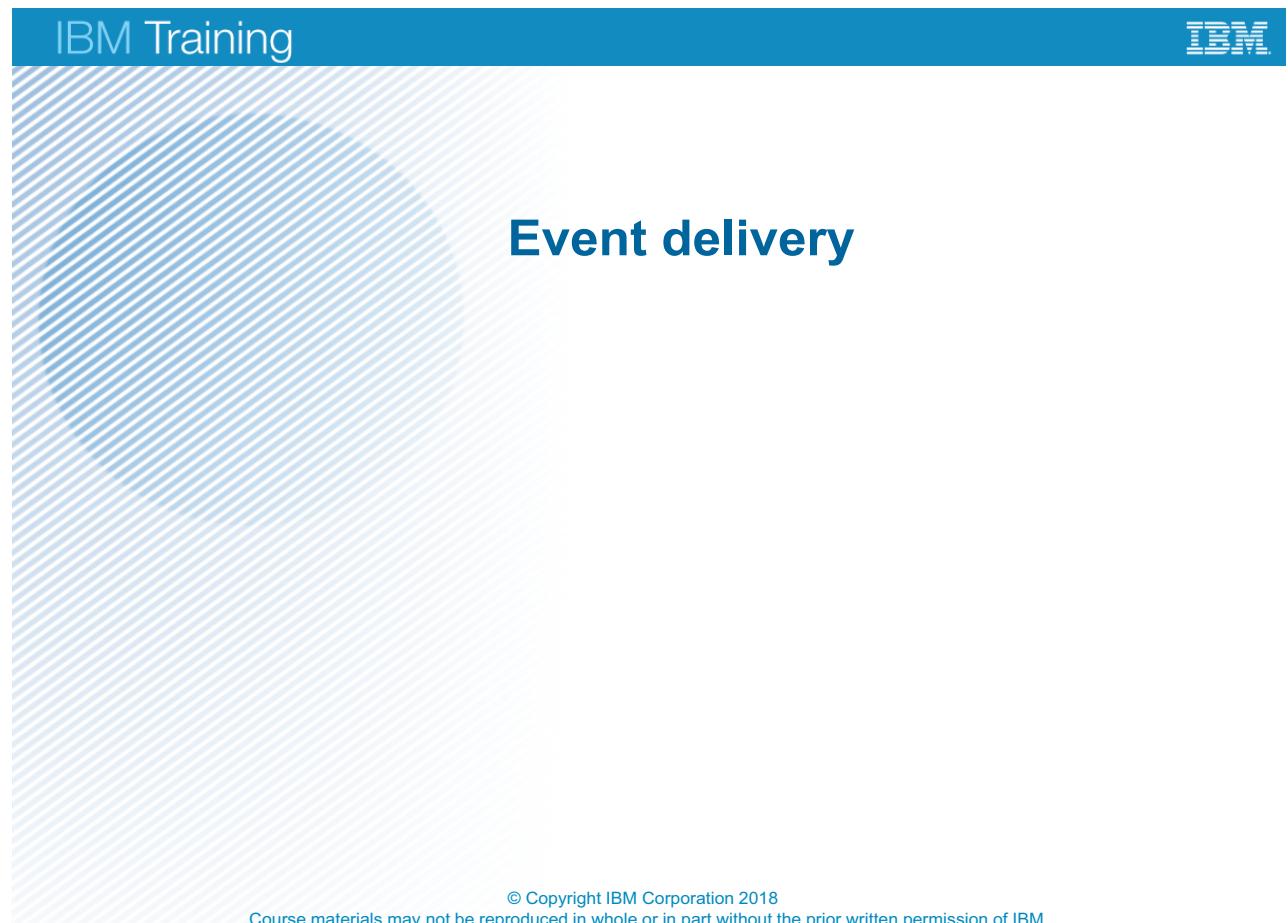
- Event delivery
- Modeling connectivity
- Defining connectivity for your solution
- Deploying connectivity
- Troubleshooting connectivity issues

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*Figure 7-2. Topics*

## 7.1. Event delivery



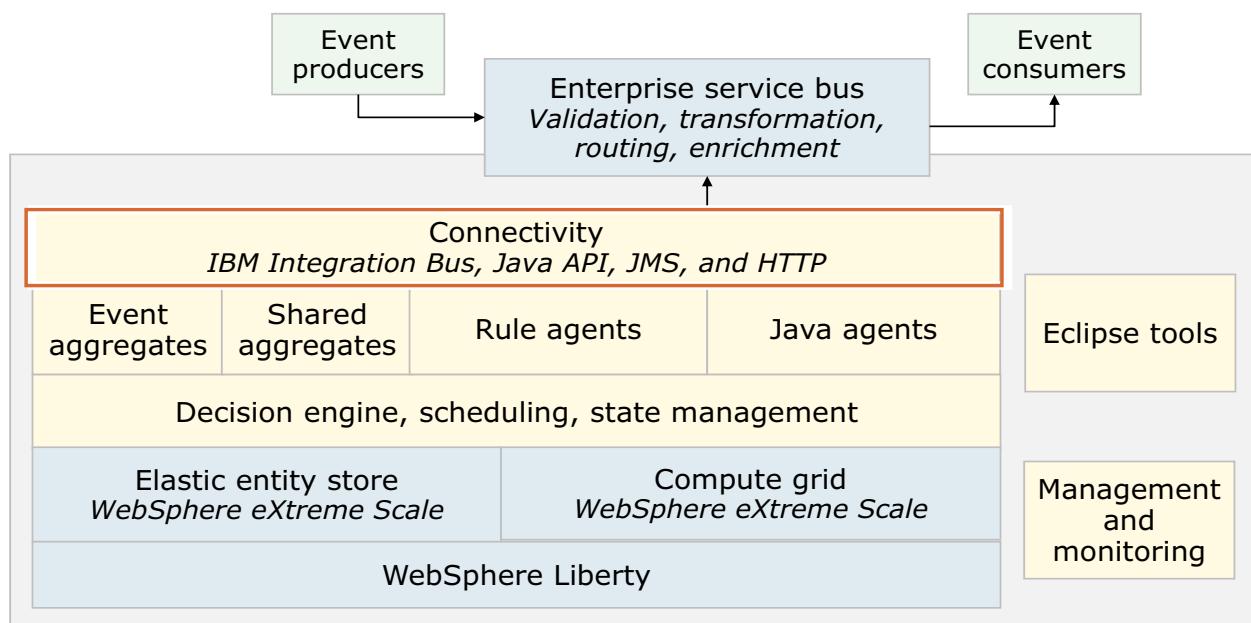
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*Figure 7-3. Event delivery*

# IBM Training



## High-level event delivery architecture



Modeling and defining connectivity

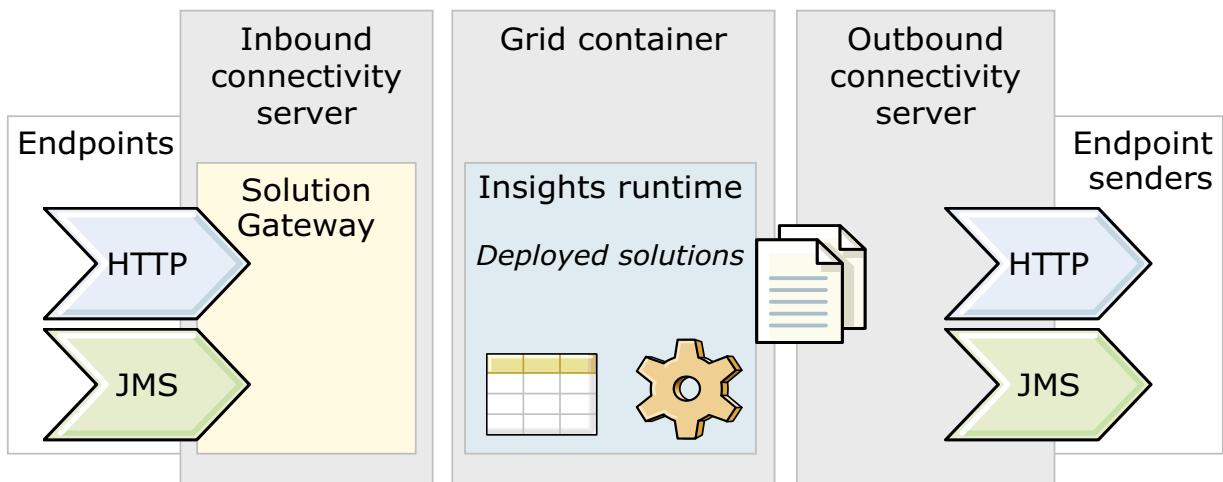
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Figure 7-4. High-level event delivery architecture

Recall that the Decision Server Insights architecture includes a connectivity tier on top of the runtime tier. Decision Server Insights interacts with the outside world through the connectivity layer.

Inbound connectivity acts as a bridge from external event producers to the runtime. Outbound connectivity is the mechanism by which events are delivered from a solution to the event consumers or action consumers.

## Connectivity architecture



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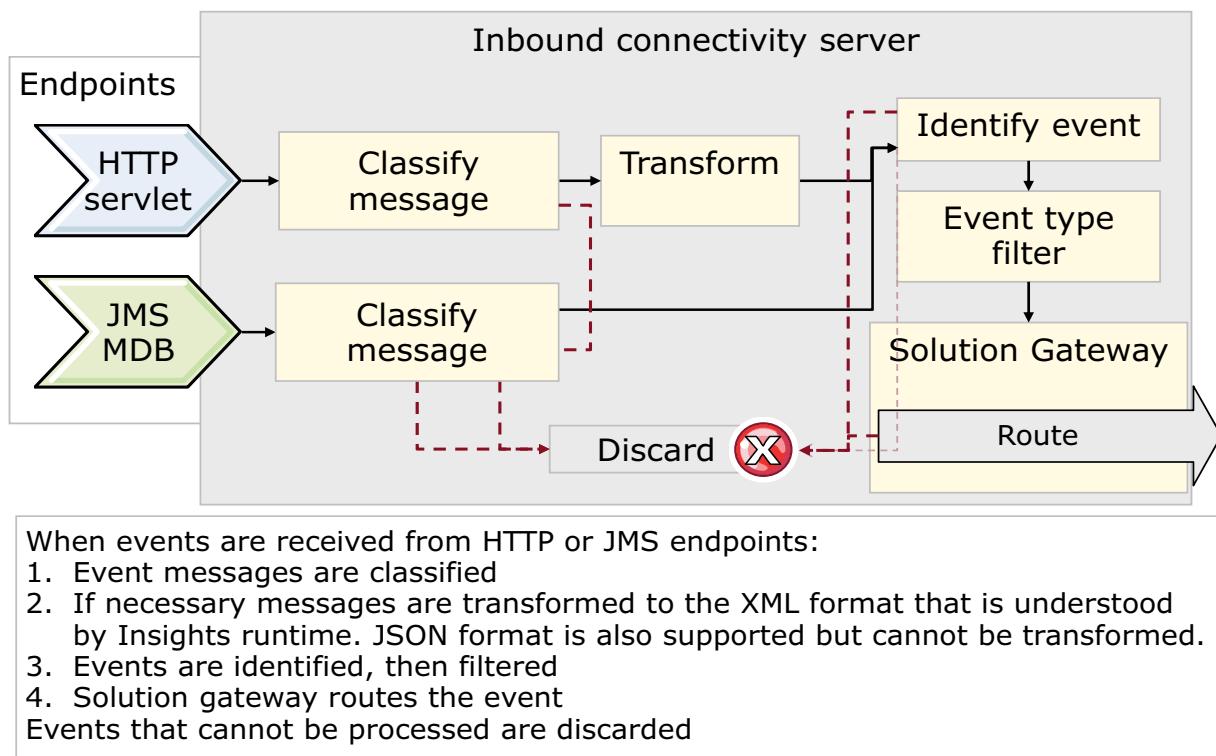
Figure 7-5. Connectivity architecture

Here, you see the structure for connectivity components.

The diagram on this slide shows an inbound server and an outbound server. You can have separate servers or you can combine them, like the sample server in Decision Server Insights (cisDev). During the labs, you used a test Java client to submit events and get the results. With the test client, no connectivity was required.

To get the events in and out of the Insights runtime, two transport types are supported: HTTP and JMS. Event producers in the outside world pass HTTP or JMS messages to Decision Server Insights. Inbound messages are received by the Solution Gateway and routed to the runtime.

## Connectivity architecture: Inbound



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*Figure 7-6. Connectivity architecture: Inbound*

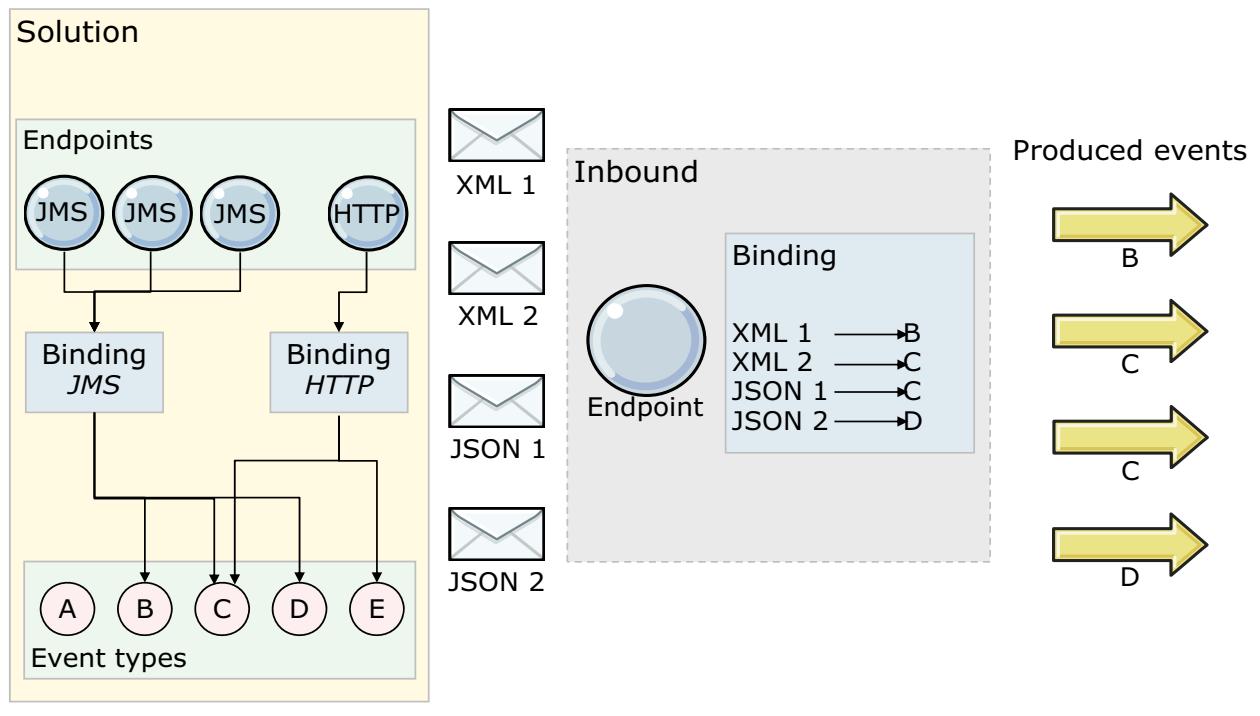
Inbound connectivity acts as a bridge from external messaging endpoints to the solution gateway.

Decision Server Insights uses inbound bindings for inbound JMS messages or XML messages over HTTP.

The inbound binding identifies the format and protocol of inbound messages, and must reference an inbound endpoint.

If an inbound message is not recognized by Decision Server Insights, the inbound binding can transform the message with an XSL transformation. Decision Server Insights classifies inbound messages by testing them against an XPath expression. If the message matches the XPath expression, the message is transformed into an event. If the message does not match the XPath expression, the message is matched against subsequent classifiers. If the message does not match any of the classifiers, a specified alternative action occurs, which can be either to discard the message, or to submit it to the runtime environment without transformation.

## Event delivery: Inbound connectivity



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Figure 7-7. Event delivery: Inbound connectivity

Bindings and endpoints define how the solution receives and sends events. Binding describes the type of transport to be used, either JMS or HTTP, the events that are processed, and how the events are represented in the message.

You associate an event with a binding. You can have multiple bindings with different events, or you can have a single binding with all the events, or you can have a combination.

You also associate endpoints with a binding. The endpoint represents the origin of the messages, either the JMS destination or the HTTP URLs.

This diagram shows four inbound endpoints and the bindings that they reference. You also see the inbound XML messages, which arrive over HTTP or JMS, and the events that those messages produce.

## Solution gateway for inbound connectivity

- The solution gateway is the entry point for events from external sources
- Access to the solution gateway
  - Directly through a Java API
  - Indirectly by modeling and deploying inbound connectivity as part of your solution
- The solution gateway establishes a connection between a solution and an object grid
  - Connections can be established between multiple solutions and a single object grid
- A gateway instance is used to submit events for processing, which involves placing them on an event queue

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Figure 7-8. Solution gateway for inbound connectivity

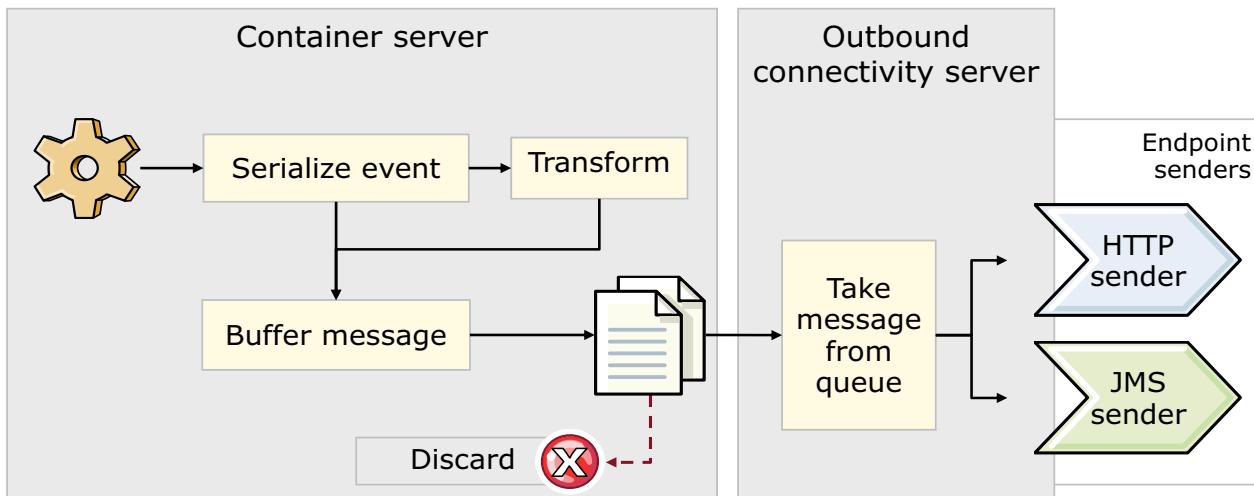
The solution gateway API is the mechanism through which inbound events are submitted to the Decision Server Insights runtime environment. The solution gateway is not used for delivering outbound event messages.

You can access the solution gateway either directly through a Java API, or indirectly by modeling and deploying inbound connectivity as part of your solution.

Each solution gateway instance represents a single, specified solution that is connected to the object grid. The solution gateway establishes a connection between a solution and an object grid. Connections can be established between multiple solutions and a single object grid.

A gateway instance is used to submit events for processing, which involves placing them on an event queue.

## Connectivity architecture: Outbound



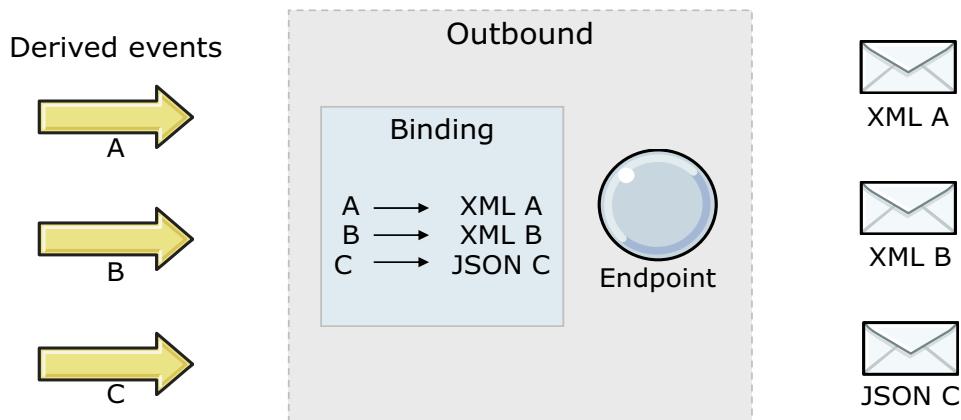
After the runtime processes events, and the result generates an outbound event:

1. Outbound events are serialized
2. Events may be transformed using XSLT but this is not recommended
3. Outbound event messages are buffered
4. Outbound connectivity server takes a buffered message from the queue and passes it to either the HTTP endpoint sender or the JMS endpoint sender
5. Events that cannot be delivered are discarded

Figure 7-9. Connectivity architecture: Outbound

Outbound connectivity is the mechanism by which events can be delivered from a solution to the outside world. Decision Server Insights uses outbound bindings for sending outbound events in the form of serialized JMS or HTTP messages. The outbound binding determines which outbound events are sent, and determines the message format and protocol to be used. The outbound binding must reference an outbound endpoint that represents the destination for outbound JMS or HTTP messages. The destination is either a JMS connection factory and destination, or an HTTP URL.

## Event delivery: Outbound connectivity



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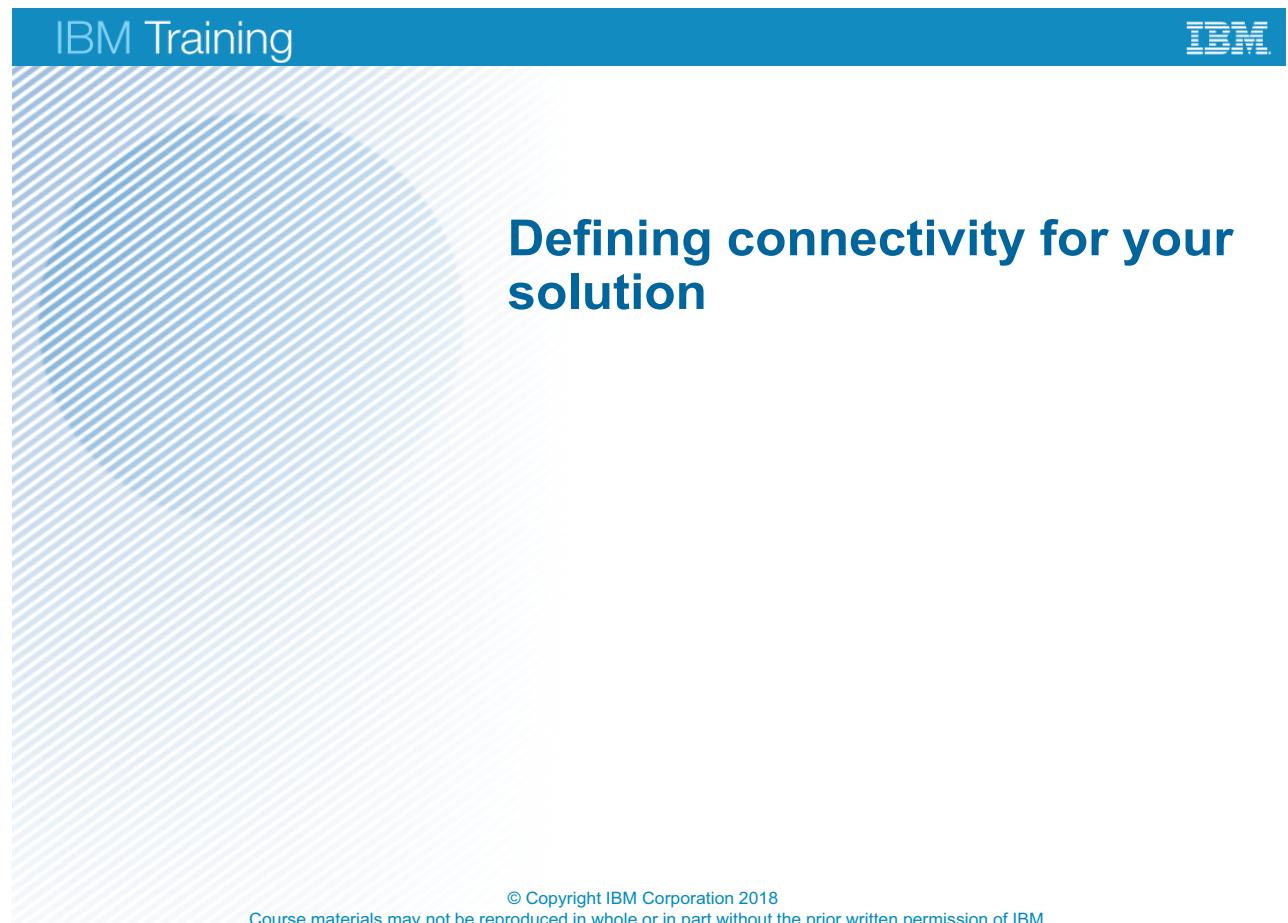
*Figure 7-10. Event delivery: Outbound connectivity*

Decision Server Insights does not have a programmatic equivalent of the solution gateway for outbound events.

Decision Server Insights uses outbound bindings for sending outbound events in the form of serialized JMS or HTTP messages. The outbound binding determines which outbound events are sent, and determines the message format and protocol to be used. The outbound binding must reference an outbound endpoint that represents the destination for outbound JMS or HTTP messages. The destination is either a JMS connection factory or a URL.

Here you see how Decision Server Insights serializes events into outbound messages that can be picked up and used by some external system.

## 7.2. Defining connectivity for your solution



*Figure 7-11. Defining connectivity for your solution*

## Defining connectivity in the solution project

- To define inbound or outbound connectivity, you create a `.cdef` file as part of the solution
  - The definition defines a binding with the type of transport to be used, either HTTP or JMS
  - The binding also defines events that will be processed
  - Endpoints are associated with a binding and define either the JMS destinations or HTTP URLs
- Steps:
  1. Define the connectivity for the solution
  2. Deploy the solution (which includes connectivity definitions)
  3. Deploy the connectivity configuration to the server

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*Figure 7-12. Defining connectivity in the solution project*

When you create a solution in Insight Designer, you are not required to use connectivity to test your solution. The solution can be deployed to the Insight runtime and tested by using the test Java client that implements the solution gateway API. When you are ready to use inbound or outbound connectivity, you create a connectivity definition file (`.cdef`) as part of the solution.

This connectivity definition file defines the binding with the type of transport to use either HTTP or JMS, and it also defines which events to process. Endpoints are associated with a binding and define either the JMS destinations or HTTP URLs.

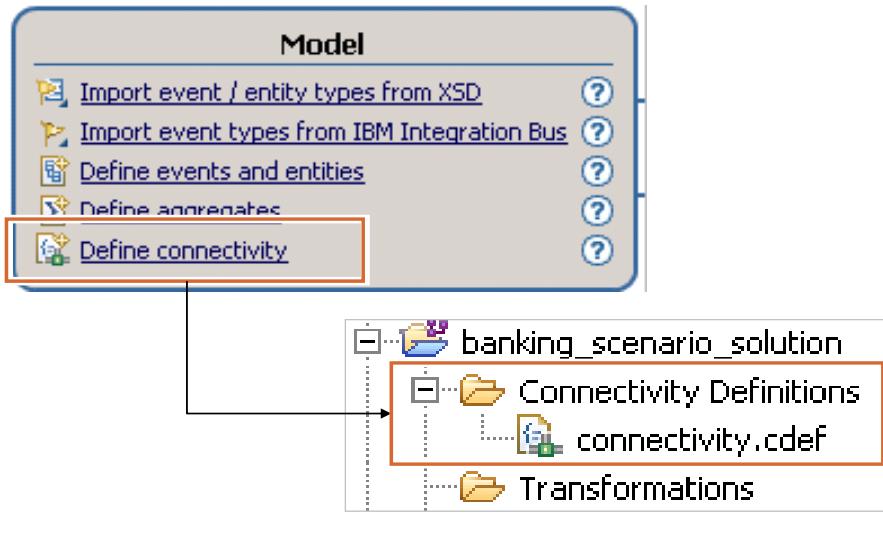
The connectivity definition file defines the solution connectivity as understood by the server, which is fixed; it cannot be changed. If you need to change it, it would need to be redeployed as a new version.

After you define connectivity for the solution, you deploy the solution to the runtime. You use the Export Solution Connectivity Server Configuration wizard to generate a connectivity configuration XML file.

To deploy the configuration, you use the `connectivityManager` command-line script. The script deploys the configuration file to the server. This configuration creates a Java Platform, Enterprise Edition application that runs on Liberty and contains the inbound endpoints. A configuration file is generated, and the `server.xml` file is updated to include this file. Client applications can then send and receive events to and from the Insights runtime.

## Define connectivity in your solution

- To define connectivity for your solution, you can use the link in the Solution Map
- A wizard opens to create the `.cdef` file in the **Connectivity Definitions** folder of your solution



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*Figure 7-13. Define connectivity in your solution*

To define connectivity, you can use the Solution Map link to open the wizard. The wizard automatically creates a `.cdef` file in the **Connectivity Definitions** folder of your solution.



## Export solution connectivity server configuration

```

1 // Connectivity definitions for the solution
2 define inbound binding 'JMSTransactionEventBinding'
3 with description "JMS Incoming transaction",
4 using message format application/xml ,
5 protocol JMS ,
6 classifying messages :
7 if matches "/event:Transaction"
8 where prefix "event" represents the namespace "http://www.ibm.com
9 transform using "transformation.xsl"
10 else discard message ,
11 accepting events :
12 - transaction .
13
14 define inbound JMS endpoint 'JMSTransactionEventEndPoint'
15 with description "JMS Incoming transaction endpoint",
16 using binding 'JMSTransactionEventBinding'.
17
18 define outbound binding 'JMSAuthorizationResponseOutputBinding'
19 with description "JMS Output authorization response",
20 using message format application/xml ,
21 protocol JMS ,
22 delivering events :
23 - authorization response .
24
25 define outbound JMS endpoint 'JMSAuthorizationResponseEndPoint'
26 with description "JMS Output authorization response end point",
27 using binding 'JMSAuthorizationResponseOutputBinding',
28 connection factory "tms/queue/JMSAuthorizationResponseEndpointConnection"

```

You can see the files that were created in the **Connectivity Definitions** folder

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Figure 7-14. Export solution connectivity server configuration

The connectivity definitions are created as part of the solution. You can put all your connectivity definitions in a single file, or use separate files for inbound and outbound connectivity definitions. The definitions are stored in .cdef files.

In the connectivity definition file, you define:

- Binding: Interface for events and their representation
- Endpoints: Logical representation of the endpoint for the environment, either:
  - JMS endpoints represent a logical JMS queue or topic
  - HTTP endpoints represent an HTTP URL

Bindings and endpoints to define how a solution receives inbound events and sends outbound event messages. A binding describes the event types that are sent or received, and how they are represented in a message.

These definitions include the following information:

- Binding name
- Message format, either `application/xml` or `text/xml` or `application/json`
- Protocol, either JMS or HTTP

- Inbound messages to be received over this binding
- Endpoint name
- Endpoint binding name
- URL path (for HTTP only)

In the example that you see here, two files are created, one for HTTP and one for JMS binding.

In this example also, the inbound and outbound definitions are combined into one file. If you have separate inbound and outbound servers, you might want to have the different configuration files on the different servers.

## Inbound binding and endpoint definitions

```

define inbound binding 'HTTPTransactionEventBinding'
 with description "HTTP Incoming Transaction" ,
 using
 message format application/xml ,
 protocol HTTP ,
 classifying messages :
 if matches "/event:Transaction"
 where prefix "event" represents the namespace "http://www.ibm.com/
 transform using "transformation.xsl"
 else discard message ,
 accepting events :
 - transaction .

define inbound HTTP endpoint 'HTTPTransactionEventEndPoint'
 with description "HTTP Incoming transaction endpoint",
 using binding 'HTTPTransactionEventBinding' ,
 url path "/connectivity/Transaction" .

```

Inbound HTTP

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*Figure 7-15. Inbound binding and endpoint definitions*

To create the definition, the editor prompts you for each piece of information that is required. While you type, you can press Ctrl+Space to be prompted.

You need to specify:

- The binding name
- The message format, either `application/xml` or `text/xml` or `application/json`
- The protocol, either JMS or HTTP,
- The inbound messages to be received over this binding
- The endpoint name
- The endpoint binding name
- The URL path for HTTP

If you define an HTTP inbound endpoint, you must provide the URL path on which this inbound endpoint receives messages. Make sure that the path contains at least two levels. The URL path is not required when you define a JMS inbound endpoint.

In this example, the inbound connectivity is bound to the “Transaction” event with the description: `HTTP Incoming Transaction`

The message format is `application/XML` and it uses the HTTP protocol. The URL for the inbound endpoint uses the path: `connectivity/Transaction`

## Outbound binding and endpoint definitions

```

define outbound binding 'HTTPTransactionOutput'
 with
 description "HTTP Transaction Output" ,
 using
 message format application/xml ,
 protocol HTTP ,
 delivering events :
 - authorization response .

define outbound HTTP endpoint 'HTTPTransactionOutputEndPoint'
 with
 description "HTTP Transaction Output endpoint" ,
 using
 binding 'HTTPTransactionOutput' ,
 url "http://localhost:9080/eventSender/response" .

```

Outbound HTTP

*Figure 7-16. Outbound binding and endpoint definitions*

This slide shows an example of an outbound binding and endpoint from a connectivity definition file.

The outbound binding definition requires:

- the binding name
- the description
- the message format, in this case, “application/xml”
- the protocol
- the event being delivered

The endpoint definition includes:

- the endpoint name
- and description
- the referenced binding
- and the destination, in this case, the destination is the URL pointing to the local host on port 9080, with the path “/eventSender/response”

## Providers for JMS

- The connectivity feature supports two JMS providers
  - WebSphere MQ
  - WebSphere Application Server
- Use the Connectivity Wizard to choose which type of provider to use
  - Wizard also prompts you for the required fields to complete the configuration
  - Note when using the WebSphere MQ Providers, the Connection Type can be only 'BINDINGS' if both Liberty and WebSphere MQ are running on the same machine
- When using WebSphere MQ, you need to set the path for the WebSphere MQ JMS Resource adapter
  - Example:

```
<variable name="wmqJmsClient.rar.location"
value="C:/wmq/wmq.jmsra.rar"/>
```
  - The server.xml file has commented-out sections that describe what needs to be enabled for the two JMS providers

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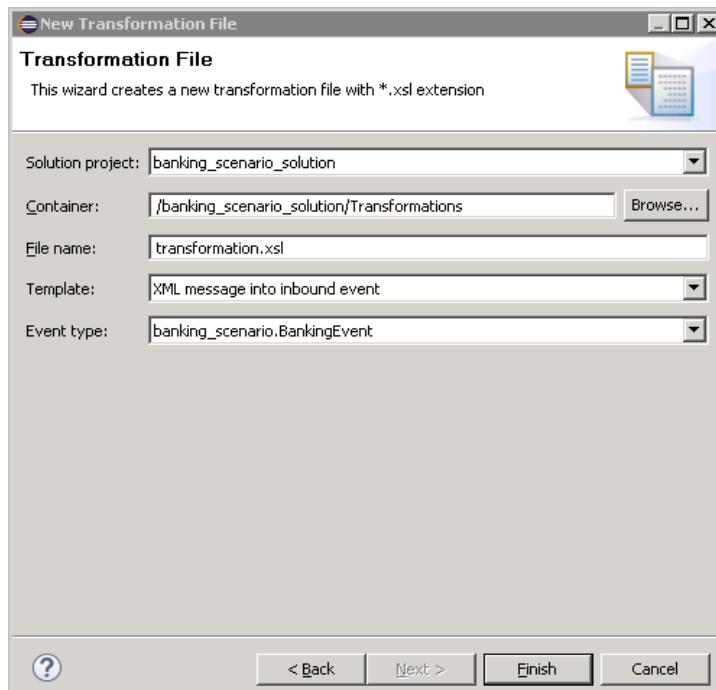
Figure 7-17. Providers for JMS

Insight Designer has a Connectivity wizard to generate connectivity configurations for WebSphere Application Server or WebSphere MQ. Other configurations can be completed by using the XML editor or the WDT server configuration editor.



## Transformations

- Use transformations to translate inbound and outbound XML messages
- Inbound XML translated into an XML message understood by Decision Server Insights
- Outbound event translated into XML file to be sent to the receiver



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*Figure 7-18. Transformations*

Transformations allow you to send an arbitrary XML message to the channel that can be translated into an XML message that Decision Server Insights can understand. You use XSLT to do that. Similarly, you can transform an outbound event into a different XML file to be sent to the receiver.

You can create the transformation file from the **File > New Transformation** file menu in the Decision Insight perspective. You complete the details in the dialog box and select whether you want to transform inbound or outbound events (a different file is required for each), and it generates a template file for you.

## Classifying inbound messages for transformation

- After the transformation is defined, the message must be classified so that a transformation can be selected
- The message is classified by using MessageContext, which you can use to make a choice of transformation based on XML or JMS headers
- Example:

```
define inbound binding 'binding1'
 using
 message format application/xml ,
 protocol JMS ,
 classifying messages :
 if matches "context:getJMSType() == 'PurchaseEvent'"
 transform using "transformPurchaseEvent.xsl"
 else discard message ,
 accepting events :
 - purchase event .
```

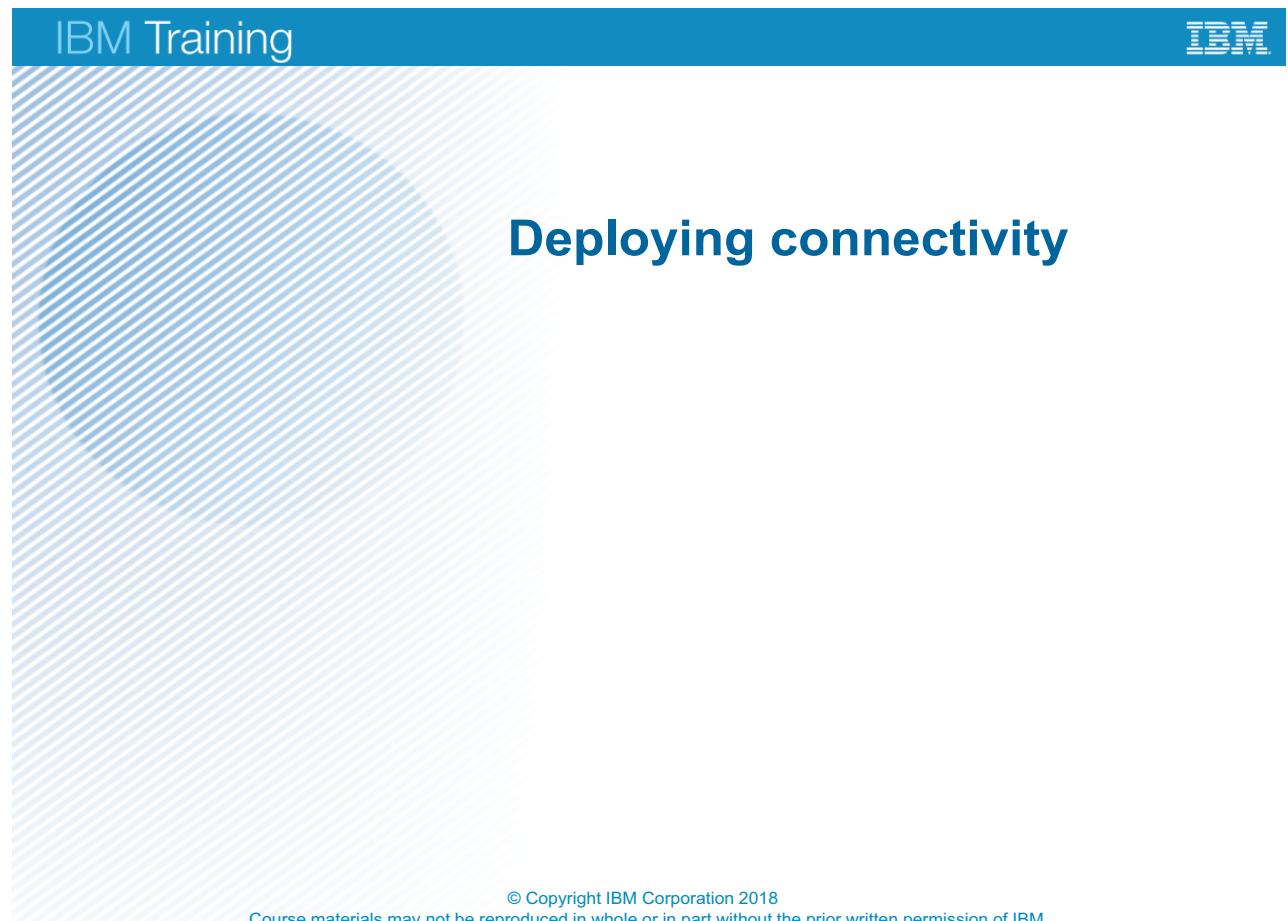
*Figure 7-19. Classifying inbound messages for transformation*

In order for transformations to take place, you need to classify the messages.

After the transformation is defined, the message must be classified as needing to be transformed. In the example here, you see that the binding includes the extra section: **classifying messages**

Transformations allow for more flexibility about how the XML gets into the system. The XML does not need to be in the correct format at the point it enters the system, which makes things easier from the client end.

## 7.3. Deploying connectivity



*Figure 7-20. Deploying connectivity*



## Steps for working with connectivity

Developers define inbound and outbound bindings and endpoints in the .cdef files as part of the solution

### Connectivity Definitions File (.cdef)

|                  |                   |
|------------------|-------------------|
| Inbound binding  | Outbound binding  |
| Inbound endpoint | Outbound endpoint |

Administrators can use an exported solution (.esa file) to manage connectivity deployment

1. Generate application EAR from deployed solution  
`connectivityManager generate application`
2. Generate solution connectivity configuration  
`connectivityManager generate config`
3. Edit the `-config.xml` file for each endpoint
4. Deploy the configuration  
`connectivityManager deploy`

Figure 7-21. Steps for working with connectivity

Developers define inbound and outbound bindings and endpoints for the solution in `.cdef` files. Those inbound and outbound connectivity files must be deployed as XML files to the inbound and outbound servers.

Developers can export a solution that contains the connectivity definitions and pass the exported `.esa` file to administrators. Administrators can deploy the solution, generate the application EAR and connectivity configuration, edit the configuration endpoints and deploy the connectivity configuration to the servers.

## Configuration and deployment

- Solution connectivity is configured as Liberty server configuration XML (`-config.xml`)
  - Identifies which endpoints the connectivity server should process
  - Maps the logical solution endpoints to the deployment environment
- Solution connectivity is deployed by using `connectivityManager`
  - Generates and deploys EAR for the requested inbound HTTP and JMS endpoints
  - Deploys solution connectivity configuration XML, which adds `include` to `server.xml`

*Figure 7-22. Configuration and deployment*

Solution connectivity is configured as a Liberty server configuration XML file. The connectivity configuration defines which endpoints the connectivity server should listen to. It also maps the logical solution endpoints to the deployment environment. For example, if you are using JMS inbound endpoints and HTTP for outbound endpoints, the configuration would include:

- JMS: Activation specifications for inbound JMS endpoints
- HTTP: Target URL, user ID, and password for outbound HTTP endpoints

When a solution has connectivity, inbound and outbound endpoints must be configured and deployed to the appropriate connectivity servers.

When you update a solution, you do not have to redeploy connectivity. You must redeploy connectivity only when the connectivity configuration for the solution changes.

## Creating a solution connectivity configuration

- Use `connectivityManager generate` command to generate a skeleton solution connectivity configuration file
  - Generates placeholder configuration for the endpoints that are specified in the command prompt
  - Complete the configuration by using an XML editor or WDT server configuration editor
  - Example:  
`connectivityManager generate config mysolution.esa  
mysolution-inbound-config.xml --inboundEndpoints="*"`
- Use the `validate` command to validate your endpoint configuration
  - Example:  
`connectivityManager validate mysolution.esa mysolution-inbound-config.xml`

Figure 7-23. Creating a solution connectivity configuration

After you generate the connectivity configurations for your endpoints, you can use the `validate` command to validate the endpoint XML.

## Editing the connectivity configuration

- Use a text editor to edit the configuration
  - Uncomment the sections that point to your application and define your endpoint
  - Map the security role

```
<?xml version="1.1" encoding="utf-8"?><server>
<!--Application definition for inbound connectivity application for solut

 <application location="connectivity_solution-inbound.ear">
 <application-bnd>
 <security-role name="iaEventSubmitter">
 <user name="admin"/>
 </security-role>
 </application-bnd>
 </application>

<!--Generated configuration for endpoint: connect1-->

 <ia_inboundHttpEndpoint endpoint="connectivity_solution/connect1" />
</server>
```

Map role to "admin"

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*Figure 7-24. Editing the connectivity configuration*

The configuration points to the application EAR file in the `<application>` entry, which you uncomment. You also map the iaEventSubmitter role. In the example that is shown here, the iaEventSubmitter role is mapped to the “admin” user.

At the end of the file, the inbound endpoint is defined for an HTTP endpoint.

## Deploying a connectivity configuration

- The connectivity configuration file must be deployed to the server or servers by using the `connectivityManager` script

- Use this command to deploy the configuration XML file to the server
  - Example:

```
connectivityManager deploy local C:/Solutions/solutionFeature
C:/Solutions/connectivity_config.xml
```

- Results of running this action at the server level

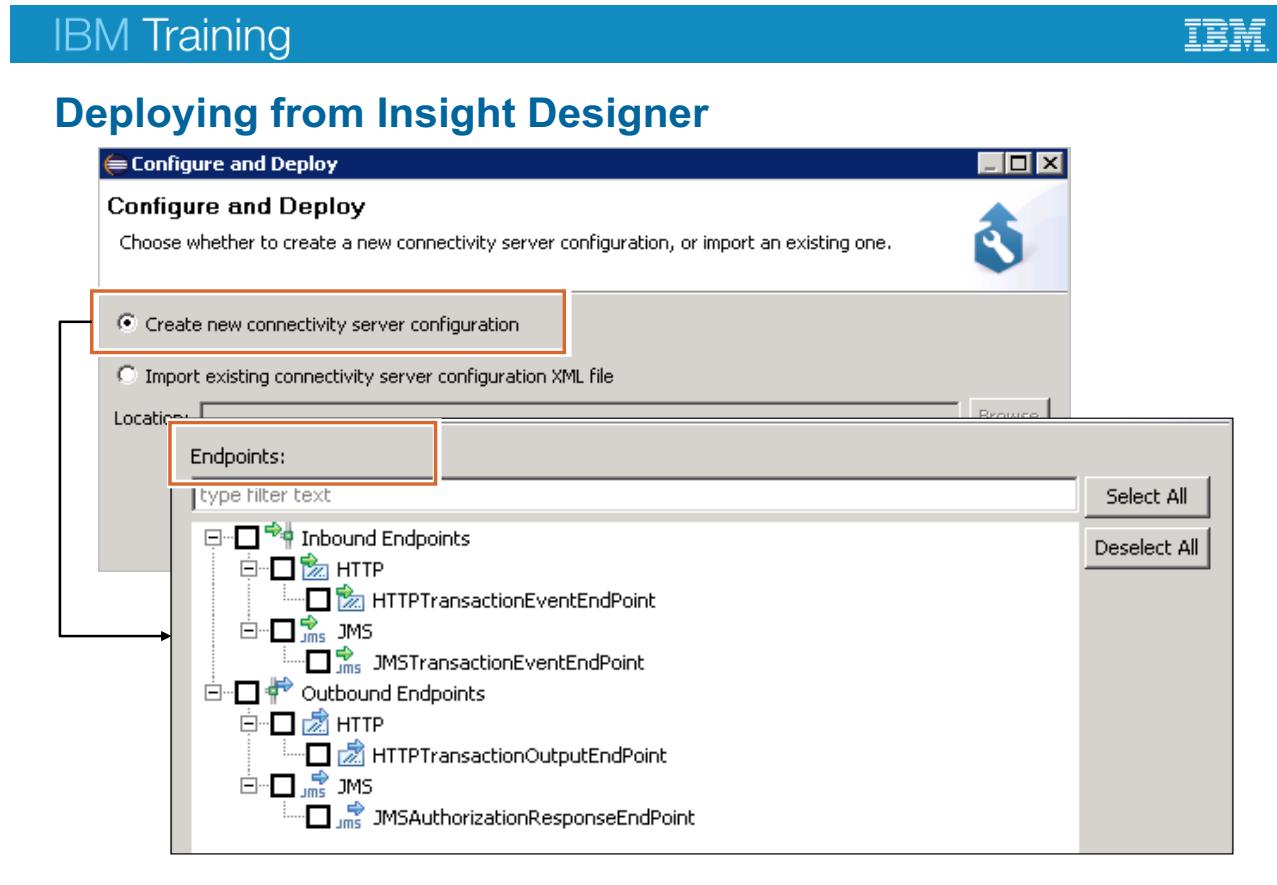
- A `<solution name>-inbound.ear` file is generated in the `apps` directory
  - A `<solution name>-config.xml` file is generated in the `root` directory of the server
  - The runtime server `server.xml` file in the root directory is updated to include the `config` file

*Figure 7-25. Deploying a connectivity configuration*

After you have your connectivity file, you use the `connectivityManager` command-line script to deploy it, which does the following tasks:

- It creates a Java Platform, Enterprise Edition application that runs on Liberty containing the inbound endpoints.
- A configuration file is generated with the connection details, and the `server.xml` file is modified to include this file.

After you restart your server, the connectivity is complete.



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*Figure 7-26. Deploying from Insight Designer*

When you deploy the solution from Insight Designer by using the Solution Map, the deployment wizard generates the **config.xml** file and application EAR file in the correct directories of the runtime server.

The wizard first prompts you to create a connectivity server configuration. You can also choose to include all or some of the endpoints that you defined in the configuration. When you finish in the wizard, the wizard deploys the solution and connectivity to the runtime server and activates the connectivity for the solution.

## 7.4. Troubleshooting connectivity issues

## Troubleshooting connectivity issues

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Figure 7-27. Troubleshooting connectivity issues

## Troubleshooting (1 of 2)

- Trace
  - The following entry in the `server.xml` file turns on trace for connectivity

```
<logging maxFiles="10"
traceSpecification="com.ibm.ia.connectivity*=fine*:*=info"
/>
```
- Specific “must gather” items for support
  - `Messages.log`
  - `Trace.log`
  - Any FFDC
  - `server.xml` file, and any connectivity configuration files that `server.xml` includes
  - The `.cdef` files from the solution
  - The solution, if the customer is willing to share it

Figure 7-28. Troubleshooting (1 of 2)

Here, you see some troubleshooting tips, including how to start the trace and which log files are relevant.

## Troubleshooting (2 of 2)

- Outbound Buffer Manager
  - Use the Outbound Buffer Manager to look at whether you have pending outbound events that cannot be sent for some reason
  - If required, you can also use the Outbound Buffer Manager to clear the events for an endpoint

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Figure 7-29. Troubleshooting (2 of 2)

Here, you see some troubleshooting tips about the Outbound Buffer Manager.

## Common issues and resources

If no messages are received at channel destinations:

- Check that the names in the configuration you are using are correct
- Check that the event that you submit to Insight Server on the inbound channel creates events that are to be sent through the outbound channels
- Use a test client to check that the events are being processed correctly by the server
  - Using a test client removes the channels from the path and determines whether events are being handled correctly

Figure 7-30. Common issues and resources

Some common issues that might cause events not to arrive might include incorrectly configuring the connection information, or the expected events are not generated by the Insights runtime because of the rule definitions.

To verify that the problem is in the connectivity, you can start by using a test client to send the event and get the results because the test client does not require connectivity. If the runtime handles the events properly, at least you know that your problem is with the connectivity.

## Unit summary

- Define inbound and outbound connectivity for a solution
- Configure and deploy connectivity

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*Figure 7-31. Unit summary*

## Checkpoint questions

1. Which protocols are supported in connectivity definitions for the solution? Select all that apply:
  - a. HTTP
  - b. SOAP
  - c. JMS
2. True or false: A solution can have many inbound connectivity definitions.
3. True or False: You can use the `connectivityManager` utility to generate and deploy connectivity configuration files for your solution.

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*Figure 7-32. Checkpoint questions*

Write your answers here:

- 1.
- 2.
- 3.

## Checkpoint answers

1. Which protocols are supported in connectivity definitions for the solution? Select all that apply:
  - a. HTTP
  - b. SOAP
  - c. JMS

**Answer: a (HTTP) and c (JMS)**

2. True or false: A solution can have many inbound connectivity definitions

**Answer: True**

3. True or False: You can use the `connectivityManager` utility to generate and deploy connectivity configuration files for your solution.

**Answer: True.**

Figure 7-33. Checkpoint answers

## Exercise: Defining connectivity

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*Figure 7-34. Exercise: Defining connectivity*

## Exercise introduction

- Configure inbound and outbound endpoints
- Generate and validate connectivity configurations



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*Figure 7-35. Exercise introduction*

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# Unit 8. Integrating Decision Server Insights

## Estimated time

01:00

## Overview

This unit explores the integration capabilities of Decision Server Insights.

## How you will check your progress

- Checkpoint

## Unit objectives

- Describe the integration capabilities of Decision Server Insights Explain the exchange event schemas between IBM Integration Bus and Decision Server Insights
- Consume IBM MQ or IBM Information Bus monitoring events

Figure 8-1. Unit objectives

## Topics

- Overview of integration requirements
- Submitting events from an Integration Bus message flow
- Consuming WebSphere Message Broker or IBM Integration Bus monitoring events within Decision Server Insights
- OSGi services

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*Figure 8-2. Topics*

## 8.1. Overview of integration requirements

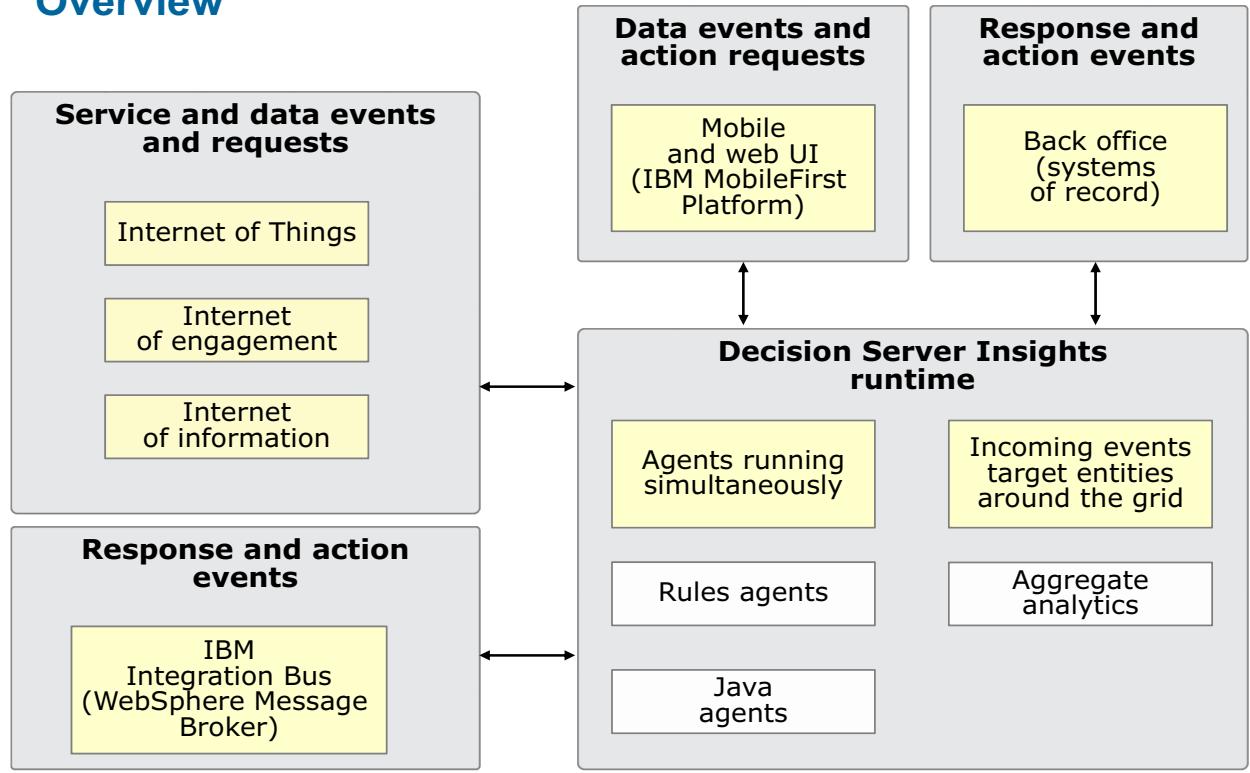
## Overview of integration requirements

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*Figure 8-3. Overview of integration requirements*



## Overview



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Figure 8-4. Overview

Here you see an overview of the interaction between Decision Server Insights and the (outside) world.

Decision Server Insight must be able to listen to anything and everything.

Event and request sources or producers can include the internet, the Internet of Things, mobile devices, and others. Action consumers can be those same event sources, or they can include systems of record, or other applications, or IBM BPM tools.

The events are brought to a Decision Server Insights runtime, where the data is. The runtime must maintain this wide-angle view of the primary entities, be aware of which events affect which entities, and be able to notify or alert systems about risks or opportunities that were detected. Data also must be replicated to permanent storage.

All this interaction must be handled at internet scale and with continuous availability in terms of hardware and software failure or updates and changes to solutions. As you can imagine, an insight solution that can meet the system requirements is a huge integration task.

## 8.2. Submitting events from an Integration Bus message flow

## Submitting events from an Integration Bus message flow

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Figure 8-5. Submitting events from an Integration Bus message flow

## Submitting events from an Integration Bus message flow

- You can emit events to your solution directly from a message flow by using the gateway API in a Java Compute Node
- You create a message flow that includes a Java Compute Node project, which has a class to submit the events
- You can use the same Java Compute Node class in multiple nodes where all nodes communicate with the same solution and grid

Figure 8-6. Submitting events from an Integration Bus message flow

To handle the millions of potential incoming event messages, the events can all be published to a bus or a message flow as a single point of entry.

To improve performance, you can bypass the Decision Server Insights connectivity tier and emit events directly to your solution from the message flow. You can create a message flow that includes the Java compute node in the project, which has a class to submit the events. Users can use an IBM Integration Bus message flow as a direct source of events without needing to go through the Insights connectivity layer, thus providing a performance enhancement for the user.

Event schemas must be exchanged between IBM Integration Bus and Decision Server Insights. A Java Compute node is added to an IBM Integration Bus message flow. The Java Compute Node class can be defined to submit the events directly to the Insights solution by using the solution gateway API.

You can use that same Java Compute node in multiple nodes where all the nodes need to communicate with the same solution and compute grid.

## Events model

- For events that are already defined in IBM Integration Bus, import the events into Decision Server Insights and use them in solutions
  - Remember: Annotations must be added to the events and their time stamps within the schemas in order for Insights to correctly import them
- For events that are already defined in Decision Server Insights:
  - Import the events by using IBM Integration Toolkit
  - Use them in message flows

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*Figure 8-7. Events model*

You can exchange event schemas between IBM Integration Bus and Decision Server Insights.

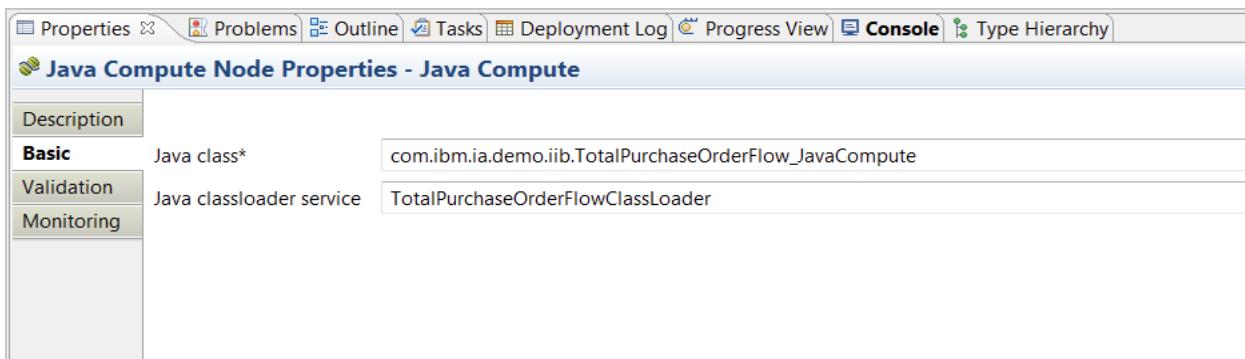
For events that are already defined in IBM Integration Bus, you import the events directly into Decision Server Insights and use in solutions. Remember that to import an XSD into Decision Server Insights, you need to add annotations to the events. By adding annotations, they can be recognized as events, and so the time stamps of those events can be imported correctly.

For events that are already defined in Decision Server Insights, you import the events by using IBM Integration Toolkit and use them in message flows.



## Java Compute Node

- After the Java Compute Node project and class are created, add the Java Compute Node to the appropriate position in the message flow
- In the Properties view, the previously defined Java class can be selected
- A name must be given for a class loader service, which is configured later during the process



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Figure 8-8. Java Compute Node

The information that is provided here is aimed at IBM Integration Bus developers. First, create the Java Compute Node Project and Class. Then, write the Java code to submit events to the Insights solution.

After the Java Compute Node Project and class are created, you add the Java Compute Node to the appropriate position in the message flow. In the Properties view, the previously defined Java class can be selected. A name must be given for a class loader service, which you also configure.

## Deploying IBM Integration Bus message flows

- Create and configure the Java class loader
- Deploying the application is then a case of dragging and dropping onto the target integration server

Figure 8-9. Deploying IBM Integration Bus message flows

After the Java class loader is created and configured, you can deploy the application.

## **8.3. Consuming WebSphere Message Broker or IBM Integration Bus monitoring events within Decision Server Insights**

## Consuming WebSphere Message Broker or IBM Integration Bus monitoring events within Decision Server Insights

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*Figure 8-10. Consuming WebSphere Message Broker or IBM Integration Bus monitoring events within Decision Server Insights*

## Consuming WebSphere Message Broker or IBM Integration Bus monitoring events within Decision Server Insights

- Insight Designer includes a wizard that allows the user to import IBM Integration Bus or WebSphere Message Broker monitoring events
  
- The wizard:
  - Directly imports each of the selected event types in the solution BOM project
  - Creates a transformation for each of the event types so that at runtime they can be transformed into a form that the Insights runtime can understand
  - Configures a JMS binding connectivity definition, containing all the necessary classifiers to process incoming events into the solution

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*Figure 8-11. Consuming WebSphere Message Broker or IBM Integration Bus monitoring events within Decision Server Insights*

IBM Integration Bus and WebSphere Message Broker can be configured to emit **monitoring** events that would be useful to Decision Server Insights users. However, the IBM Integration Bus events are structured in a complex manner and by default, cannot be understood in Insights, nor did they have schemas that can be imported into Decision Server Insights.

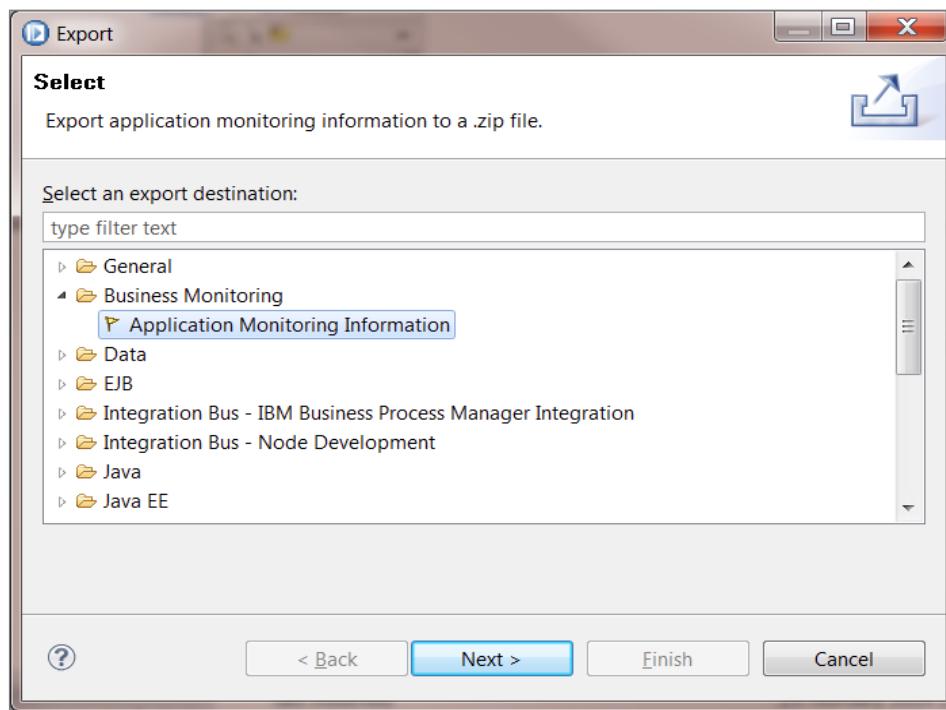
Decision Server Insights provides a wizard that you can use to directly import each of the selected event types into the solution BOM. You can create a transformation for each of the event types, so that at runtime, the events can be understood and transformed into the correct format.

The wizard also configures JMS binding connectivity definitions that contain all the necessary classifiers to process events that are incoming to the solution.

Trying to do these types of transformations manually can be time-consuming and tricky to get right, so this integration feature is a significant time-to-value add.

# IBM Training

## Step 1



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Figure 8-12. Step 1

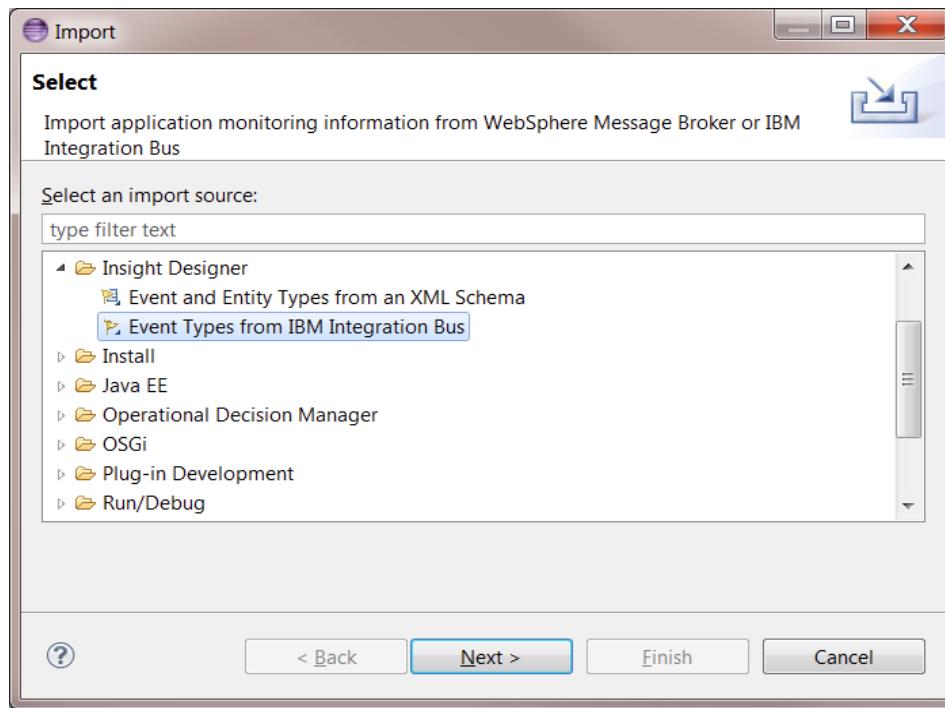
So, how would this work? The first step is to export the application monitoring information from the IBM Integration Bus or WebSphere Message Broker tools by using the provided wizard.

Through the wizard, you select the flows that you want to export monitoring information from, and it produces a `.zip` file.

- Configure the Monitoring events on the IBM Integration Bus or WebSphere Message Broker message flows
- Export the **Application Monitoring Information** from the IBM Integration Bus or WebSphere Message Broker tools

## IBM Training

### Step 2



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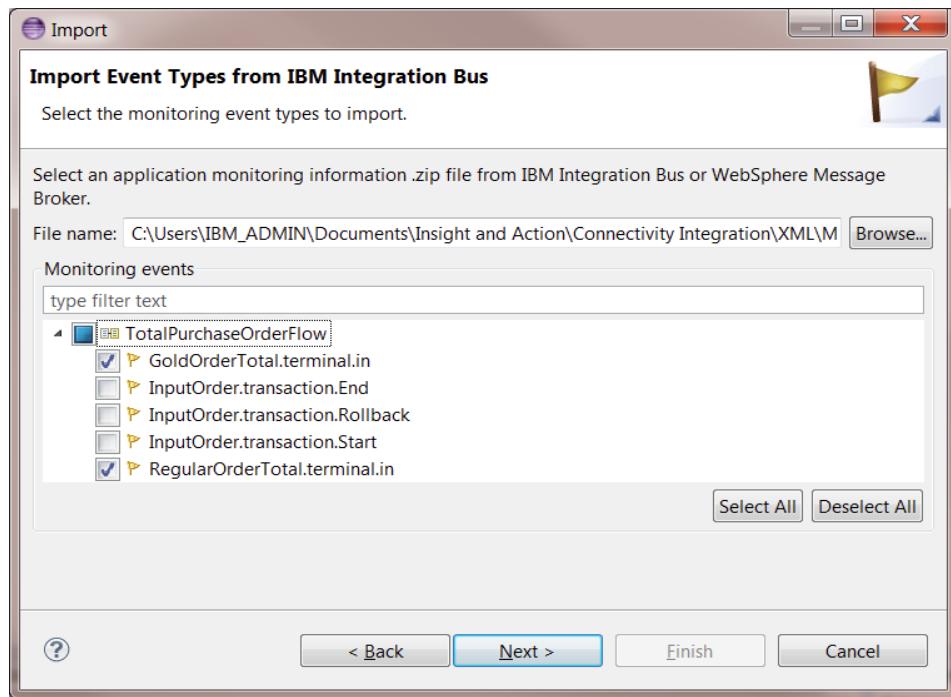
Figure 8-13. Step 2

The **.zip** file can then be imported into Decision Server Insights by using the wizard that is highlighted, called “Event Types from IBM Integration Bus”.

- To import the event types into a Decision Server Insights solution, use the “Import Event Types from IBM Integration Bus” wizard
- This wizard can be found on the **File > Import** menu, or by using the Solution Map

IBM Training 

## Step 3



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*Figure 8-14. Step 3*

The first step is to select the **.zip** file that you exported from IBM Integration Bus or WebSphere Message Broker. You can then import that compressed file into your Decision Server Insights solution.

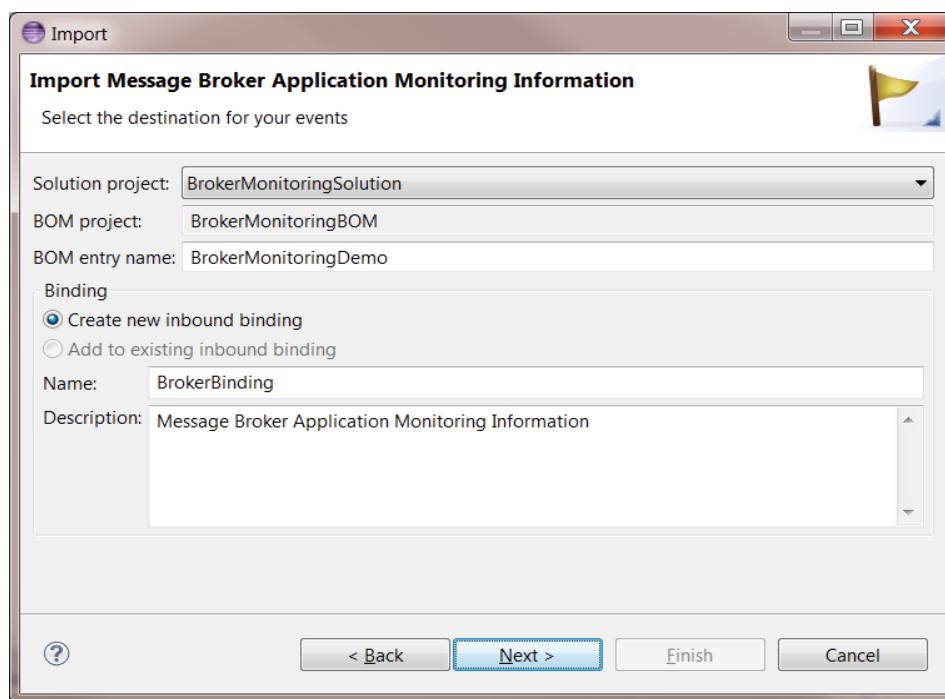
Importing the compressed file produces a list of monitoring events that are contained in that monitoring information file. You then select which events you want to import.

In the screen capture, you see that five monitoring events are listed, but only two are of interest and selected.

- Select the **Application Monitoring Information** file, which was exported from the IBM Integration Bus or WebSphere Message Broker tools
- The wizard then lists the events that it finds within the file so that the ones that should be imported can be selected



## Step 4



A number of elements can be specified:

- The solution, in which to import the event types
- The BOM entry name, where the event types should live
- A binding name for the JMS connectivity definition

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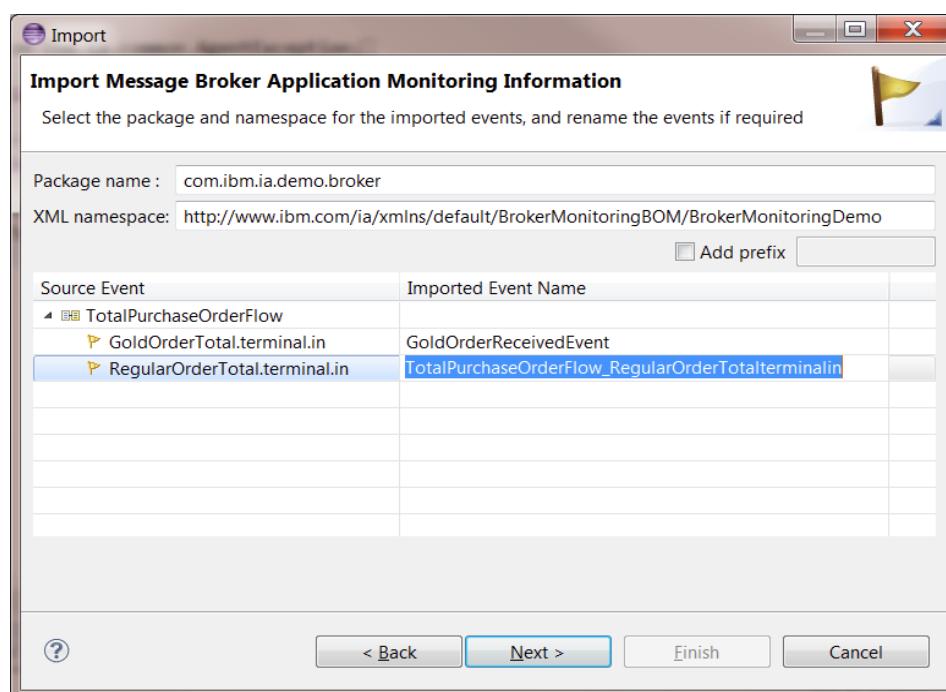
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Figure 8-15. Step 4

On the next page of the wizard, you see a number of elements that you specify. These elements include the solution into which you import the event types, the BOM entry name where the event types should live, and a binding name for the JMS connectivity definition. You can also select whether you want to create an inbound binding or add to an existing binding.



## Step 5



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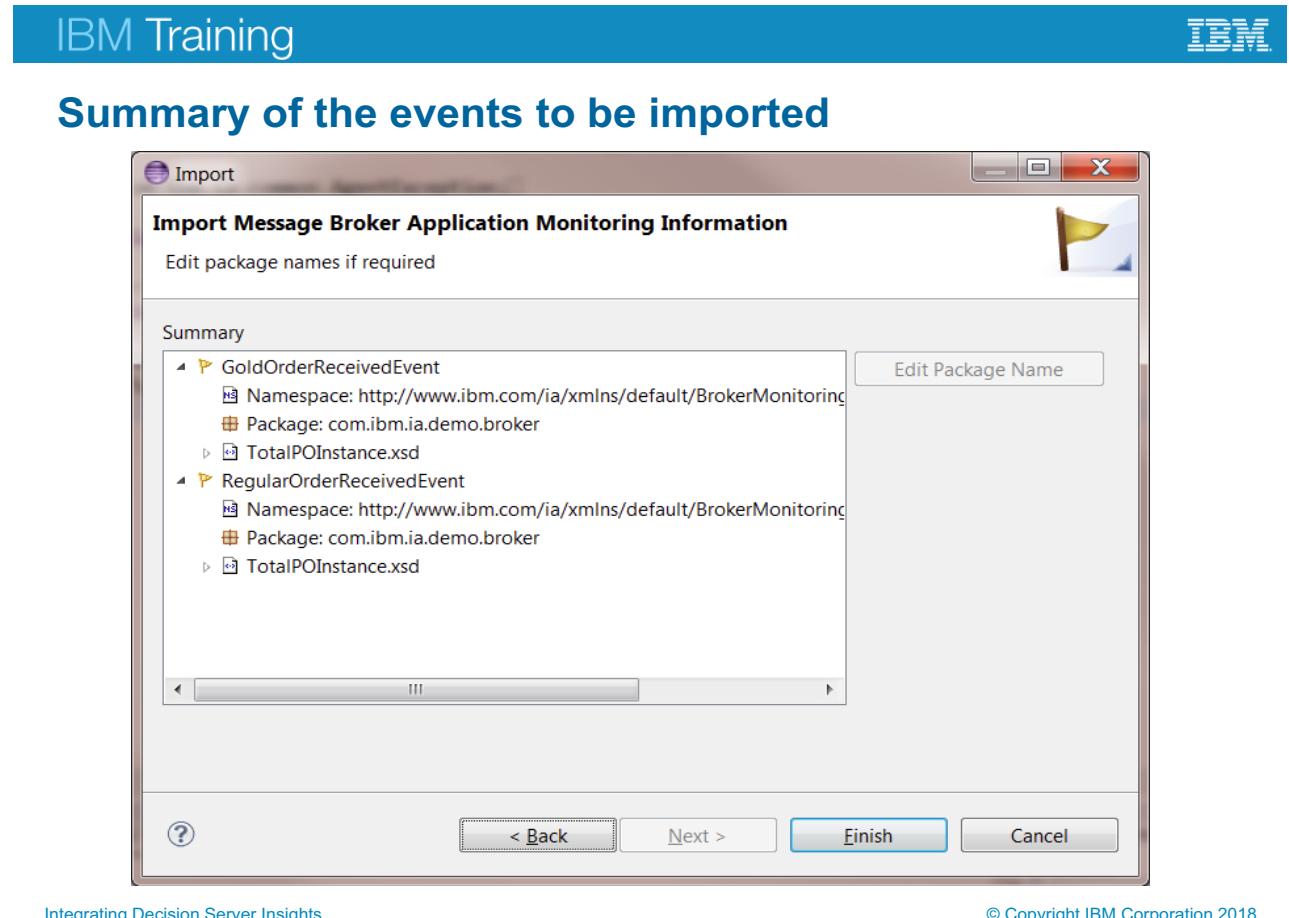
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*Figure 8-16. Step 5*

Define the package that these events should belong to.

You have an opportunity here to rename the monitoring events. You can use a name that has a more meaningful verbalization than the default name that comes from the IBM Integration Bus and WebSphere Message Broker tools.

- On the third page, you can specify the package for the events and the namespace for the transformed events



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Figure 8-17. Summary of the events to be imported

The final page of the wizard provides a summary of the events to be imported, the namespaces and packages, and it notifies you about any additional schemas that are being imported.

## The result

- On completion, a new BOM entry is added to the BOM project
- This new BOM entry contains the imported events
  - In this case, it also imported an additional schema that was required for the events
- A new connectivity definition (.cdef) file was added, defining a binding to classify the new events
- Two transformations were added to the Transformations folder of the solution
- The events are now ready for the user to use within agents, aggregates, and others
- All that remains for the user to do is to add a second connectivity definition for an inbound JMS endpoint that uses the generated binding
  - This connectivity definition can be in a separate connectivity definition file

Figure 8-18. The result

On completion, you have a new BOM entry that is added to the BOM project. The new BOM entry contains the imported events and any additional schemas that were required for those events.

You also have the connectivity definition, which defines the binding to classify the new events. The required transformations are added to the transformations folder of the solution, and events are ready for use within your agents or aggregates or other artifacts.

All that is left for you to do is to add another connectivity definition for an inbound JMS endpoint that uses the generated binding.

The endpoint needs to be configured to listen to the appropriate monitoring topic of the broker and that can be done by using the Export Connectivity Configuration wizard.

If monitoring event types change, you might need to update your Insights solution, and you can use the wizard again to reimport the monitoring definition. If the BOM name is the same as the first time you ran the wizard, all event types can be updated automatically.

## 8.4. OSGi services

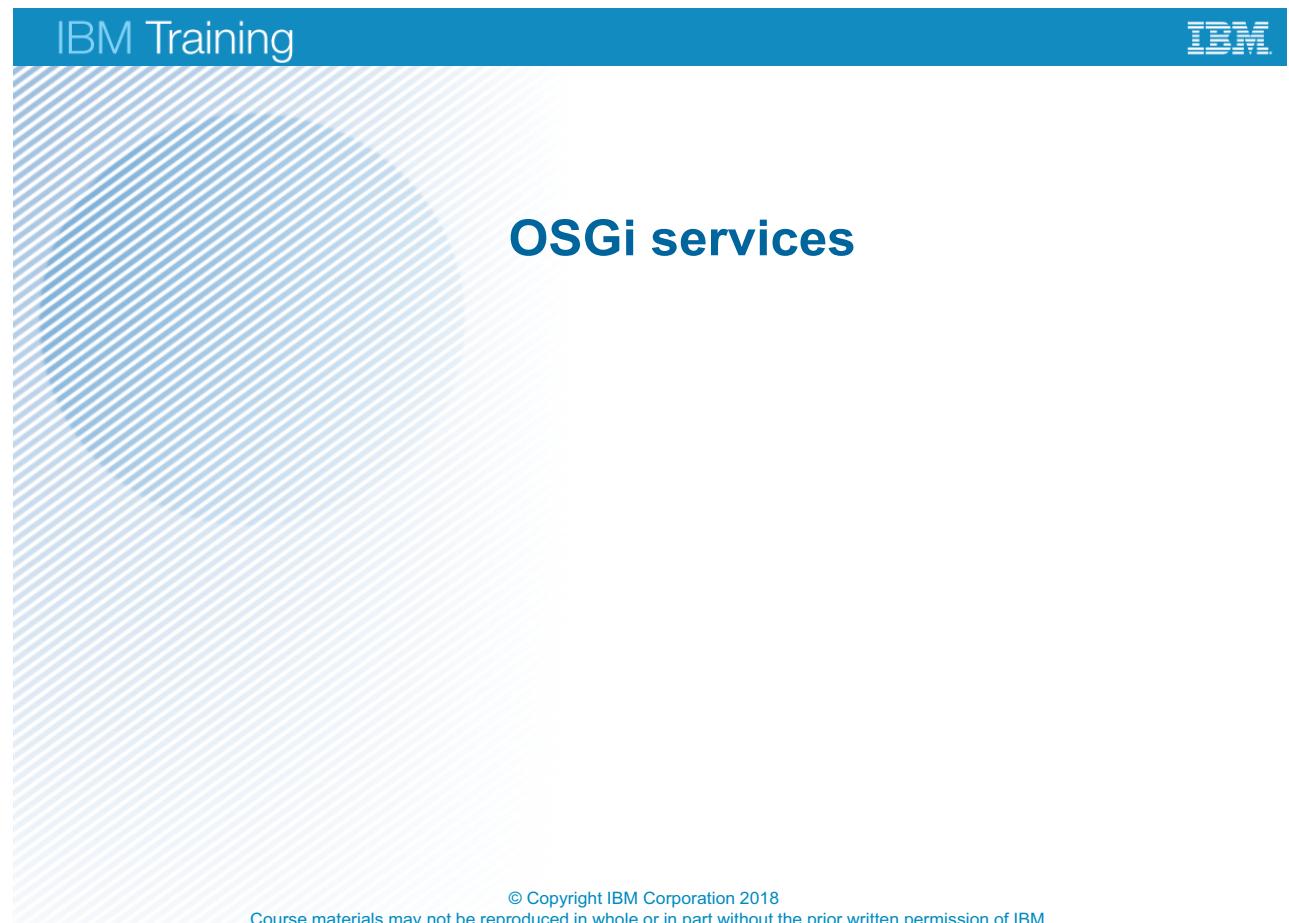


Figure 8-19. OSGi services

## OSGi Services

- An OSGi service is a service that is defined by a Java interface and packaged within an OSGi bundle
- A service can be called from a Java agent or a rule agent to provide access to external systems or advanced computation capabilities

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Figure 8-20. OSGi Services

An OSGi service is a service that is defined by a Java interface and packaged within an OSGi bundle.

A service can be called from a Java agent or a rule agent to provide access to external systems or advanced computation capabilities.

If you want to call an OSGi service from a Java agent or a rule agent, you must make the service available to Insight Server. You can either deploy the OSGi bundle that contains your service independently of the solution, or package the OSGi bundle inside the solution.

- To package the bundle in the solution archive, you add a reference in the solution project.
- To package an OSGi service inside a solution, you add a reference to the OSGi plug-in project in the solution project.

To access an OSGi service from the rules, you must create a business object model (BOM) that maps to the Java code of the service. First, you create a project to contain the BOM, and then you reference the project in the rule agent.

The OSGi service is represented by a verbalized BOM class that corresponds to the Java interface of the OSGi service. This BOM class must contain a custom property named OSGi.service. The value of this property is the fully qualified name of the Java interface.

The BOM class for the OSGi service must be created in a separate rule project because it cannot be hosted by the solution BOM project. This rule project must have a reference to the plug-in project that contains the Java interface. This plug-in project serves as the Java Execution Model (XOM).

To be accessible in the rules, a method of the service must have a corresponding method in the BOM. This corresponding method must be static, and have the same name and the same number of parameters. Each parameter must have a type that corresponds to the Java type of the parameter in the Java interface. The corresponding BOM type usually has the same name as the Java type.

## Unit summary

- Describe the integration capabilities of Decision Server Insights Explain the exchange event schemas between IBM Integration Bus and Decision Server Insights
- Consume IBM MQ or IBM Information Bus monitoring events

Figure 8-21. Unit summary

## Review questions

1. True or false: Decision Server Insights can receive events that are submitted from IBM Integration Bus message flow.
2. True or false: An IBM Integration Bus event type can be imported into a Decision Server Insights solution.

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*Figure 8-22. Review questions*

Write your answers here:

- 1.
- 2.
- 3.

## Review answers

1. True or false: Decision Server Insights can receive events that are submitted from IBM Integration Bus message flow.

**Answer: True**

2. True or false: An IBM Integration Bus event type can be imported into a Decision Server Insights solution.

**Answer: True**

Figure 8-23. Review answers

---

# Unit 9. Configuring Insight Server

## Estimated time

01:00

## Overview

This unit explains how to configure Decision Server Insights.

## How you will check your progress

- Checkpoint
- Exercises

## Unit objectives

- Describe WebSphere eXtreme Scale basics
- Describe the Decision Server Insights reference topology
- Design and configure a production topology

## Topics

- eXtreme Scale basics
- Topologies
- Sizing
- Configuring production topology

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*Figure 9-2. Topics*

## 9.1. WebSphere eXtreme Scale basics

## eXtreme Scale basics

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*Figure 9-3. WebSphere eXtreme Scale basics*

## What is IBM WebSphere eXtreme Scale

- eXtreme Scale is an elastic, scalable, in-memory data grid
  - Dynamically processes, partitions, replicates, and manages application data across hundreds of servers
  - Provides transactional integrity and transparent failover
- Principles of extreme scalability
  - Put data in memory
  - Partition the data to enable linear horizontal scale-out
  - Caching

Figure 9-4. What is IBM WebSphere eXtreme Scale

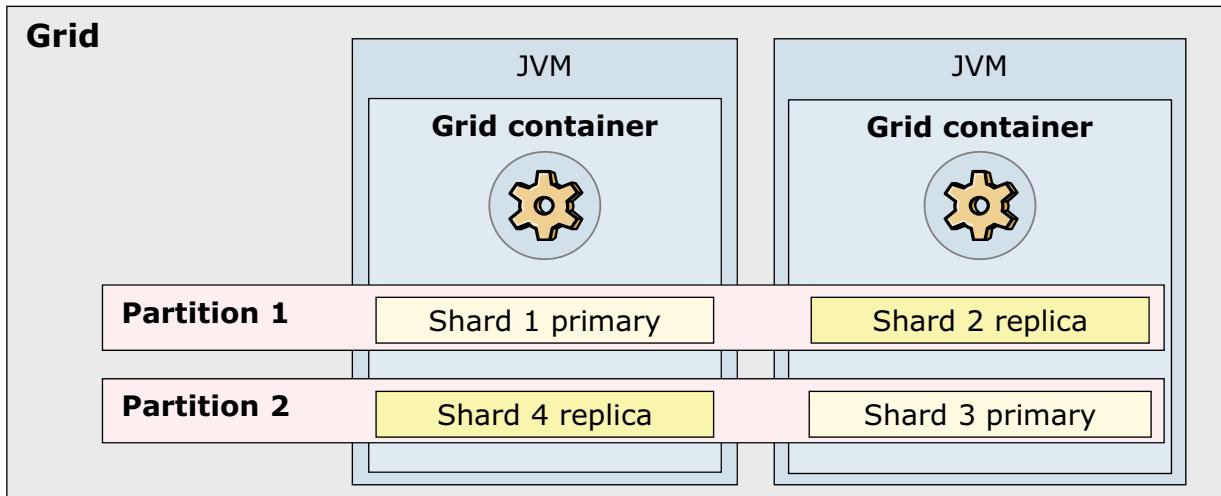
IBM WebSphere eXtreme Scale is an elastic, scalable, in-memory data grid. It dynamically processes, partitions, replicates, and manages application data across hundreds of servers. eXtreme Scale can perform massive volumes of transaction processing with high efficiency and linear scalability. It provides transactional integrity and transparent failover to ensure high availability, high reliability, and consistent response times.

The term elastic means the grid monitor and manages itself, and is self-healing by automatically recovering from failures. It allows *scale-out*, which means memory capacity can be added while the grid is running without a restart. And it allows *scale-in*, which is dynamic removal of memory capacity. This elastic capability means that the grid can automatically recover from failures.

The principles of extreme scalability include putting data in memory, partitioning the data to allow horizontal scale-out, and caching.

## Understanding a grid

- *Grids* divide the data into partitions
- Each *partition* holds an exclusive subset of the data
- Within the partition, the data is stored in *shards*
  - Primary shard contains the primary copy of the subset of data
  - Replica shards contain copies of the primary shard



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Figure 9-5. Understanding a grid

Grids, partitions, and shards are the major building blocks when you do capacity planning for WebSphere eXtreme Scale. Maps are important as a way for you to determine the size of the data that you store in the grid. You need to calculate the data that is stored in each map in your grid to arrive at a total size of data that you want to store.

- A *grid* divides the data set into partitions
- Each partition holds an exclusive subset of the data. The data can be partitioned based on the key and the data for a partition is stored at run time in a set of shards.
- A shard represents a partition that is placed on a *container*. Each partition has an instance that is a *primary shard* for the primary copy of the data. You can also configure a number of *replica* shards. The replica shards are either synchronous or asynchronous.

The relationship between the grid, partitions, and shards is illustrated on the slide.

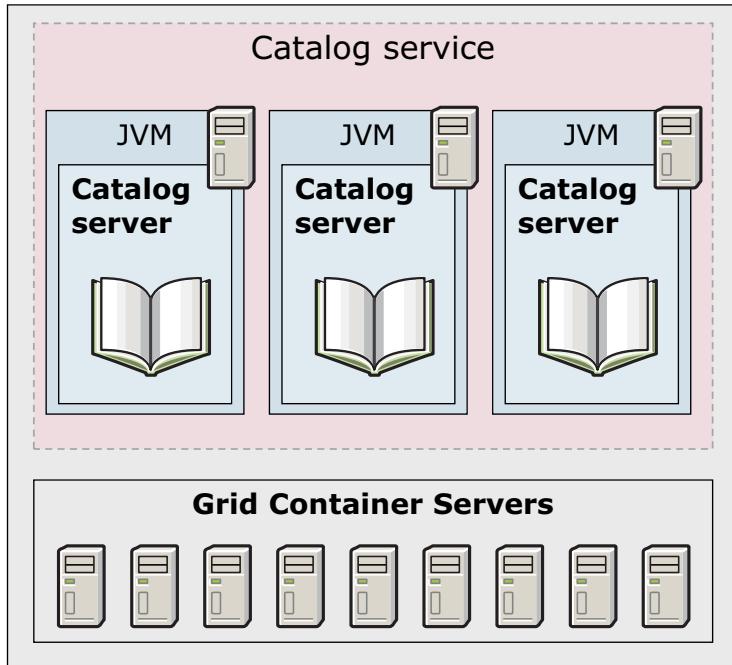
A *container server* physically holds the application data for the grid.

A grid has one or more partitions. Each partition is represented by a primary shard that is hosted on a container, and optionally one or more replica shards that are hosted on other containers.

Any number of containers can be run on a host (vertical scaling) and any number of hosts can run extra containers (horizontal scaling). A key feature of an eXtreme Scale grid is that more containers can be added dynamically on any server in the network.

## Catalog service

- Catalogs become central nervous system of the grid



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Figure 9-6. Catalog service

The *catalog service* parses the deployment policy and grid configuration files. It uses their definitions to control placement of shards across the available container servers in the grid. It also discovers and monitors the health of the containers, automatically balancing shard placement as necessary when a new container is added to the configuration, or if a container is stopped.

One or several catalog servers can run in your grid environment. However, only one is chosen automatically as the *master catalog*. The catalog service is designed to service hundreds or thousands of container servers.

WebSphere eXtreme Scale uses logical placement rules (implemented by the catalog server) to ensure that replica shards are held in containers that are running on different host machines than the primary shard. WebSphere eXtreme Scale determines the types and placement of replica shards by using a deployment policy, which specifies the minimum and maximum number of synchronous and asynchronous replicas.

## WebSphere eXtreme Scale terminology (1 of 3)

Term	Definition
<b>Map</b>	A cache that stores Java objects based on key-value pairs.
<b>Mapset</b>	A collection of logically related maps that can be partitioned and replicated over a number of servers.
<b>Grid</b>	A collection of mapsets that might span multiple Java virtual machines and that you can connect to and access data.
<b>Partition</b>	<p>Logical representation of a subset of the data in the mapset, plus any replicas that each subset might have.</p> <ul style="list-style-type: none"> <li>• The number of partitions (<math>n</math>) is a configurable attribute of a mapset</li> <li>• Partition numbering starts at 0</li> <li>• The mapset data is distributed across the <math>n</math> partitions</li> </ul>
<b>Replica</b>	<p>A copy of the primary data that is stored remotely about the primary and other replicas.</p> <ul style="list-style-type: none"> <li>• <i>Synchronous replica</i>: Updated transactionally when the primary is updated to ensure no data loss when the primary data is lost.</li> <li>• <i>Asynchronous replica</i>: Updated after the transaction is complete for faster transaction performance, but with increased risk of data loss in the face of failures.</li> </ul>

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Figure 9-7. WebSphere eXtreme Scale terminology (1 of 3)

On these slides, you see a list of eXtreme Scale terms that are relevant to Decision Server Insights.

## WebSphere eXtreme Scale terminology (2 of 3)

Term	Definition
<b>Shard</b>	<p>Provides the physical memory storage for the contents of a partition.</p> <ul style="list-style-type: none"> <li>• <i>Primary shard</i>: Contains the primary partition.</li> <li>• <i>Replica shards</i>: Backup of all the data in the primary shard.</li> </ul>
<b>Grid container</b>	<p>A container for the shards (all the cached data).</p>
<b>Container server</b>	<p>A Java virtual machine that runs WebSphere eXtreme Scale and hosts one or more grid containers. Decision Server Insights uses a WebSphere Application Server Liberty profile as its grid container servers.</p>
<b>Catalog server</b>	<p>Provides management of the entire grid. When there is more than one catalog server, one of them is the <i>master</i> or <i>primary</i> catalog server, and coordinates work among the servers to provide the catalog services.</p>
<b>Catalog service</b>	<ul style="list-style-type: none"> <li>• Keeps track of partitions and shards.</li> <li>• Redistributions shards when a container joins or leaves the grid.</li> <li>• Monitors the health of the grid.</li> <li>• Provides data location services to grid clients.</li> </ul>

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Figure 9-8. WebSphere eXtreme Scale terminology (2 of 3)

For Decision Server Insights, the preferred grid topology has only one grid container per grid container server. In addition, only one grid container server runs on each host machine. For this reason, this course uses the term *container* to refer to both the grid container (runtime) server and grid container, except in cases where appropriate differentiation is required.

## WebSphere eXtreme Scale terminology (3 of 3)

Term	Definition
<b>Catalog service domain</b>	The group of catalog servers, together with the group of container servers that they oversee.
<b>Quorum</b>	<p>An agreement between members of the catalog server group on what needs to be done for grid lifecycle operations.</p> <ul style="list-style-type: none"> <li>For example, when a network brownout occurs, communication between catalog servers might be lost, and more than one catalog server becomes the primary server; known as <i>split-brain syndrome</i>.</li> <li>If a split-brain syndrome occurs when quorum is enabled, grid work is suspended.</li> <li>Recovery from the loss of quorum typically requires manual intervention.</li> </ul>
<b>Majority quorum</b>	Ensures that quorum is achieved and grid work can be performed while more than half of the catalog service members are active and aware of each other.
<b>Catalog server cluster endpoints</b>	Configured for container servers to establish a communications link with the catalog servers. These endpoints become part of the catalog service domain (which means they are part of the grid).

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Figure 9-9. WebSphere eXtreme Scale terminology (3 of 3)

## 9.2. Topologies

# Topologies

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*Figure 9-10. Topologies*

## Designing a topology

- Consider:
  - How many servers of each type you require, and allocate unique names to them
  - Whether to configure persistence for your grid data
- Inbound and outbound connectivity servers
  - Use one of each?
  - HTTP or JMS?
- Catalog service
  - High availability requires 2 catalog servers
  - Use 3 catalogs configured with majority quorum if you run catalogs on the same machines as the containers.
- Container servers
  - High availability requires a minimum of 2 servers
  - How many solutions must run in the grid?
  - What is the volume of events that must be processed?
  - How many partitions must be allotted for the primary data and replicas?

*Figure 9-11. Designing a topology*

When designing your topology, consider the questions that are listed here.

## Reference topology goals

- The grid must be highly and continuously available in a normal operation mode
  - Must withstand the loss of one container server without any loss of data and without loss of access to data
  - Must tolerate the controlled shutdown of one container at a time for the purpose of applying "rolling updates" or for any other maintenance activity
  - Should accept and use new containers (within a limit that is determined by the configured number of partitions and replicas)
- Catalog service should be highly available
- Grid data must be recoverable in case of disaster or in case of a controlled shutdown of the grid
- The system should tolerate the failure of at least one inbound and one outbound connectivity server
- Event throughput should not suffer significantly as a result of the previous requirements

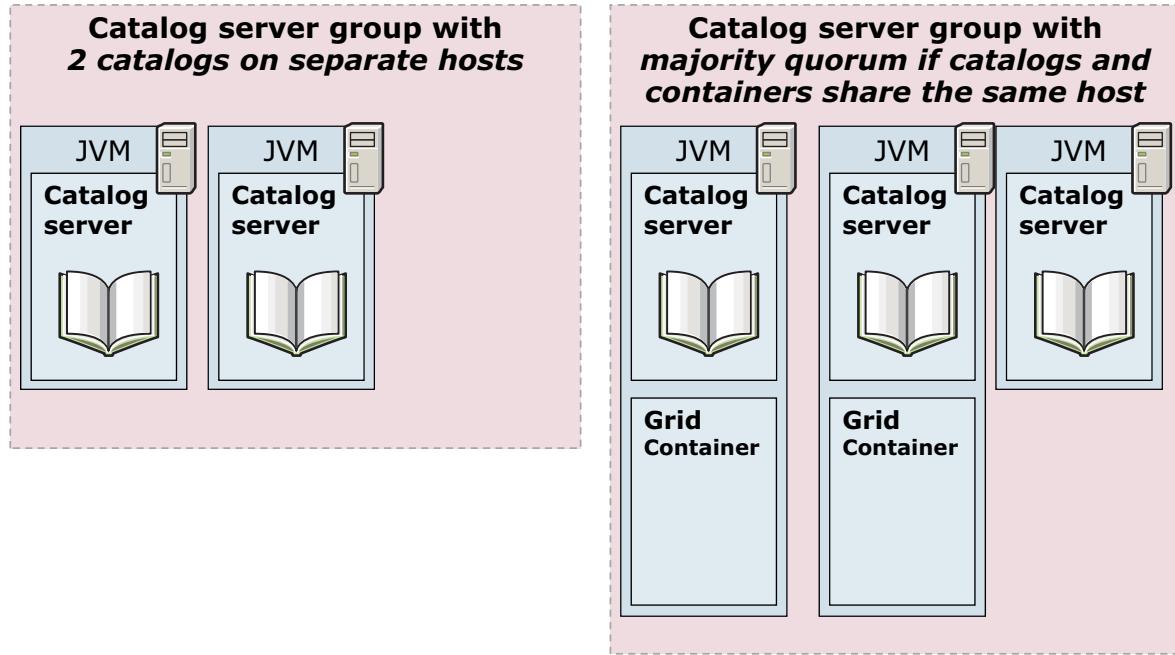
Figure 9-12. Reference topology goals

To meet the goals of high and continuous availability, the grid must be able to support loss of a container without losing data or access to data.

Grid data must be recoverable if you have a disaster where more than two containers are lost, such as during a power outage. If you need a controlled shutdown of the grid, such as when you increase the number of partitions, the data must be recoverable.

## Catalog service

- For high availability: 2 catalogs minimum
  - 3 with majority quorum if catalogs are not run on separate hosts.



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Figure 9-13. Catalog service

The catalog service provides intelligent management of the grid. It keeps track of partitions and shards, redistributes shards when a container joins or leaves the grid, monitors the health of the grid, and provides data location services to grid clients.

One or more catalog servers coordinate to provide the catalog services. When you use more than one catalog server, one is designated primary and has special responsibilities. The group of catalog servers, along with the group of container servers that are overseen, make up a catalog service domain.

Members of the catalog server group must agree on which actions are required for grid lifecycle operations. This agreement is called *quorum*. To illustrate, when a network brownout occurs, communication between catalog servers might be lost, resulting in more than one catalog server becoming the primary server. This situation is known as split-brain syndrome. If quorum is enabled, grid work would be suspended. Recovery from the loss of quorum would typically require manual intervention. However, WebSphere eXtreme Scale uses majority quorum. So as long as more than half of the members in a catalog service group remain active and aware of each other, quorum is achieved and grid work can continue. This is one good reason to use an odd number of catalog servers instead of an even number (for example, 3 instead of 2).

Containers use *catalog server cluster endpoints* to establish a communications link with the catalog servers. These cluster endpoints are included in the container server configuration, which makes the container servers part of the catalog service domain, meaning they become part of the grid.

For more information, see Catalog server quorums in the WebSphere eXtreme Scale V8.6 documentation.

## Containers and partitions (1 of 2)

- For high availability, use a minimum of 2 container servers
  - Use 4 container servers
    - to reduce the impact of a container loss on event throughput (only 25% of CPU capacity lost)
    - to better balance load between servers (with 2 containers, all primary shards can be on the same server).
- Each container should run on a single host
- Each host should have a minimum of two cores

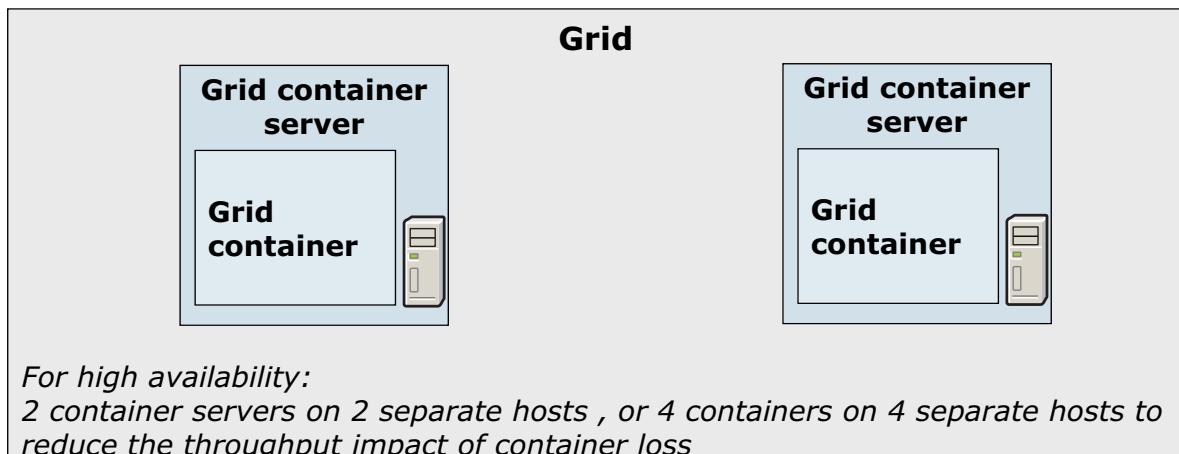


Figure 9-14. Containers and partitions (1 of 2)

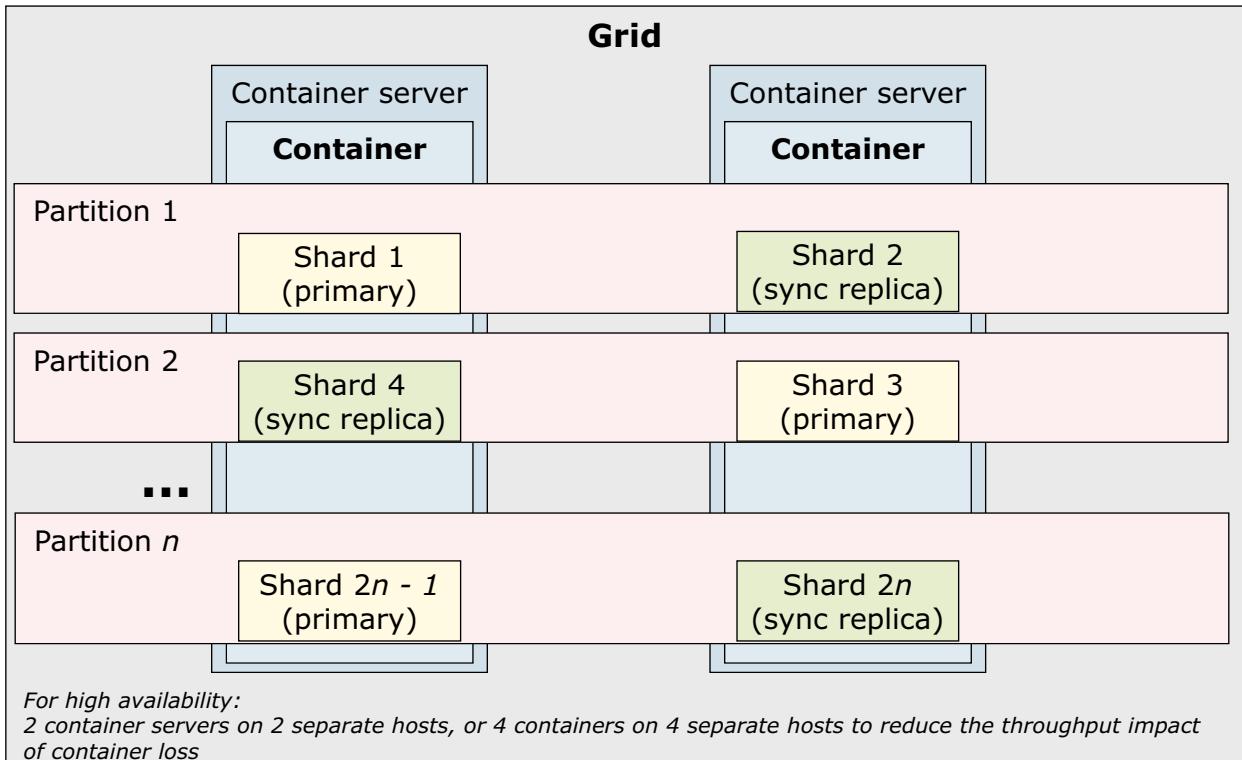
The number of required container servers depends on the number and type of solutions that are running on the grid and the volume of events that they process. This number can grow or shrink.

From the topology goals, you can infer that, in addition to the primary data, you should have a synchronous replica and an asynchronous replica. If the primary data is lost, the synchronous replica immediately becomes the primary, and the asynchronous replica becomes synchronous. This configuration meets high availability goals and ensures that maintenance can be performed on one container at a time. A suggested practice is to use four containers that run on four separate hosts, regardless of throughput.

The maximum number of containers that you can dynamically add to the grid is constrained by the number of partitions and the number of replicas that you configure for each partition. The number of partitions is configured when you set up the grid and can be changed only when the grid is down. You do not need more container servers than the maximum number that can be used to allocate partitions.

Having many partitions can facilitate growth and better balancing of memory resources, but also means more threads, increased use of grid communication resources, and greater level of balancing work. When you have many partitions but few containers, adding or removing containers involves a significant amount of grid reconfiguration work.

## Containers and partitions (2 of 2)



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Figure 9-15. Containers and partitions (2 of 2)

The minimum suggested number of cores is two per server to enable faster start, stop, and management of external operating system (OS) requests without interrupting the workload.

Because the suggested practice is to use one container server per machine, you can determine the number of partitions to use with this equation:  $C \times M \times 2$

Where:

- C is the maximum number of containers that you expect to have
- M is the number of cores of the container host

This equation assumes that you have an equal number of cores in each container host machine.

Certain eXtreme Scale operations are more efficient if the number of partitions is a prime number, so a good practice is to round the number of partitions up to the next prime number.

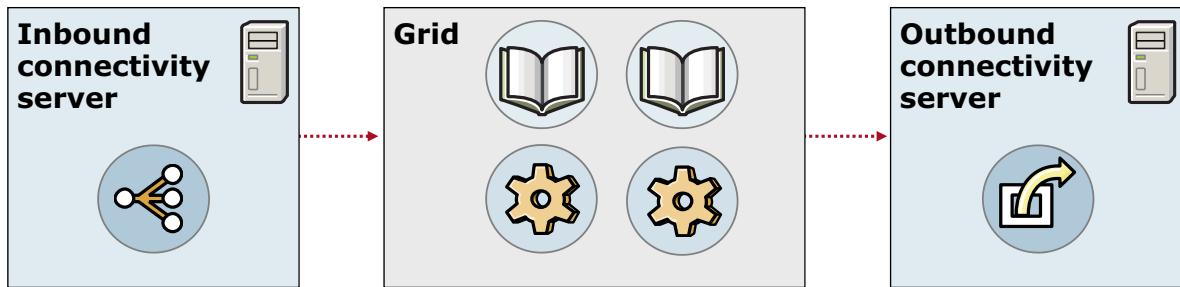
Example:

- Assume that you have a maximum of 6 container server hosts (C = 6), each with 4 cores (M = 4).
- Number of partitions =  $C \times M \times 2 = 6 \times 4 \times 2 = 48$
- Round the result up to the next prime number: 53

The default product configuration for the number of partitions is 127.

## Inbound and outbound connectivity

- Minimum configuration:
  - One inbound server
  - One outbound server
  - Can run on the same host as a catalog server.



- For high availability, use two nodes each for inbound and outbound connectivity
  - You can reduce to two nodes, each with an inbound and outbound connectivity server
  - To scale vertically, add more servers to the same host
  - To scale horizontally, add more hosts

*Figure 9-16. Inbound and outbound connectivity*

Connectivity servers manage event flow to and from the system. Redundancy is required to avoid a single point of failure.

Inbound and outbound connectivity servers are responsible for the event flow in and out of the system, so there should be some redundancy for these servers. A good starting point is to use one of each on two different machines, which is the minimum requirement to avoid a single point of failure.

No rule exists for determining the actual number of inbound or outbound servers that are required for a particular event throughput. The number of inbound and outbound servers varies according to several parameters, including:

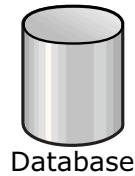
- Size of the event data
- Type of event transformations that might be performed
- Whether event persistence is used for Messaging Service (JMS)
- Type of protocol used (for example, HTTP or JMS)

For best results, start with the two servers and monitor resource usage (for example, CPU and memory).

For high-event rates, you can add inbound and outbound connectivity servers to the same machine until the machine's ideal resource consumption threshold is reached. After the threshold is reached, you can add new machines if required.

## Data persistence

- In a single site topology, persist grid data to a database
  - Enable recovery from a disaster
  - Enable any rare maintenance activities that require the grid to be shut down
  - Enable data offloading.
- Synchronous mode (write-through)
  - Performance penalty
  - Ensures no data loss
- Asynchronous mode (write-behind)
  - Performs database updates in batches
  - Risk of some data loss
- Reference topology uses synchronous persistence



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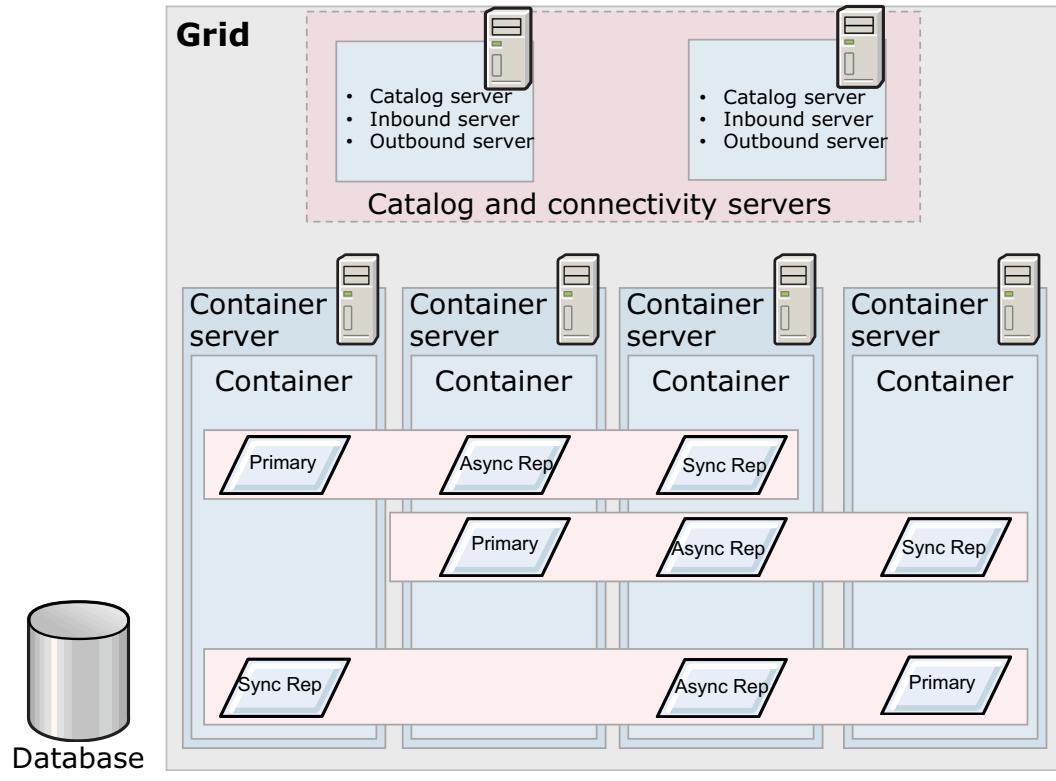
*Figure 9-17. Data persistence*

Decision Server Insights operates on an in-memory data grid. However, persistence of grid data is required to enable disaster recovery or maintenance shutdown of the grid.

You can choose between synchronous (write-through) or asynchronous (write-behind) database persistence modes. Synchronous persistence is included in DSI transactions, but includes a performance penalty. Asynchronous persistence performs the database updates in batches and carries a small performance penalty. The frequency of database updates might vary depending on the level of accepted risk. It is set in terms of a time interval and the number of batched updates that use a parameter that is called `writeBehind`. For example, if you set the `writeBehind` value to `T20;C200` then a write to the database happens every 20 seconds or every time the number of pending updates reaches 200, whichever condition happens first.

WebSphere eXtreme Scale can queue the database updates, allowing for some database downtime, but ideally the database should be highly available (for example, by using DB2 high availability disaster recovery). For high event loads, consider using a highly scalable database to ensure that the database does not become a bottleneck.

## Decision Server Insights reference topology



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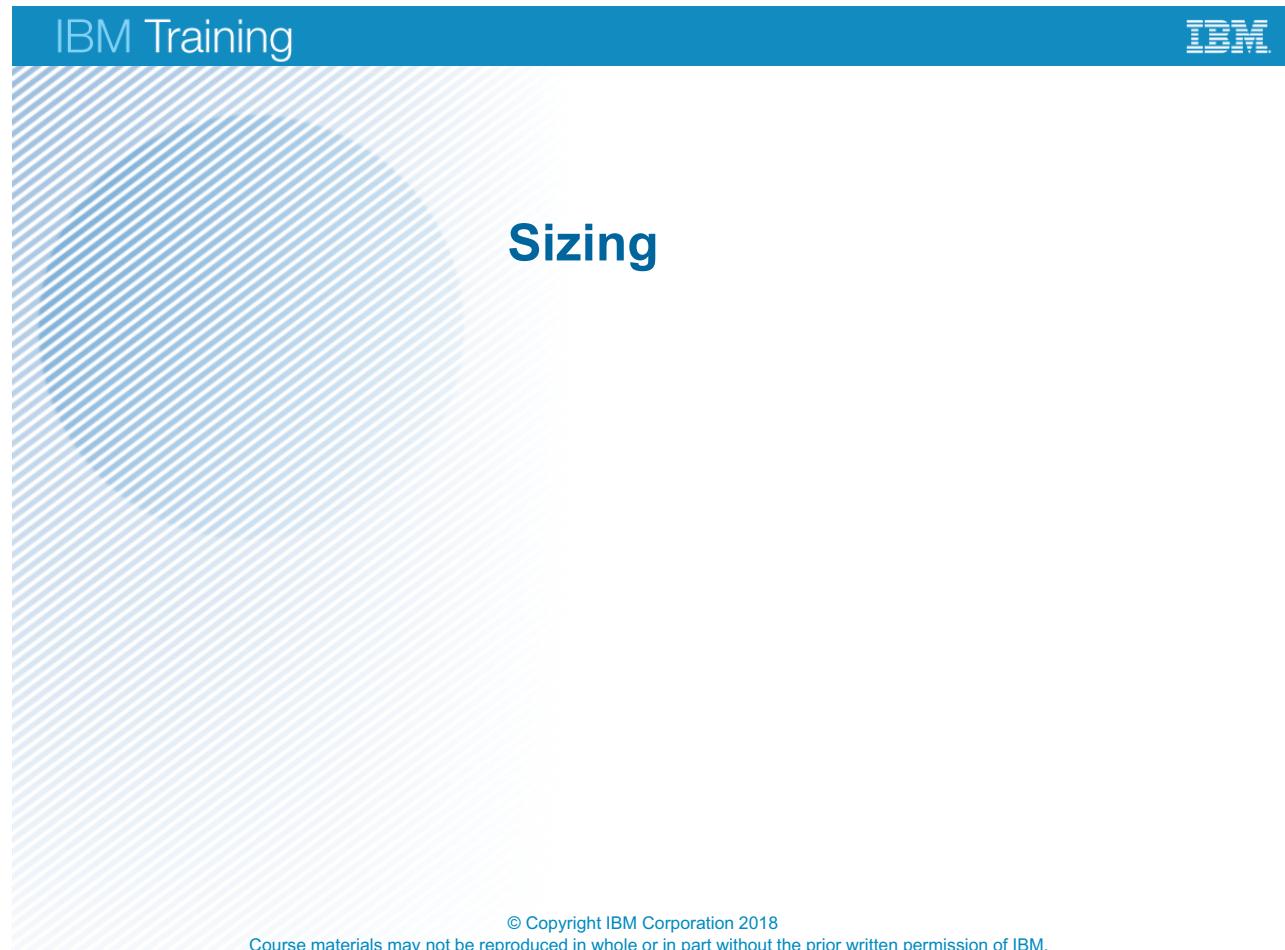
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*Figure 9-18. Decision Server Insights reference topology*

The reference topology uses a different physical server for each Decision Server Insights server in the topology. This configuration provides a high degree of isolation between components.

The high availability and recoverability objectives can be met with a minimum of three physical servers, not counting the database. However, a topology with four servers would be more appropriate as a minimal high availability topology. The reference topology uses four container servers, one on each host machine. Three machines can have a catalog server. Additionally, you should have inbound and outbound servers on at least 2 of the 4 physical servers.

## 9.3. Sizing



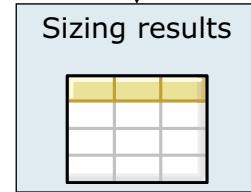
*Figure 9-19. Sizing*

## Capacity planning for containers in the grid

- Steps to estimate the hardware, JVM, and grid configuration

1. Collect the information about the data (Java objects) to be stored
2. Determine the memory requirements and partition count
3. Determine the CPU size and server count

- Sizing results include:
  - Number of servers (physical machines)
  - Number of CPUs
  - Total physical memory
  - Number of containers
  - Maximum heap size per JVM (Xmx)
  - Number of partitions
- JVM recommendation for each container: 70% heap utilization



*Figure 9-20. Capacity planning for containers in the grid*

When you are planning for your grid topology, you need to consider the factors that you see listed on the slide and in your notes. Your calculations are affected by the size and types of entities, the number of events and their size, event rate, whether or not you use event horizons, or delayed events, shared aggregates, whether or not you use high availability, how many replicas you use, entity and memento offloading, or if you are using eXtreme Memory.

The inputs to the container sizing process include:

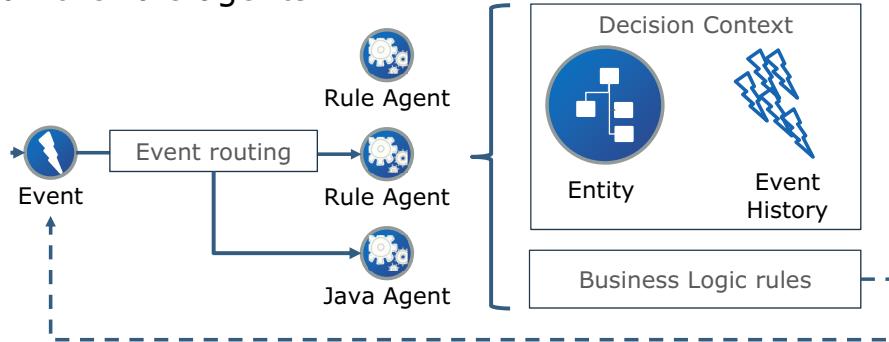
- Average event size for each event type
  - Identify maximum event size if the size is significantly larger than the average
- Estimated event rate for each event type
  - Identify peaks if you anticipate sustained peak event processing
- Event horizon for each event type
- Estimated number of delayed (scheduled) events at anticipated peak times
- Average entity size for each entity type
  - Identify maximum entity size if the size is significantly larger than the average
- Shared aggregates (with 'available for' and resolution values)

- High availability requirements
- Number of replicas
- Whether to use entity and memento offloading
- Whether to use eXtreme Memory

## Estimating the number of CPUs

Generally, the CPU time per event is used to:

- Restore and update the decision context (entity and events)
- Run the rule agents



Decision Context restored in less than 20 ms CPU time, **with data offloading**



Entity < 25 KB  
About 200 string fields of 80 chars



Event History < 50 events  
Event size < 2KB

Figure 9-21. Estimating the number of CPUs

CPU time per event is used to restore and update the decision context for entities and events, and to run the rule agents. This slide provides an example of how to calculate the number of CPUs required.

In this example, a solution processes 50 events per second per core, which equates to 20 milliseconds of CPU time per event. This supports a simple rule agent with a decision context that is made of a 25 KB entity (5 ms CPU) and 50 events of 2 KB in the event history size (15 ms CPU).

## Estimating the number of CPUs

- For a 2 container topology, target 45% of CPU usage, so that the cluster continues to support the workload with one server lost or if all primary shards are on the same server.
- For a 4 container topology, target 70% of CPU usage
- Example:
  - Decision context estimated at 20ms CPU per event (50 events/s per core)
  - Estimated throughput of 200 events per second
  - 2 container topology:  
-> The need is 4 cores per container, running at 50% CPU capacity when both containers are up

*Figure 9-22. Estimating the number of CPUs*

The results depicted in the previous example are obtained by dividing the estimated throughput by the estimated number of events that can be processed.

The example estimates throughput at 200 events per second, and estimates that 50 events per second per CPU core (20 milliseconds CPU time per event) can be processed, so the equation is  $200 / 50$ . The result is the total number of CPU cores required to process all events (without spare capacity), in this case, 4 cores.

This corresponds to one container with 4 cores, but for high availability, and to have some spare capacity, you need another container with 4 cores. When both containers are up, and assuming that event processing distribution is even, each container processes roughly 100 events per second, using half the container's CPU capacity.

## Estimating the total physical memory

1. Estimate the total size of the data
2. Determine if data offloading should be used
3. If data offloading is used, define the data offloading configuration

Figure 9-23. Estimating the total physical memory

For container memory sizing you have to carefully estimate the size of the data (entities, events, aggregates) required by all solutions running in the grid. For each solution, gather:

- Average event size for each event type
- Estimated event rate for each event type
- Event horizon for each event type
- Estimated number of delayed (scheduled) events at anticipated peak times.
- Average entity size for each entity type
- Shared aggregates (with ‘available for’ and resolution values)

If you make the decision to use data offloading, you do not need to be very rigorous in your memory estimates. With data offloading, depending on the offloading policy that you choose and the processing patterns of your solutions, data will be offloaded when you run out of memory (or exceed a configurable threshold). Thus you will end up needing less memory and a smaller number of containers (but possibly more IO operations and more CPU).

## Estimate the total size of the data

Data size =

```
Total number of entities * (
 entity size +
 event history size per entity * event size +
 + shared aggregates (size for a shared aggregate: 1KB + 100B per time bucket)
 + delayed events per entity * 1KB
)
```

To view the size of your objects or events, use:

```
xscmd - showMapSizes -cep localhost
```

Example:

100K entities of type Wagon; size 10KB each  
 Receiving 1 event per hour kept during 2 days; size 1.2KB each  
 History of 50 events per Wagon (1 per hour kept for 2 days)  
 Each Wagon has a scheduled event

```
Data size = 100 000 * (
 10KB + // entity size
 50 * 1.2KB + // event history per entity
 1* 1KB) // delayed events
= 7GB
```

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*Figure 9-24. Estimate the total size of the data*

This slide outlines how to estimate the total size of the data.

For each entity type in all your solutions, you repeat the calculation that you see on this slide.

Your must also calculate the event history size (the number of events in the history) for each event type.

Estimated event rate for the event type and multiply that by the event horizon. Make sure you use the same units. For example, if your event rate is 5 events per minute and your event horizon is 1 hour, estimate the event history size to be:  $5 \times 60 = 300$ .

To calculate the number of buckets for shared aggregates, divide the 'available for' period by the resolution. Again, make sure that you use the same units. For example, if 'available for' is 5 days and the resolution is 12 hours then the number of buckets is:  $120/12=10$ .

## Determine if data offloading should be used

- 1.** For 2 containers or 4 containers topologies, each container must be able to contain all the grid
  - To support a container loss
  - To host replicas
  - To avoid OutOfMemory issues in a grid controlled shutdown.
  
- 2.** The grid size per container is limited
  - If Xtreme Memory is used, avoid exceeding 30GB of data per container, to reduce grid perturbation time during a container failover.
  - If Xtreme Memory is not used, avoid exceeding 10GB, to avoid long GCs.
  
- 3.** Without data offloading data load at grid restart is proportional to the entity volume.
  - Can take 10 minutes or more for dozen of GB of entities.
  
- 4.** Global entity aggregates and global event aggregates are not compatible with data offloading.
  
- 5.** Consider data offloading
  - If your data cannot fit in a single container
  - If you target data load at grid restart under 5 minutes.
  - If you are not using features not compatible with entity offloading such as global aggregates.

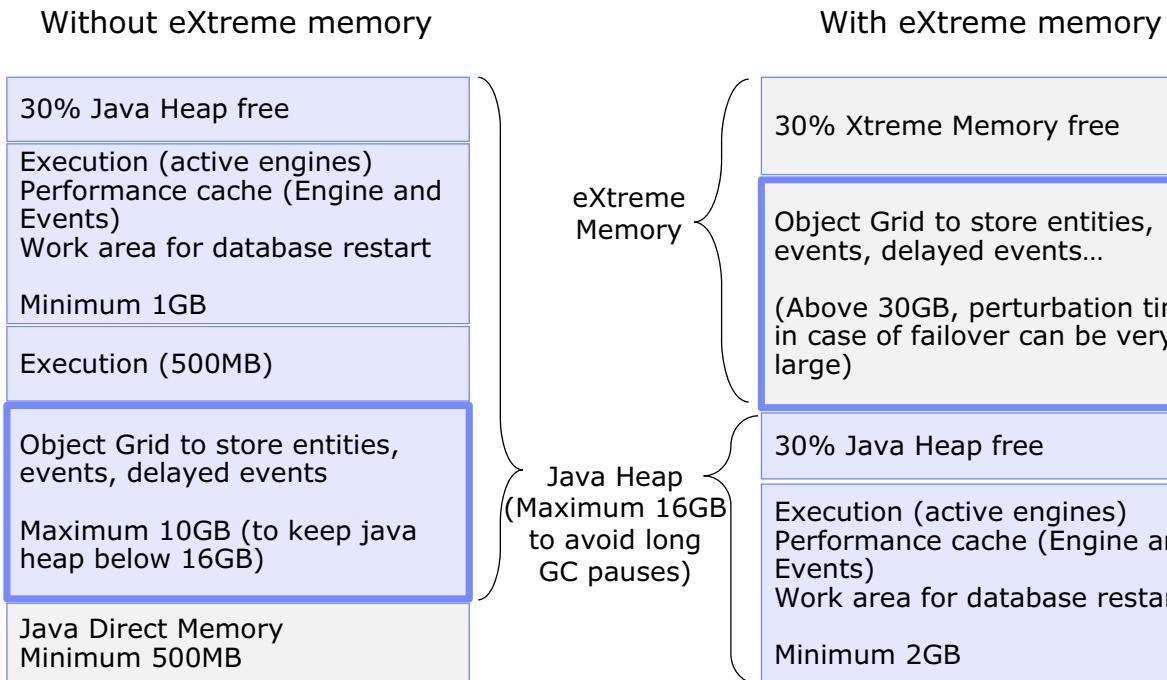
Data offloading is recommended but take into account that the additional database activity can add overhead.

Figure 9-25. Determine if data offloading should be used

As you can see, there are advantages and disadvantages to using data offloading. In general, we recommend the use of data offloading, provided that the database does not become a bottleneck and that the (expected) minor degradation in throughput and latency is tolerable by the use case. Even in these cases you can sometimes work around these limitations by using a high performance database and adding more containers/CPU cores to the topology.



## Grid capacity per container



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*Figure 9-26. Grid capacity per container*

If you are not using eXtreme memory it's important to keep the Java heap size small (below 16GB). Large heap sizes can result in long garbage collection (GC) pauses that can lead to the loss of the entire grid. The alternative is to use a larger number of containers with smaller heaps, or to use eXtreme memory.

eXtreme Memory is always recommended if you have large data requirements and you are not using data offloading.

## Total grid size percentage stored per container

Number of runtime containers	1 replica	2 replicas	Comment
2	100%	-	Each container has 50% of the grid and replicas
3	100%	100%	For 1 replica, the shard replicas are recreated if a container stops
4	66%	100%	For 2 replicas, the shard replicas are recreated if a container stops
5	50%	75%	
6	40%	60%	
7	33%	50%	
8	28%	42%	

Figure 9-27. Total grid size percentage stored per container

This table shows the amount of memory required by each container as a percentage of the total grid size. Note that ‘total grid size’ refers to the primary data size only.

Assuming that the grid size is 10GB and that you allow 1 container to go offline:

- Case of 2 containers: Capacity required = 10GB for primary + 10GB for 1 replica = 20GB  
However, a replica cannot be allocated on the same host as the primary so each server only needs 10GB, which is 100% of grid size.
- Case of 3 containers + 1 replica: Each container must have 10GB, which is 100% of grid size
- Case of 3 containers + 2 replicas: 30GB is required for the primary and the replicas, but the primary and each of the replicas need to be allocated on separate hosts. In the case of one container going offline, each container will hold only 10GB, which is 100% of the grid size.
- Case of 4 containers + 1 replica: 20 GB is required, which must fit in 3 containers:  
 $20\text{GB}/3 = 6.6\text{GB} = 66\%$  of grid size
- Case of 4 containers + 2 replicas: 30 GB is required, which must fit in 3 containers:  
 $30\text{GB}/3 = 10\text{GB} = 100\%$  of grid size

## Define the offloading configuration

- Configuration goals
  - Do not exceed the available memory size
  - Keep the grid small (to minimize perturbations in case of failover)
  - Maximize the percentage of cache hits (data already in memory when an event is received)
- Configuration actions
  - Define the `eventCacheDuration` solution property to activate event offloading
  - Set the `entityOffloading` runtime property to true to activate entity offloading
  - Define evictors for the `ENTITY`, `RULESET` and `EVENTSTORE` maps (and only for those maps)
- Evictor definition
  - To keep the memory small, use also a TTL evictor of type `LAST_ACCESS_TIME`
  - Do not use values smaller than 10 minutes (600 seconds)
  - You can also control the maximum memory usage, by using a memory based evictor if the grid is in the Java heap, or an LRU evictor if eXtreme Memory is activated
- Verify the grid size evolution with:

```
xscmd - showMapSizes -cep localhost
```

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*Figure 9-28. Define the offloading configuration*

Decision Server Insights supports 3 evictor types, each implementing a different approach to removing data from memory. An evictor may be used on its own or combined with a Java heap memory threshold trigger mechanism (aka Memory-based) that activates the evictor when the threshold is reached (for example 70% of heap memory usage has been reached). These evictor types are:

- Time to Live (TTL)
- Least Recently Used (LRU)
- Least Frequently Used (LFU)

The choice of the type of evictor to use and whether or not you want to use the memory-based trigger mechanism constitutes your eviction policy. You should aim to maximize the number of cache hits but this is often not straight forward, mainly due to the following reasons:

- An application's event processing patterns are often only known after the application has been in production for a while.
- Even if you monitor patterns in production you may find that some patterns occur randomly or there may be complex scheduling patterns – generated by scheduled events - that are difficult to predict. Scheduled events (aka delayed events) are internal events that are created when you use an “has occurred” clause in a rule. This causes the processing of the rule to be delayed and the

event to be scheduled for future processing. When this scheduled event is finally processed it will need the entity that it is correlated with to be available in memory.

- In DSI, the same eviction policies apply to all entity types and it is often the case that what is optimal for one entity type may not be for another.

## Evictor policies for offloading

- Offloading evictors can be configured to support the following policies:
  - Time to Live (TTL)
    - Entities are evicted after a configurable fixed amount of time after being created, updated or read. The time is measured from a create, update or read operation on the entity depending on what TTL evictor type you configure.
  - Least recently used (LRU)
    - Least recently used entities are evicted from the grid every X seconds (X is configurable)
  - Least frequently used (LFU)
    - Least frequently used entities are evicted from the grid every X seconds (X is configurable)
  - Memory-based Eviction
    - Memory-based eviction is used, in conjunction with one of the previous eviction policies, to limit memory usage to a specific amount (specified as a percentage of the available memory)

*Figure 9-29. Evictor policies for offloading*

### What eviction policy should I use?

It's hard to decide on an eviction policy but a reasonable place to start is to dedicate some time during the development and test phases to understanding processing patterns and thus get an idea of which eviction policy might work best. You can then use this policy in your first configuration. Your initial decision can be revisited later if, after doing some production monitoring, you determine that there is a need to change your chosen policy or its configuration. Note that changing eviction policies requires a grid configuration change and that means that you'll need a grid restart to make a new policy effective.

In addition to processing patterns, there is another factor that may influence your decision and that is whether or not your DSI topology is configured to use extreme memory (XM). Extreme memory is native memory that is used instead of Java heap memory to store your solution's objects (entities, mementos, events, etc.). Extreme memory is typically used in larger grids to minimize the negative impact of Java garbage collection. Because XM is not Java heap memory, you cannot use the memory-based mechanism with XM. This means that you need to pay more attention to memory sizing when you use evictors with XM.

For smaller grids that use exclusively Java heap memory, the memory-based trigger mechanism is recommended. Using this mechanism means that you do not have to perform rigorous grid sizing activities up front and that the likelihood that you'll run out of memory is significantly reduced.

## Example of offloading configuration

Example:

1. TTL evictor set to 30 minutes (the decision context of an entity is removed from memory if an entity does not receive an event in 30 minutes)
2. LRU evictor limiting the number of events to 5300 per partition and per event type (10MB per partition and event type if the event size is 2KB)

### File objectgrid.xml

```

<backingMap name="EventStore.*"
 template="true"
 lockStrategy="PESSIMISTIC"
 copyMode="COPY_TO_BYTES"
 pluginCollectionRef="EventStorePlugins"
 ttlEvictorType="LAST_ACCESS_TIME"
 timeToLive=< 1800"/>
<backingMapPluginCollection id=" EventStorePlugins ">
 ...
 <bean id="Evictor" className="com.ibm.websphere.objectgrid.plugins.builtins.LRUEvictor">
 <property name="maxSize" type="int" value="100" description="max size for each LRU queue" />
 <property name="sleepTime" type="int" value="15" description="evictor thread sleep time" />
 <property name="numberOfLRUQueues" type="int" value="53" description="number of LRU queues" />
 </bean>
</backingMapPluginCollection>
```

Repeat the configuration for maps Rulesets.\* and Entity.\*

*Figure 9-30. Example of offloading configuration*

On this slide, you see an example of using the Time To Live evictor, which has 2 configurable parameters. The timeToLive parameter is set to 30 minutes (1800 seconds) and ttlEvictorType is set to LAST\_ACCESS\_TIME. So the entity is ready for evictions 30 minutes after the last time it is accessed.

The ttlEvictorType parameter values can be one of CREATION\_TIME, LAST\_ACCESS\_TIME or LAST\_UPDATE\_TIME allows more control over the behaviour of the TTL evictor.

The TTL evictor is usually preferred when you use extreme Memory because it is easier to configure and easier to estimate the memory requirements of the grid. If you're not using eXtreme Memory, and you use the memory-based trigger (recommended) instead, eviction might happen earlier than the time to live period, if the memory threshold is exceeded.

The LRU and LFU evictors have 2 parameters that are the same: sleepTime and MaxSize but because they use different internal data structures to optimize the process of finding out which entities need to be evicted, LRU has a numberLRUQueues parameter, while LFU has a corresponding numberOfHeaps parameter. Having more than one queue or heap structure to keep track of the entities that need to be evicted allows processing to happen in parallel, thus significantly increasing the performance of the eviction mechanisms. The MaxSize parameter is used to determine how many entities to evict when the evictor kicks in. Note that eviction only

happens if the heap or queue has more than MaxSize elements and this allows you to have some control over the number of entities that will be in memory at any given time.

The evictor removes entities every sleepTime seconds (and not continuously) for performance reasons. If the sleep time value is too low performance is impacted but if it is too high not enough entities will be offloaded and you'll likely need more memory. A RoT is to make sleepTime equal to 15 seconds.

## Determining number of partitions

- Set the number of partitions (P) to a prime number
  - Maximum number of containers (C)
  - Number of cores per container host (M)

Without persistency or with persistency in write-behind mode:

**Number of partitions** =  $(C * M * 2)$  rounded up to next prime number

With persistency in write-through mode, increase the number of partitions to compensate for the database latency at transaction time

**Number of partitions** =  $(C * M * 10)$  rounded up to next prime number

- You must limit the number of containers that are running to match the number of partitions
  - If number of partitions is P, you cannot use more than  $P*(1+\text{number of replicas})$  containers to host data
  - Additional containers start but do not receive any partition to host

Figure 9-31. Determining number of partitions

The maximum number of containers that you can dynamically add to the grid is constrained by the number of partitions and the number of replicas that you configure in each partition. This constraint stems from the fact that the number of partitions can only be changed if the grid is down and also because it doesn't make sense to have more container servers than the maximum number that can be used. This number is determined by the number of partitions  $\times (1 + \text{the number of replicas})$ . For example, if the number of partitions is 20 and you have 2 replicas, that means that you have 20 primaries  $+ 20 \times 2$  replicas ( $= 20*(1+2)$ ), which results in a maximum of 60 containers that can be added to the grid and that are actually used (with one replica or primary shard on each machine).

With this constraint in mind, choosing a large number of partitions seems to facilitate growth and allow for better balancing of memory resource. However, you must balance this against the greater number of threads, increased grid communication overhead, and greater level of balancing work, whenever the grid changes. When the number of partitions is large and the number of containers is small, the amount of grid reconfiguration work can be significant when removing or adding a container.

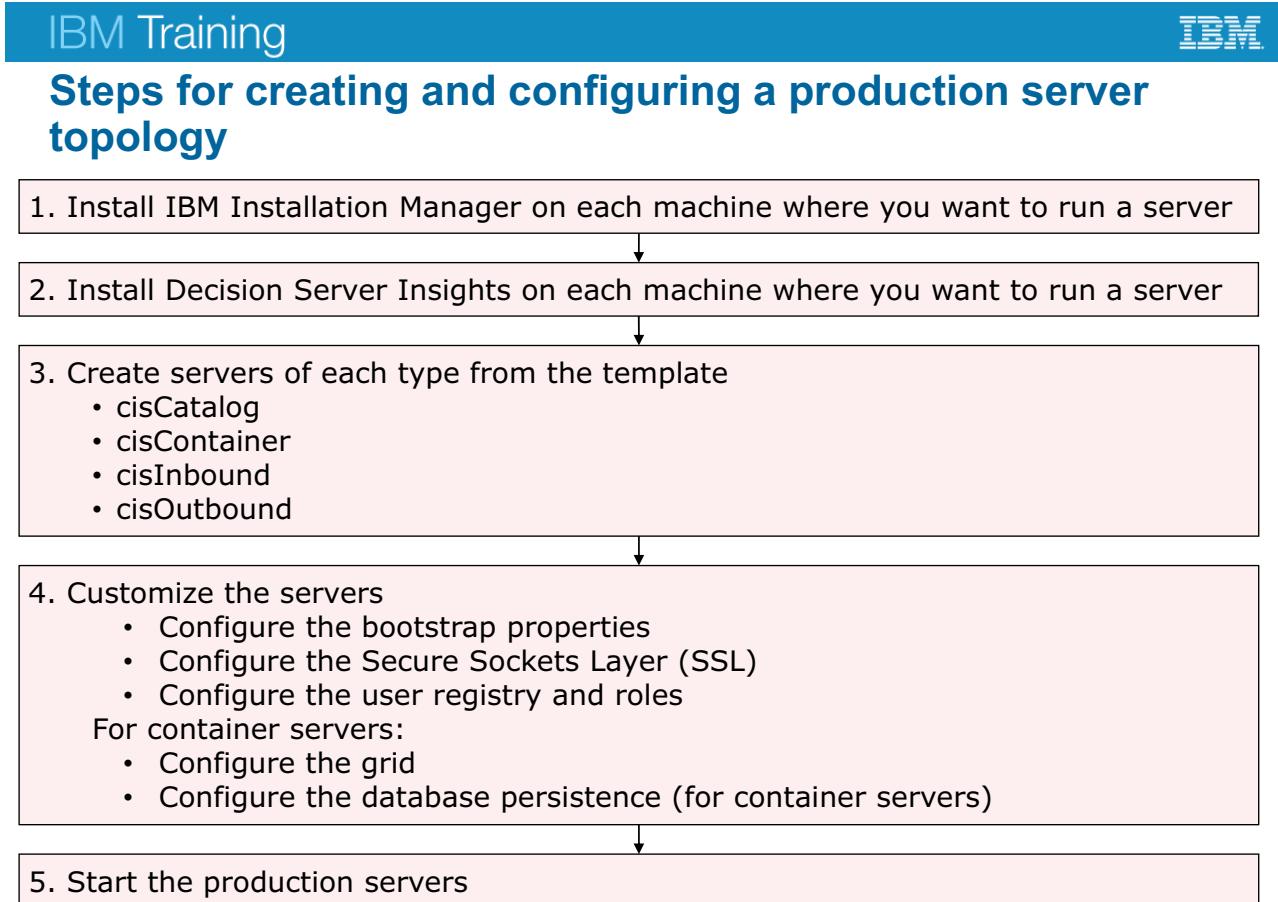
## 9.4. Configuring a production topology

## Configuring a production topology

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*Figure 9-32. Configuring a production topology*



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*Figure 9-33. Steps for creating and configuring a production server topology*

This slide outlines the steps for creating and configuring a production topology.

## Server templates

- Create servers with Decision Server Insights server templates

Server templates	Description
Catalog cisCatalog	<ul style="list-style-type: none"> <li>• Required for high availability</li> <li>• A production topology contains a minimum of three catalog servers</li> <li>• Catalog servers and container servers cannot coexist on the same host</li> </ul>
Container cisContainer	<ul style="list-style-type: none"> <li>• Stores entities and system information, and runs agents and analytics jobs</li> <li>• A production topology contains a minimum of three container servers</li> <li>• Container servers and catalog servers cannot coexist on the same host</li> </ul>
Inbound cisInbound	<ul style="list-style-type: none"> <li>• Submits inbound events to the grid either through the gateway API, through HTTP, or through JMS</li> <li>• A production topology contains at least one inbound server</li> </ul>
Outbound cisOutbound	<ul style="list-style-type: none"> <li>• Emits outbound events through HTTP or through JMS</li> <li>• A production topology contains at least one outbound server</li> </ul>

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Figure 9-34. Server templates

Decision Server Insights provides templates for you to generate the various server types that you use to set up your topology.

After you create a server from the template, you customize it by configuring the bootstrap properties, security, and JVM options.

## Customizing servers

- For each server that you create, you edit these files:
  - `bootstrap.properties`
  - `server.xml`
- For catalog servers, edit `bootstrap.properties` to configure `ia.catalogClusterEndpoints`
  - Declares the host and server names, and peer connection ports of all catalog servers in the topology
- For container servers, inbound servers, and outbound servers, edit `bootstrap.properties` to configure `ia.bootstrapEndpoints`
  - Declares the host names and client listener ports of the catalog servers in your topology

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*Figure 9-35. Customizing servers*

For catalog servers, edit `bootstrap.properties` to configure `ia.catalogClusterEndpoints`. This property declares the host and server names, and peer connection ports of all catalog servers in the topology.

Set this property by using the following format:

```
computer_name-server_name:computer_name:port_number:port_number,
computer_name-server_name:computer_name:port_number:port_number
```

For container servers, inbound servers, and outbound servers, edit `bootstrap.properties` to configure `ia.bootstrapEndpoints`. This property declares the host names and client listener ports of the catalog servers in your topology.

Set this property by using the following format:

```
computer_name:port_number,computer_name:port_number
```

## Configuring security (1 of 2)

- To configure SSL, security and roles, you edit the `server.xml` file for each of the servers
- Generate a keystore (`key.jks`) by using the `securityUtility`
  - It is not necessary for all of the servers to use the same keystore
  - The keystores contain the certificates that are required for establishing trust
  - Example:  
`securityUtility createSSLCertificate --server=cisCatalog1 --password=insights`
- You must also provide a user registry configuration that defines which users are authorized to access the server
  - The user registry can also authorize the administrator to use the JMX and REST APIs, if necessary

Figure 9-36. Configuring security (1 of 2)

To configure security, you first generate a keystore, and then you edit the `server.xml` file for each server to provide authentication credentials.

## Configuring security (2 of 2)

- Provide a basic or LDAP user registry configuration
  - Defines which users are authorized to access the server
  - Example:

```
<basicRegistry id="basic" realm="SimpleRealm">
 <user name="SimpleAdmin" password="abcdefg"/>
 <group name="SimpleAdministratorsGroup">
 <member name="SimpleAdmin"/>
 </group>
</basicRegistry>
```

- Configure authorization roles for server administration

- Example:

```
<administrator-role>
 <group>SimpleAdministratorsGroup</group>
</administrator-role>
```

Figure 9-37. Configuring security (2 of 2)

This slide shows an example of a basic or LDAP registry configuration and an example of an authorization role for server administration.

## Configuring heap size for container servers

- Customize the heap size for container servers in the `jvm.options` file by setting the `-Xms` and `-Xmx` properties
- Configure the grid in the `objectGridDeployment.xml` file, including these properties:
  - `numberOfPartitions`
  - `numInitialContainers`
  - `maxSyncReplicas`
  - `maxAsyncReplicas`

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*Figure 9-38. Configuring heap size for container servers*

For container servers, you edit the `jvm.options` file to set the heap size.

You use the `objectGridDeployment.xml` file to define various grid properties.

## Starting the servers

- Start all servers from the `runtime/wlp/bin/server` directory
  - `server start <serverName>`
- Startup sequence:
  - Catalogs
  - Containers
  - Outbound connectivity
  - Inbound connectivity
- When using multiple catalog servers, at least two must be started concurrently

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Figure 9-39. Starting the servers

To manage the servers, you use the `server` and the `serverManager` utilities.

- Use `server` to start your three catalog servers; all catalogs should be started concurrently
- Use `serverManager` to suspend balancing
- SSH into your four containers and start them by using the `server` command.
- Use `serverManager` to resume balancing
- Use `server` to start your outbound server
- Use `server` to start your inbound server

## Unit summary

- Describe WebSphere eXtreme Scale basics
- Describe the Decision Server Insights reference topology
- Design and configure a production topology

## Review questions

- 1. True or False:** A Decision Server Insights reference topology requires a minimum of 4 servers.
- 2. True or False:** To reduce hardware requirements, you can run inbound and outbound servers on the same physical machine.
- 3. True or False:** For a 2 container topology, run on one separate server each, you can target 70% of CPU usage of the two servers.

*Figure 9-41. Review questions*

Write your answers here:

- 1.
- 2.
- 3.

## Review answers

- 1. True or False:** A Decision Server Insights reference topology requires a minimum of 4 servers.  
**True.** *Two servers for 2 containers, and two servers for the catalogs and connectivity servers*
- 2. True or False:** To reduce hardware requirements, you can run inbound and outbound servers on the same physical machine.  
**True**
- 3. True or False:** For a 2 container topology, run on one separate server each, you can target 70% of CPU usage of the two servers.  
**False.** *You should target 45% usage of the two servers so that the cluster continues to support the workload with one server lost or if all primary shards are on the same server.*

## Exercise: Installing Decision Server Insights

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*Figure 9-43. Exercise: Installing Decision Server Insights*

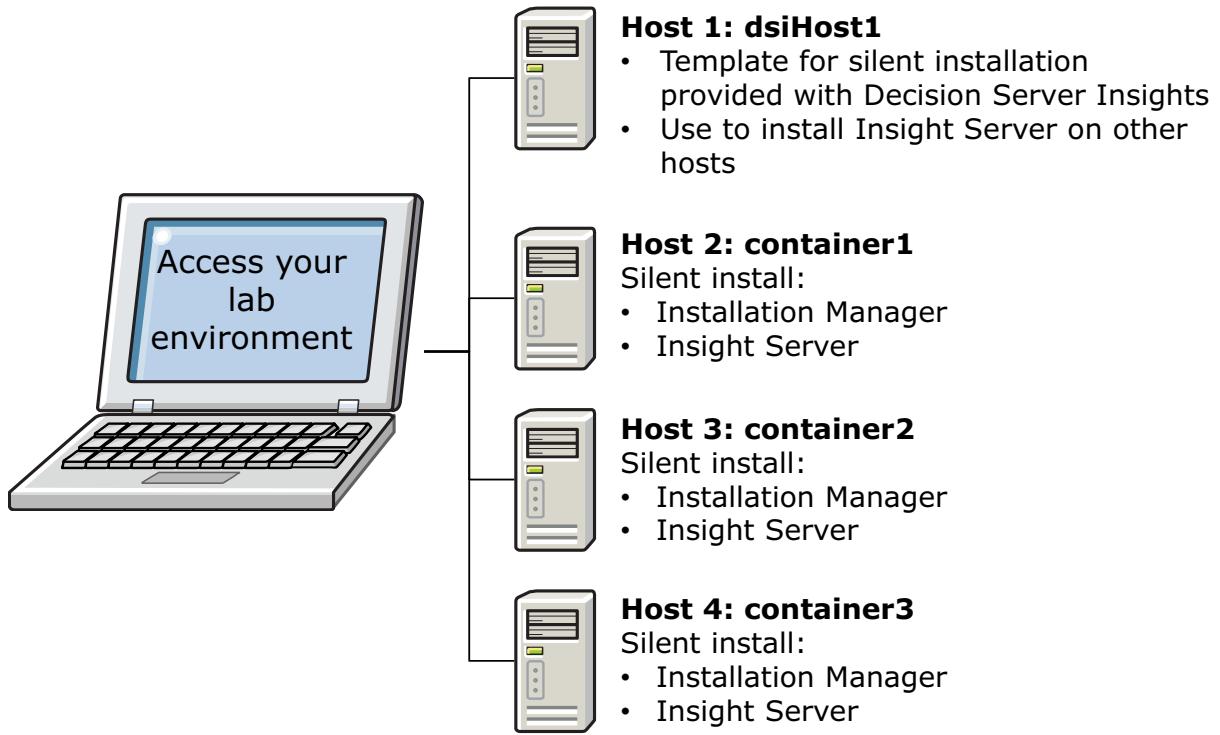
## Exercise introduction

- Install IBM Installation Manager on every machine in the lab environment where Insight Server should run
- Use Installation Manager to install Decision Server Insights on every machine in the lab environment where Insight Server should run



Figure 9-44. Exercise introduction

## Exercise environment (1 of 3)



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Figure 9-45. Exercise environment (1 of 3)

During the lab, you install Decision Server Insights on each of your container hosts.



**Stop**

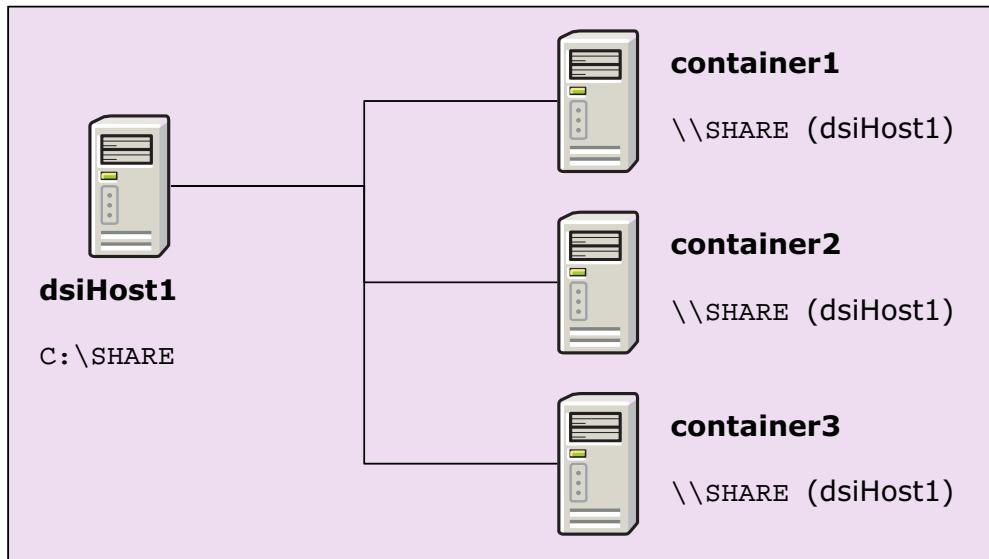
The default host names are: dsiHost1, container1, container2, and container3.

Your hosts might be assigned different unique host names. Make sure that you know and use the actual host names for your environment during the exercises.

---

You perform a silent installation of Installation Manager and Decision Server Insights (Insight Server only) on Host 2, Host 3, and Host 4, which are your container hosts.

## Exercise environment (2 of 3)



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Figure 9-46. Exercise environment (2 of 3)

To transfer files from one virtual machine to another, you use a shared directory.

On your main host (**dsiHost1**), the **C:\SHARE** folder is used to move files from the main host to the remote host. The other machines have a drive that is mapped to the **SHARE** folder.

## Exercise environment (3 of 3)

### Main host

*Default host name: dsiHost1*

Assigned host  
name: \_\_\_\_\_

IP: \_\_\_\_\_

### Container 1 host

*Default host name: container1*

Assigned host  
name: \_\_\_\_\_

IP: \_\_\_\_\_

### Container 2 host

*Default host name: container2*

Assigned host  
name: \_\_\_\_\_

IP: \_\_\_\_\_

### Container 3 host

*Default host name: container3*

Assigned host  
name: \_\_\_\_\_

IP: \_\_\_\_\_

Figure 9-47. Exercise environment (3 of 3)

This graphic is in the final appendix of your exercise guide. Use that appendix as a reference to make a note of the IP addresses and host names that are assigned to your virtual machines.

## Exercise: Configuring Decision Server Insights

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*Figure 9-48. Exercise: Configuring Decision Server Insights*

## Exercise introduction

- Create and configure catalog, container, and inbound and outbound servers

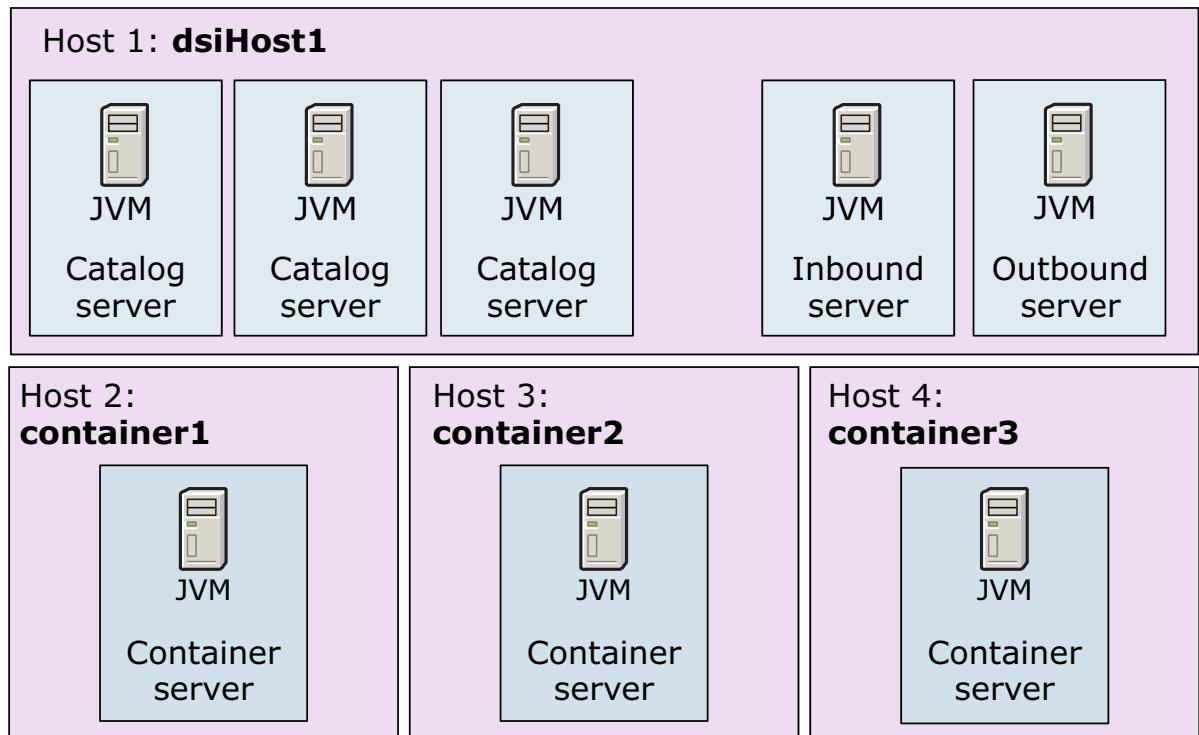


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*Figure 9-49. Exercise introduction*

## Course topology: 4 VMware images



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Figure 9-50. Course topology: 4 VMware images

For this lab, you use four VMware images.

- **dsiHost1**: Hosts the complete Decision Server Insights installation. On this host, you create the catalog, inbound, and outbound servers. Each catalog server is configured to be aware of the other catalogs and the other server types in the grid.

For this course, because these servers are all on the same host, you must modify the ports so the catalogs, inbound, and outbound servers are not all listening to the same ports.

- **container1, container2, and container3**: Each of these hosts is used as a container server.



### Questions

Configuring the grid: How many partitions would this topology use, with each container running on a single core machine?

$C * M * 2 = <\text{next prime number}>$

Answer: 3 containers \* 3 cores \* 2 = 18, which must be rounded up to the next prime number: 19.

**Stop**

The default host names are: dsiHost1, container1, container2, and container3.

Your hosts might be assigned different unique host names. Make sure that you know and use the actual host names for your environment during the exercises.

---

# Unit 10. Managing deployment

## Estimated time

01:00

## Overview

This unit explains how to deploy to Insight Server.

## How you will check your progress

- Review
- Exercise

## Unit objectives

- Explain how to export and deploy solutions
- Describe how to manage solutions with the solutionManager script
- Manage deployment to multiple hosts

Figure 10-1. Unit objectives

## Topics

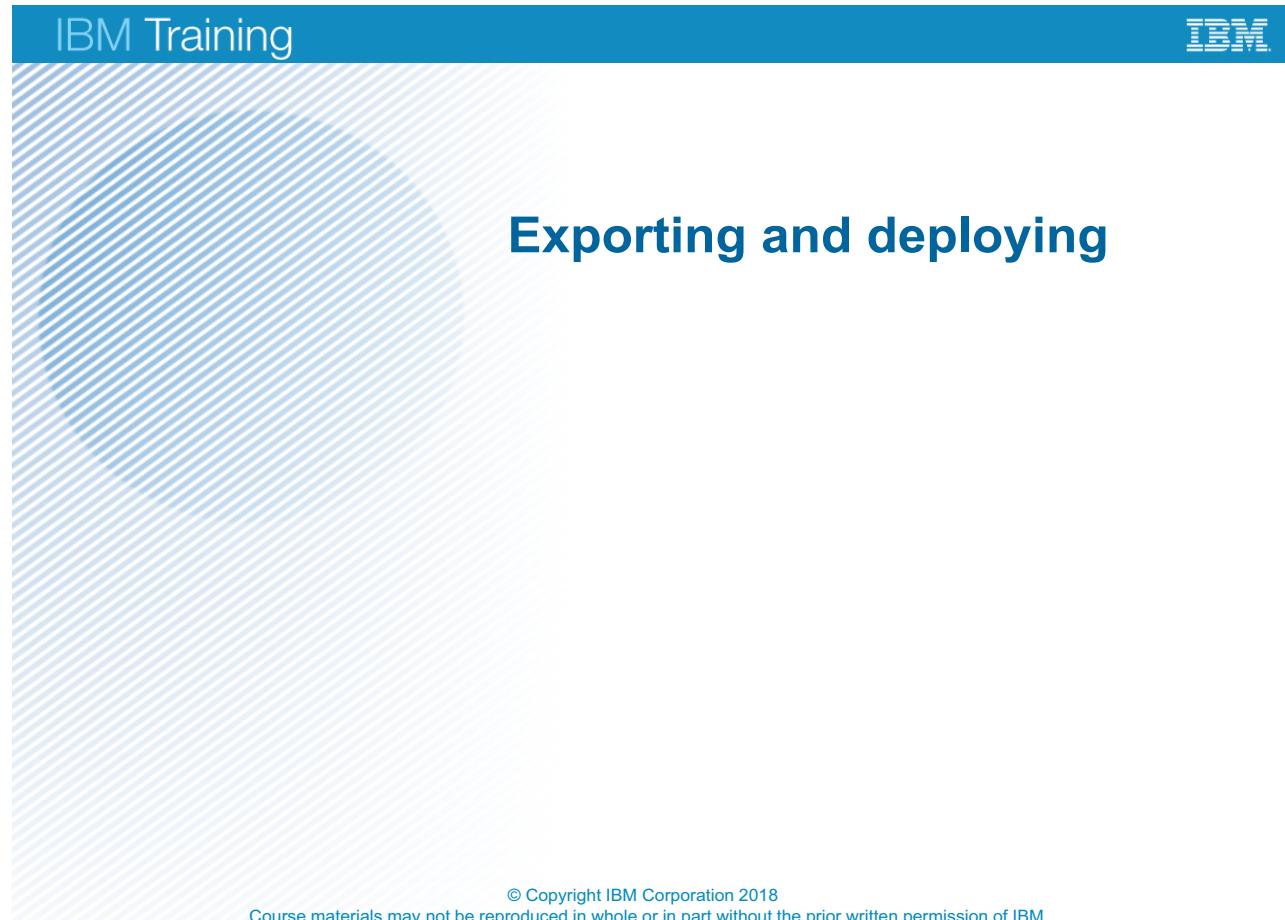
- Exporting and deploying

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*Figure 10-2. Topics*

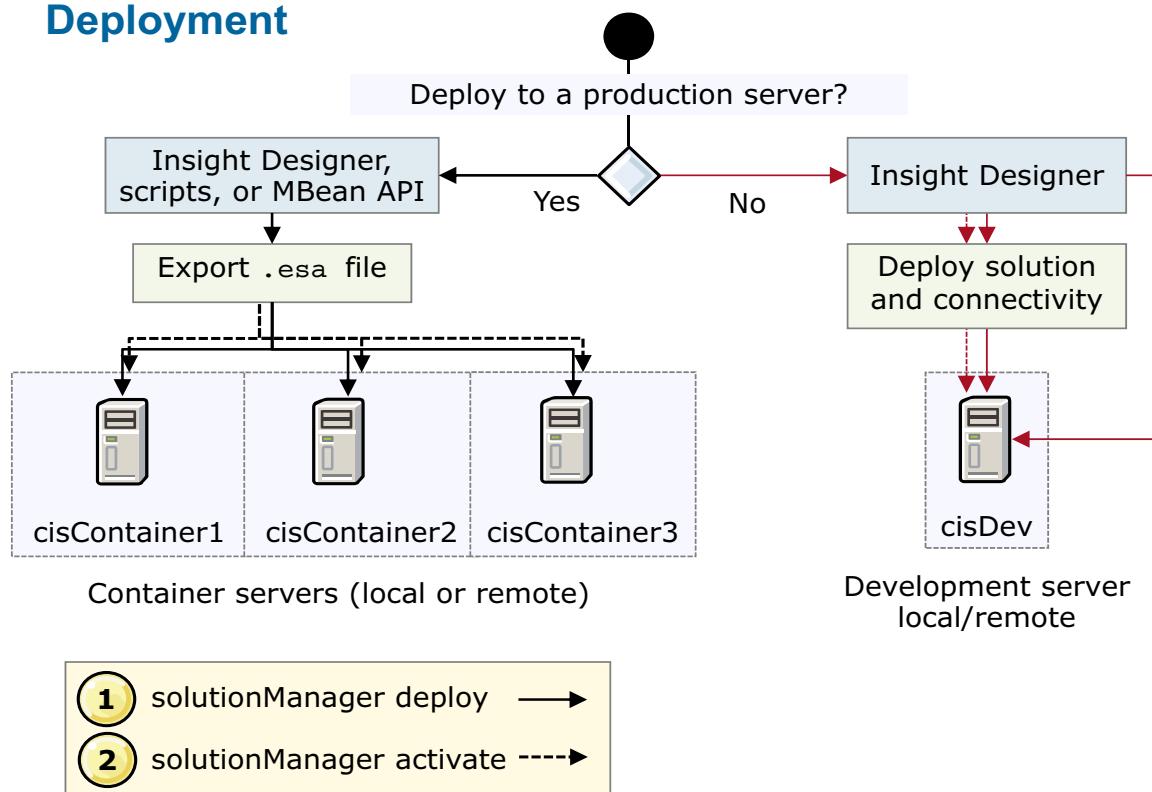
## 10.1. Exporting and deploying



*Figure 10-3. Exporting and deploying*



## Deployment



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Figure 10-4. Deployment

You can deploy a solution from Insight Designer or by using scripts.

Deployment includes exporting the solution to an archive (.esa), which can be stored and managed by administrators.

Decision Server Insights provides several ways to deploy solutions to both local and remote servers.

In the development environment, you can use Insight Designer to deploy to the development server, cisDev, either locally or remotely. If you have a test or development environment that is set up on multiple hosts to match your production environment, you can test both local and remote deployment.

To deploy to multiple container servers on remote hosts, you can use scripts to automate deployment. The deployment scripts can automate the export of the solution to an archive, deployment of the archive to the servers, and activation of the solution on the servers.

## Exporting solutions and agents

- When you export a full solution or a single agent, Insight Designer creates an `.esa` archive
- Solution and agent archives are OSGi subsystem archives that contain OSGi bundles
  - Deployable to Insight Server
- Exporting solutions
  - By default, the archive uses the solution name plus version as the archive name
  - All agents that are referenced in the solution project are packaged into the solution archive
  - Example: `banking_solution-1.0.esa`
- Exporting agents
  - Only the agent is packaged in the archive, but the name includes the solution name plus the archive name plus version
  - Example:  
`banking_solution-0.1-banking_solution.banking_agent_fraud_detection-0.1.0.esa`

Figure 10-5. Exporting solutions and agents

When you export a solution and its agents to an archive, it creates a `.esa` file. You then deploy the archive to an Insight Server.

If you modify an agent, you can export the agent independently from the solution to update it. The solution must exist on the server before you deploy a single agent.



## Version policy

- By default, solutions are deployed with the version 1.0

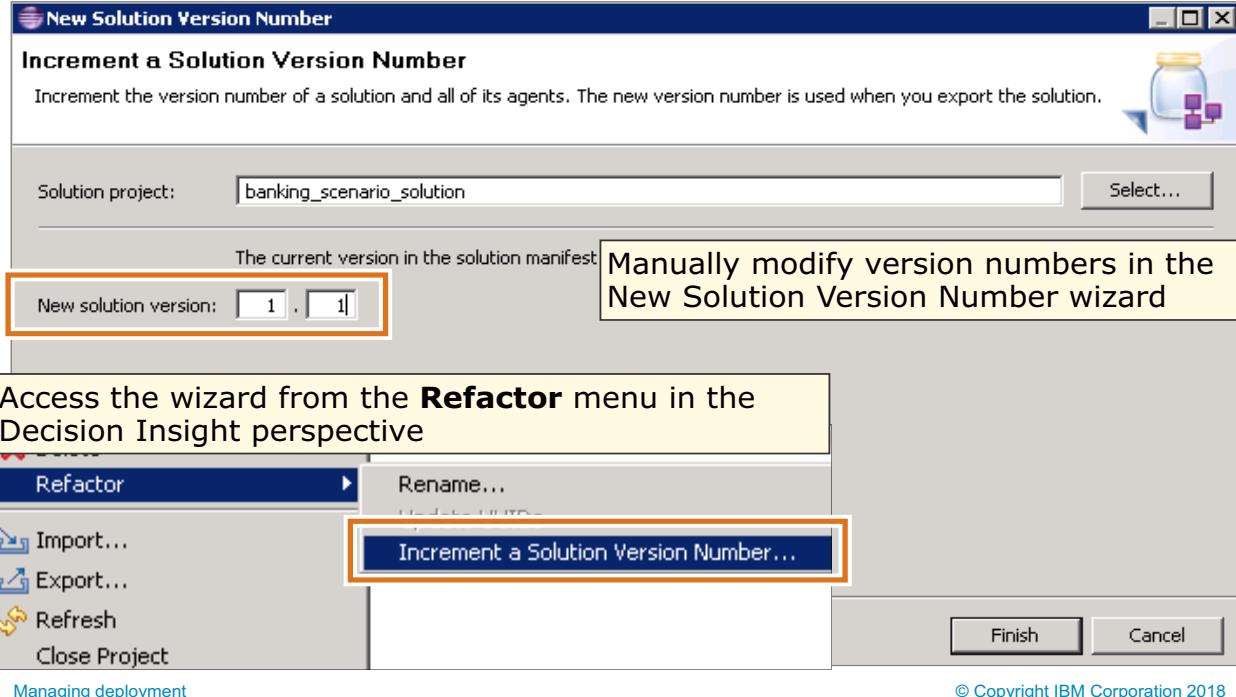


Figure 10-6. Version policy

Before you export a new or updated version of a solution, you can use the New Solution Version Numbers wizard to increment the version number of the solution project and its agents.

Incrementing the version before you export prevents overwriting a deployed solution.

When you export an agent, the Export wizard increments the micro number, for example: 1.0.1. This version is recorded in the manifest file of the agent project.

The `MANIFEST.MF` files of Java agent and OSGi projects might contain import and export declarations that include a version. When you increment the solution version, the version in the `Import-Package` and `Export-Package` headers is synchronized with the new version. This update happens only if the export and import declarations have a `version` attribute that is the same as the bundle version, and if it ends with the `.qualifier` property.

## Deploying solution archives

- To deploy a solution from Insight Designer, you can:
  - Create a deployment configuration for the solution
  - Run the `solutionManager` script
  - Use JMX MBeans
- Deployment installs the solution files on the server and updates the `server.xml` file to activate the solution on the Liberty server
- Run the `solutionManager` script on Windows from the `<InstallDir>/runtime/ia/bin` directory
- You can deploy locally or remotely

*Figure 10-7. Deploying solution archives*

You can deploy a solution by running the `solutionManager` script or by using JMS MBeans. Deployment installs the solution files on the target server and updates the `server.xml` file. When you deploy to a grid, the same solution must be installed on all the runtime servers in the grid.

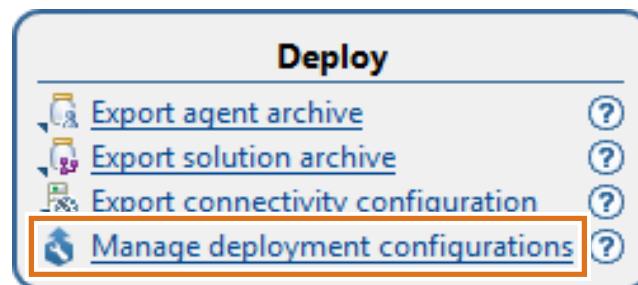
You can run the `solutionManager` script to deploy locally or remotely. For example:

```
solutionManager deploy remote C:\solution.esa --host=someRemoteHost --port=9080
--username=user1 --password=user1
--trustStoreLocation=<InstallDir>\runtime\wlp\usr\servers\cisDev\resources\
security\key.jks --trustStorePassword=truststore
```

The `solutionManager` script is run from the `<InstallDir>/runtime/ia/bin` directory.

## Using a deployment configuration

- Use the **Configure and Deploy** wizard to generate a deployment configuration for your solution
  - Define local or remote servers
  - Define connection properties
- Use the **Configure and Deploy** wizard with either of these methods:
  - Right-click the solution and select **Deploy > Configure and Deploy**
  - In the Deploy goal of the Solution Map, click **Manage deployment configurations**



- Configurations are stored in the **Deployment Configurations** folder of the solution project

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Figure 10-8. Using a deployment configuration

## Local deployment

- Using the local parameter
  - Run the script with the Liberty server started or stopped
  - If the server is stopped when you deploy an archive, the solution or agent is accounted for when the server starts
- Example

```
solutionManager deploy local C:\solution.esa --
server=cisDev
```

Figure 10-9. Local deployment

## Remote deployment

- Using the `remote` parameter
  - The script establishes an HTTP connection to a running Liberty server on the remote host
  - You must provide administrator authentication credentials to run the script
- Example

```
solutionManager deploy remote C:\solution.esa --
host=cisContainer1 --port=9080 --username=user1
--password=insights
--trustStoreLocation=C:\IBM\ODMInsights88\runtime\wlp\usr\
servers\cisCatalog1\resources\security\key.jks
--trustStorePassword=insights
```

Figure 10-10. Remote deployment

## Using connection properties files

- Create a unique `connection.properties` file for each remote server

```
solutionManager deploy remote C:\mySolution-0.0.esa
--propertiesFile=../etc/connectionC01.properties
```

- Example connection properties for a container

- `server=cisContainer1`
- `host=containerHost1`
- `port=9443`
- `username=admin`
- `password=ins1ghts`
- `trustStoreLocation=${wlp.user.dir}/servers/cisCatalog1/
resources/security/key.jks`
- `trustStorePassword=ins1ghts`
- `sslProtocol=TLS`
- `disableSSLHostnameVerification=true`

*Figure 10-11. Using connection properties files*

To simplify passing the remote host parameters to the remote `deploy` command, you can pass a properties file through the `propertiesFile` parameter.

```
--propertiesFile=InstallDir/runtime/ia/etc/myconnection.properties
```

You can define unique `connection.properties` files for each server that you are using.

## Deploying to multiple servers

- Multiple servers that are hosted on the same computer
  1. Deploy a solution to one runtime server
  2. Deploy the same solution to the other runtime servers by using the `activateOnly=true` parameter with the `solutionManager deploy` command
  
- Multiple servers on remote hosts
  - Set the `solutionAutoStart` property in the `server.xml` files to `false`
  - The auto-start property places a new version of a deployed solution on hold so that you can deploy the new solution version on all the container servers in the topology before you make it active

*Figure 10-12. Deploying to multiple servers*

In a topology where multiple servers are hosted on the same host, you first deploy a solution to one container server. You then deploy the same solution to the other runtime servers by using the `activateOnly=true` parameter with the `solutionManager deploy` command. This parameter ensures that the `server.xml` file is updated, without attempting to redeploy the solution archives. Another use of the `activateOnly` parameter is when you undeploy a solution version and you then want to deploy it again. The `undeploy` command does not delete the archives from the host.

In a production topology with multiple servers, the `solutionAutoStart` property in the `server.xml` files is set to `false`. This auto-start property places a new version of a deployed solution on hold. You can then deploy the new solution version on all the container servers in the topology before you make it active by running the `activate` command.

If the `deploy` command fails and displays an error because the solution was previously deployed but not activated, you can rerun the command with the `activateOverride` parameter to force the deployment of the solution.

## Deployed solutions files

- After you deploy, the solution is copied to the `<InstallDir>/runtime/wlp/usr/extension/lib` directory
  - Agents and aggregates are copied to the `/runtime/wlp/usr/extension/lib` folder
  - The solution manifest file is copied to the `/runtime/wlp/usr/extension/lib/features` folder
- Use the REST API to verify deployment by typing this URL in a browser:

```
http://hostname:port/ibm/ia/rest/solutions
```

Figure 10-13. Deployed solutions files

After you deploy a solution, you can open Windows Explorer to find the solution files that are stored in the `runtime/wlp/usr/extension/lib` folder. The solution manifest file is stored in the `lib/features` folder.

You can also verify deployment with the REST API in a browser, as you saw during the exercises.

## Undeploying (1 of 2)

- Before you undeploy a solution, you must stop it
- Run the `solutionManager stop` command to stop and deactivate a solution
  - Example:  
`solutionManager stop banking_solution`
- If you try to undeploy a solution while it is active, you get errors

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Figure 10-14. Undeploying (1 of 2)

If you need to undeploy a solution, you first need to stop the solution and deactivate it.

You might choose to stop and deactivate the active solution if, for example:

- The solution is not working correctly and must be stopped, deployed again, and then restarted
- You want to undeploy and remove the active version of the solution
- An update to the business object model (BOM) makes the previous and active solution versions incompatible
- You want to stop the solution from processing events without undeploying the solution

If you attempt to undeploy a solution version when it is the active version and it is processing events, an error occurs.

## Undeploying (2 of 2)

- After running the `stop` command, you can undeploy by running the `undeploy` command
  - Example:

```
solutionManager undeploy local MySolution --server=cisDev
```
- The `undeploy` command removes the solution feature from the `server.xml` file
- Solution artifact files, such as the manifest file and the feature `.jar` files are left in the  
`<InstallDir>/runtime/wlp/usr/extension/lib` directory
  - Before you redeploy, you must delete these files
- If you try to deploy the solution again without incrementing the solution version number, the script detects the solution feature in the manifest files and displays an error

Figure 10-15. Undeploying (2 of 2)

When you undeploy a solution, the solution feature is removed from the `server.xml` file.

The solution artifact files, such as `.jar` files and the manifest files, remain in the file system. If the solution artifact files are not used by other installed solutions, you can delete these files by running the `solutionManager delete` command.

## Deleting solution files

- To remove a solution from the server after running the `undeploy` command, use the `solutionManager delete` command
  - Example: `solutionManager delete banking_solution-0.1`
- The `solutionManager delete` command deletes the solution manifest (`.mf`) file and the solution feature `.jar` files
  - After removing these files, you can deploy the same version of the solution again
- To delete the solution:
  1. Stop the server  
`server stop cisDev`
  2. Run the `solutionManager delete` command  
`solutionManager delete banking_solution-0.1`
  3. Restart the server with the `-clean` option to remove any cached files  
`server start cisDev --clean`

*Figure 10-16. Deleting solution files*

To delete these files, open the `<InstallDir>/runtime/wlp/usr/extension/lib` directory and delete them when you want to remove the solution from the server completely. To delete the retained solution files, run the `solutionManager delete` command.

You can stop and start the server by using the server management script, which is stored in the `<InstallDir>/runtime/wlp/bin` directory. This script includes these actions:

- **create**: Creates a server
- **start**: Starts a server as a background process
- **stop**: Stops a server

## Unit summary

- Explain how to export and deploy solutions
- Describe how to manage solutions with the solutionManager script
- Manage deployment to multiple hosts

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*Figure 10-17. Unit summary*

## Review questions

1. True or false: Decision Server Insights supports hot deployment.
2. True or false: You can undeploy a solution without stopping it.
3. True or false: An agent archive can be deployed by itself.
4. True or False: You use the `solutionManager deploy` command for local deployment only.

Figure 10-18. Review questions

Write your answers here:

- 1.
- 2.
- 3.
- 4.

## Review answers

1. True or false: Decision Server Insights supports hot deployment.

**Answer: True.**

2. True or false: You can undeploy a solution without stopping it.

**Answer: False. You must stop the solution first.**

3. True or false: An agent archive can be deployed by itself.

**Answer: True.**

4. True or False: You use the `solutionManager deploy` command for local deployment only.

**Answer: False. You use the `solutionManager deploy` command for both local and remote deployment.**

Figure 10-19. Review answers

## Exercise: Deploying solutions

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*Figure 10-20. Exercise: Deploying solutions*

## Exercise introduction

- Use solutionManager to deploy solutions
- Manage deployment and connectivity for a grid environment

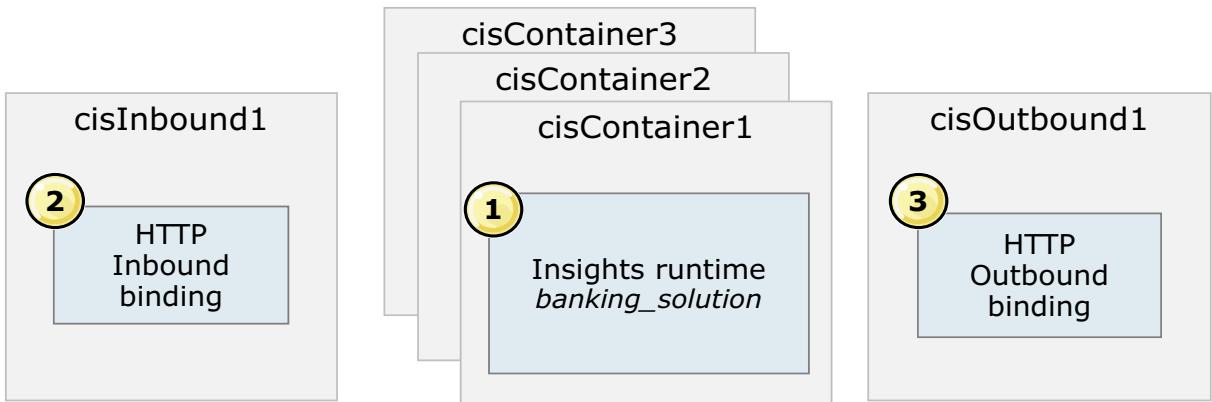


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*Figure 10-21. Exercise introduction*

## Exercise overview: Deploying a solution and connectivity



1. Deploy solution to runtime servers on container hosts
2. Deploy inbound connectivity configuration to inbound server
3. Deploy outbound connectivity configuration to outbound server

Figure 10-22. Exercise overview: Deploying a solution and connectivity

During the exercise, you deploy a solution to the grid containers. You deploy inbound connectivity to the inbound server, and outbound connectivity to the outbound server.

## Exercise overview: Testing connectivity

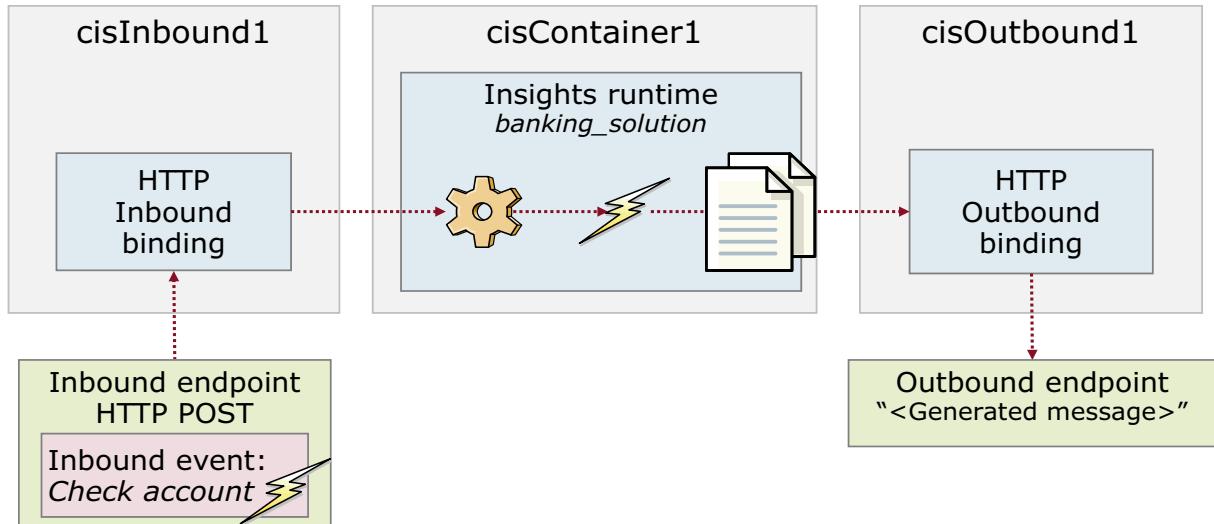


Figure 10-23. Exercise overview: Testing connectivity

To test the deployment, you use an HTTP tool to submit an event through the inbound server. The result of successful processing of the event is that an outbound message is generated by the runtime and the outbound connectivity server sends that message to the outbound endpoint.

---

# Unit 11. Administering Decision Server Insights

## Estimated time

01:00

## Overview

This unit explains how to administer Decision Server Insights.

## How you will check your progress

- Checkpoint
- Exercise

## Unit objectives

- Use administration scripts to monitor status and activity of your servers and grid
- Use trace files and logging to monitor Decision Server Insights
- Describe how to monitor WebSphere eXtreme Scale and WebSphere MQ

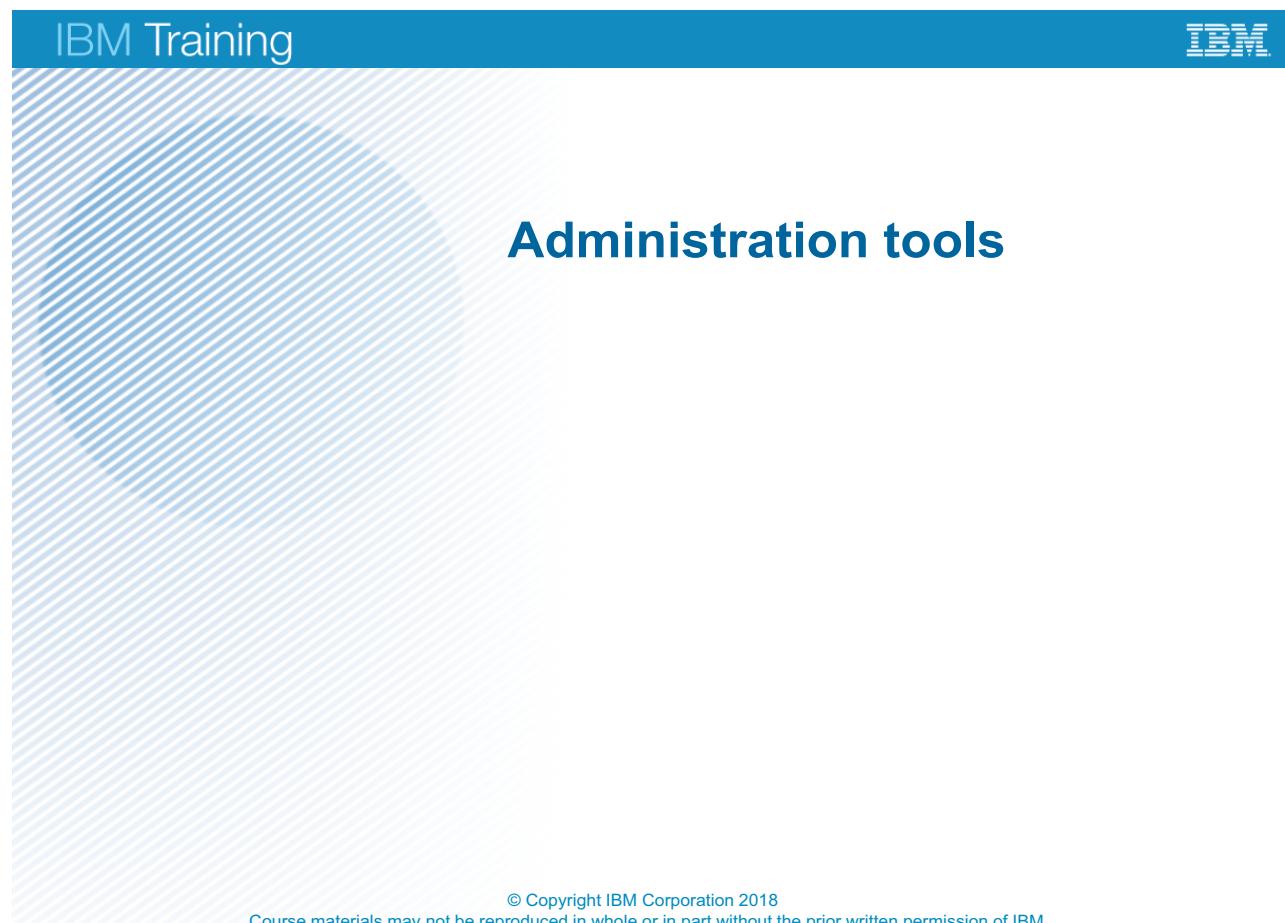
Figure 11-1. Unit objectives

## Topics

- Administration tools
- Logging
- Monitoring WebSphere eXtreme Scale
- Monitoring WebSphere MQ

*Figure 11-2. Topics*

## 11.1. Administration tools



*Figure 11-3. Administration tools*

## Liberty profile monitoring

- JVM monitoring
  - Use the JvmStats MXBean for JVM monitoring in the Liberty profile
- ThreadPool monitoring
  - Use a ThreadPool MXBean
- Multiple components monitoring with Insight Monitor
  - Use the `monitor-1.0` feature

Figure 11-4. *Liberty profile monitoring*

Some of the important monitor components that you want to monitor as part of Decision Server Insights and WebSphere eXtreme Scale are JVM and ThreadPool. ThreadPool is critical when you have a large number of partitions on a server or on a single host server. If you have hundreds of partitions per server, thousands of threads are allocated, which can quickly lead to resource contention.

## Server administration scripts

- Decision Server Insights administration scripts to:
  - Deploy and manage solutions
  - Deploy and manage connectivity
  - Manage server properties and activity

Property	Description
<b>propertyManager</b>	Use the propertyManager script to get, set, and manage server properties
<b>connectivityManager</b>	Use the connectivityManager script to generate, deploy, and activate connectivity for your solution
<b>serverManager</b>	Use the serverManager script to pause or shutdown server processes, and check the <code>isonline</code> status for a server
<b>solutionManager</b>	Use solutionManager to deploy and manage solutions across your servers

Figure 11-5. Server administration scripts

Here you see listed some of the administration scripts that you use for managing servers, solutions, and connectivity. You worked with the `solutionManager` and `connectivityManager` scripts during the connectivity and deployment exercises.

For more information about using these scripts, see the “Reference” section of the product documentation.

## Managing servers

- Use `serverManager isonline` command to determine whether a server is running
- Run from the `InstallDir\runtime\ia\bin` directory

```
serverManager isonline [--propertiesFile=properties_file]
[--username=username] [--password=password]
[--host=hostname] [--port=port]
[--keyStoreLocation=keystore_location]
[--keyStorePassword=keystore_password]
[--sslProtocol=sslProtocol]
[--trustStorePassword=truststore_password]
[--trustStoreLocation=truststore_location]
[--disableSSLHostnameVerification=true|false]
```

- Example

```
serverManager isonline --propertiesFile=../etc/
connectionC1.properties
```

Figure 11-6. Managing servers

The `serverManager` script includes the `isonline` command, which checks for running and active local or remote servers. Use the command to identify a local or remote server where you can deploy or activate solutions.

You must provide administrator authentication credentials to run the script. Specify the server host name and port to determine the status of a remote server. You can pass these credentials and server details through a unique `connection.properties` file with the `propertiesFile` parameter.

## Managing server properties

- Use `propertyManager` to set and retrieve server properties and log settings
- Run from the `InstallDir\runtime\ia\bin` directory

```
propertyManager list [--propertiesFile=properties_file]
[--username=username] [--password=password]
[--host=hostname] [--port=port]
[--keyStoreLocation=keystore_location]
[--keyStorePassword=keystore_password]
[--sslProtocol=sslProtocol]
[--trustStorePassword=truststore_password]
[--trustStoreLocation=truststore_location]
[--disableSSLHostnameVerification=true|false]
```

- Example

```
propertyManager list --propertiesFile=../etc/
connectionC1.properties
```

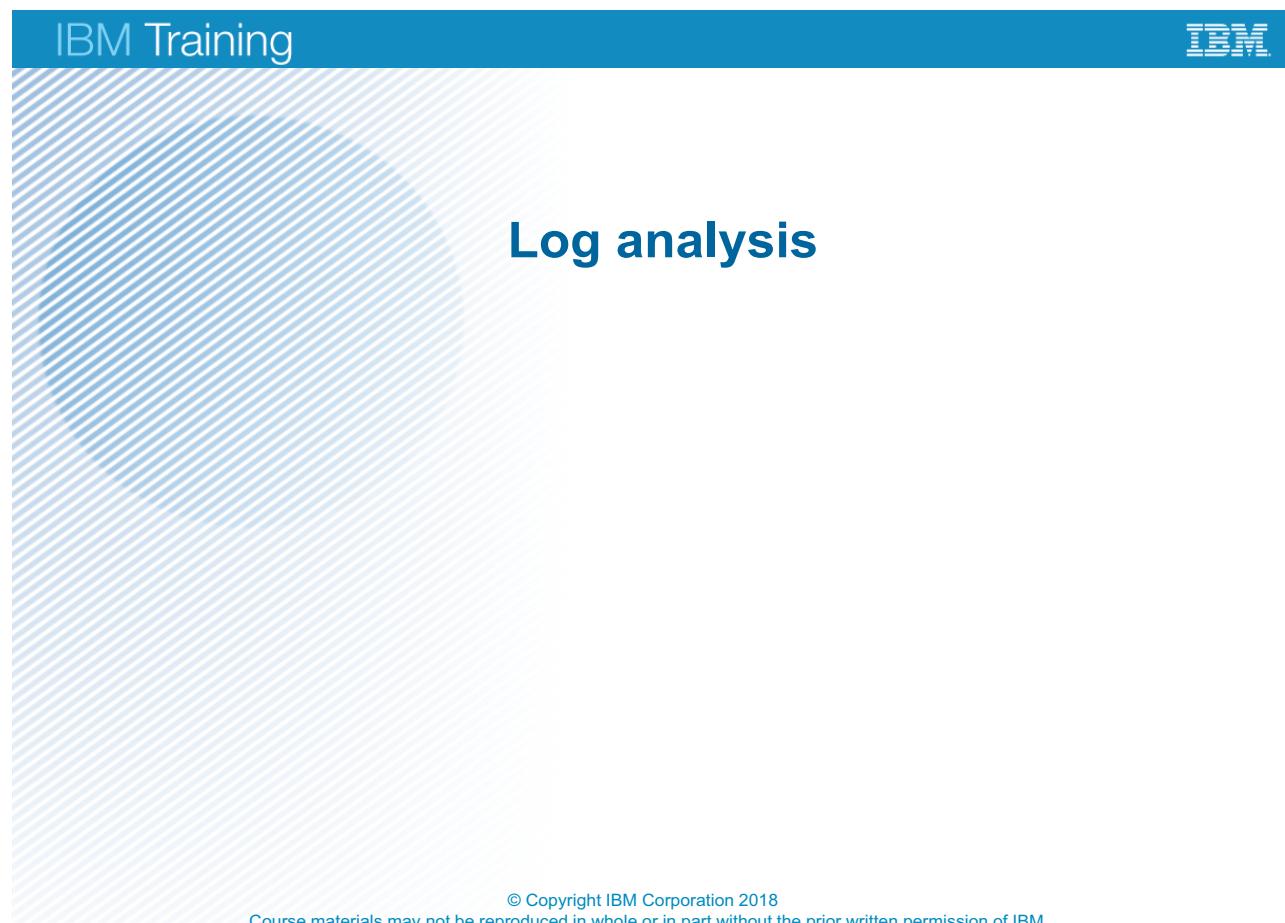
*Figure 11-7. Managing server properties*

You use the `propertyManager` script to manage log settings and server properties. This script includes the `list` command to list which properties can be set on your server.

To view the list of properties that you can set with the `propertyManager` script, run the `list` command.

As with the `serverManager` script, you can pass credentials and server details through a unique `connection.properties` file with the `propertiesFile` parameter.

## 11.2. Log analysis



*Figure 11-8. Log analysis*

## Why are log files important?

- Runtime components (Insights Runtime, eXtreme Scale, Rule Engine, Connectivity) all log to the Liberty server logs
- The processing of an “update account” event on the Getting Starting solution in a cisDev server: about 1000 lines in the `trace.log` file
  - The answer is likely to be within those lines
- Key information for finding your way in the logs:
  - JSON serialization of events and entities
  - Keywords to spot the processing by agents and rules
- Beware of null handling in rule agents, prevents NPE but renders rules silent

*Figure 11-9. Why are log files important?*

Log analysis for runtime components is essential for troubleshooting. The runtime components, including the Insights runtime, Extreme Scale, the rule engine, and connectivity all log to the Liberty server logs. You need to go through these logs when you run into problems.

The trace log is verbose. For example, say that you run the Getting Started tutorial solution that is provided with the product and you check the logs after processing just one event. For the update account event, the log generates about 1000 lines. Your answer to a problem is probably in that log, but it can be difficult to go through it. You can use something like the JSON serialization of events and entries to make the log more readable. Or if you search for the processing that is done by agents and rules, you can use keywords to help focus your search.

If you look for the execution of a specific rule but you cannot find that rule in the log (as if the execution did not happen), the reason might be a Null Pointer Error (NPE). The rule might have been called, then silently ignored because the entity that it was supposed to test either did not exist or was not initialized. Keep in mind that an NPE might have occurred, which would be why you cannot find the execution log entry for the specific rule.

## Where and what to gather

- The `trace.log` and First Failure Data Capture (FFDC) files
- Also, collect the configuration files of the servers:

```
wlp/
+-usr/
 +-servers/
 +-<my_server>
 +-grids/
 +-bootstrap.properties
 +-jvm.options
 +-server.xml
 +-logs/
```

- Collect these files for each server of the grid

Figure 11-10. Where and what to gather

When you gather files for troubleshooting, make sure that you include the trace log and the FFDC files.

FFDC files capture the exception stack and any additional data that is generated when an exception error occurs. For example, if an NPE occurs, it generates an FFDC record.

Along with the trace log and FFDC files, you should also gather the configuration files that you see listed here for all your runtime nodes.

## Log analysis

- To search for incoming events: the keyword is "**received [event]**"
- To search for the agent that is processing the event: the keyword is "**begin processing**"
- Note the ThreadID: **000001ae**
  - It differentiates agents that are processing events simultaneously
- Bound entity, if any, is visible a few lines before
  - The keyword is "**retrieved entity**"
- Exception in the action part: generates an FFDC
- What if you do not see the "Rule [...] execution started"?
  - "Null handling" might be responsible
  - In conditions of the rules, any potential NPE is detected and makes the condition false

*Figure 11-11. Log analysis*

To help you analyze the log, you can search for these keywords.

Examples:

- To see incoming events, you can search with the keywords: **received [events]**
- To find a bound entity, you can search: **retrieved entity**
- To the start point for where an agent processes and event, use the keywords: **begin processing**

Pay attention to the thread ID, which distinguishes agents that work simultaneously.

- If you need to find a particular rule execution, you can search: **Rule [...] execution started**
- If the execution does not exist, remember it might be due to an NPE. You need to find entity value before that agent starts processing, the agent that calls your missing rule, and check the value of that entity before the execution should start.

## Log and trace files

- Use these files to monitor the activity and status of your servers

File	When to use	Supported tasks
<code>console.log</code>	<p>Use to view standard process output and error messages from the runtime environment, for run and debug actions.</p> <p>Messages are redirected to the <code>server_name/logs/console.log</code> file when you start the server.</p>	<p>View a message that confirms that a solution is deployed and ready to use, for example: CWMBD0060I: Solution ConnectivitySolution-0.1 ready</p> <p>View other standard process output and error messages.</p>
<code>messages.log</code>	Use to view operational messages and information that is generated by the system.	<p>View INFO, AUDIT, WARNING, ERROR, and FAILURE messages.</p> <p>View time stamps and the IDs of issuing threads.</p>
<code>trace.log</code>	Use to gather and view debug information.	Gather and view debug information that is obtained by basic, enhanced, or advanced tracing.

Figure 11-12. Log and trace files

On this slide, you see some of the main files that you use to monitor the activity and status of your servers.

For more information, see “Trace and logging” in the WebSphere Application Server, Liberty core documentation.

## Server log settings

Attribute	Description
<code>maxFileSize</code>	If an enforced maximum file size exists, this setting is used to determine how many of each of the log files are kept. This setting also applies to the number of exception logs that summarize exceptions that occurred on any particular day. The default value is 2.  <b>Note:</b> <code>maxFiles</code> does not apply to the <code>console.log</code> file.
<code>consoleLogLevel</code>	This filter controls the granularity of messages that go to the <code>console.log</code> file. The valid values are INFO, AUDIT, WARNING, ERROR, and OFF. The default level is AUDIT.
<code>traceSpecification</code>	This attribute controls the format of the trace log. The default format for the Liberty profile is ENHANCED. You can also use BASIC and ADVANCED formats as in the full profile.

Figure 11-13. Server log settings

The logging component can be controlled through the server configuration. The primary location for the logging configuration is in the `server.xml` file. Occasionally, you might need to configure trace to diagnose a problem that occurs before the `server.xml` file is processed. In this case, the equivalent configuration properties can be specified in the `bootstrap.properties` file. If a configuration property is specified in both the `bootstrap.properties` file and the `server.xml` file, the value in `bootstrap.properties` is used until the `server.xml` file is processed. Then, the value in the `server.xml` file is used. Avoid specifying different values for the same configuration property in both the `bootstrap.properties` and the `server.xml` file.

You can set logging properties in the server configuration file by selecting **Logging and Tracing** in the Server Configuration view in the developer tools. You can also add a logging element to the server configuration file as follows:

```
<component> = <level>
```

In this case, `<component>` is the component for which to set a log detail level, and `<level>` is one of the valid log levels (off, fatal, severe, warning, audit, info, config, detail, fine, finer, finest, all). Separate multiple log detail level specifications with colons (:).

For more information, see “Trace and logging” in the WebSphere Application Server, Liberty core documentation.

## Server log settings

- Default log levels are set for each server type
- The following `server.xml` elements define the default log levels for each server type

Server type	Log level
<b>cisDev</b> (default development server)	<code>&lt;logging traceSpecification="*=info" maxFiles="5" /&gt;</code>
<b>cisCatalog</b>	<code>&lt;logging traceSpecification="*=info" maxFiles="5" /&gt;</code>
<b>cisContainer,</b> <b>cisInbound,</b> <b>cisOutbound</b>	<code>&lt;logging traceSpecification="com.ibm.ia.*=info:com.ibm.rules.*=info:*=info" maxFiles="5" /&gt;</code>

- You can set the logging level to one of the following values:  
`severe, warning, audit, info, fine, finer, finest, off`

Figure 11-14. Server log settings

You change the level for a log by editing the `server.xml` files, and in some cases the `bootstrap.properties` file.

## Changing log and trace settings

- Edit the trace and logging properties in the `server.xml` file on each of the containers, inbound and outbound servers, and catalogs
  - **Note:** Make a backup of the `server.xml` file before you edit

- Create a trace file for a solution with `messageFileName` parameter to the `<logging>` entry

- Example:

```
<logging
 traceSpecification="com.ibm.rules.generated.dataie.banking
 -scenari.* =detail:com.ibm.ia.*=warning:
 com.ibm.ia.runtime.SolutionProviderMgr=finest:com.ibm.rule
 s.*=info:*=warning" maxFiles="10"
 messageFileName="bankingSolutionMessags.log"/>
```

*Figure 11-15. Changing log and trace settings*

To change log settings for your grid, you edit the `server.xml` files for each of the containers, the inbound and outbound servers, and the catalogs. You can make these changes while the servers are running. You do not need to restart the servers because the changes are detected and applied automatically.

To generate more extensive traces of a solution, you can add or modify logging entries in the `server.xml` file. For example, you can create a trace file to capture logs for a particular solution by adding the `messageFileName` parameter. You can also increase the number of files that are generated for each log by setting the `maxFiles` parameter. If you increase this number to 10, for example, you might have 10 message logs, 10 trace logs, and 10 exception summaries in the `ffdc` directory. The trace file is created only if you enable additional trace.

## Finding troubleshooting information in log and trace files

- Analyze the `trace.log` and `messages.log` files
- Search for key phrases

Key phrase	Information
<code>received event_name</code>	ID, timestamp, and other attributes of an incoming event
<code>begin processing</code>	Agent processing activity
<code>retrieved entity</code>	Class name, ID, and other attributes of a bound entity
<code>rule rule_name execution started</code>	Rule processing and output

Figure 11-16. Finding troubleshooting information in log and trace files

## Server administration properties

- Server properties include the following properties

Property	Description	Default
<b>debugPort</b>	Indicates one or more ports that the server monitors for connections from a test driver instance. The value is a single port, or a range or ports, which matches the <code>httpport</code> property as specified in the <code>testdriver.properties</code> file.	None
<b>LogSuppressionThreshold</b>	Defines the number of occurrences of any log message that is allowed in a specified time period. The value of this property determines the number of times a log message is produced before it is suppressed.	10
<b>LogSuppressionThresholdPeriod</b>	Defines the time period during which log messages are counted. A log message rate is calculated from the value of the log threshold and the time period for the threshold. When the message rate is deemed too high, all subsequent messages are suppressed. Messages are produced again only when the rate falls to an acceptable volume.	20000

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Figure 11-17. Server administration properties

The `propertyManager set` command sets properties that modify the behavior and characteristics of the server. The properties apply across to all solutions on the server.

In the development environment, the `<ia runtime>` entry might include the `debugPort` property and `solutionAutoStart="true"`.

```
<ia_runtime debugPort="6543" solutionAutoStart="true"/>
```

You can use the `LogSuppressionThreshold` to limit the number of times a log message is produced before it is suppressed. For example, you can reduce the threshold from 10 to 2. This value means that after 2 log messages are generated within the threshold period, subsequent messages are suppressed.

You can also change other values, such as `LogSuppressionThresholdPeriod`, which defines the time period over which log messages are counted. The default is 20000 ms. If you increase this value, the same number of messages are produced, but over a longer period. As a result, you receive fewer messages.

## 11.3. Monitoring WebSphere eXtreme Scale

## Monitoring WebSphere eXtreme Scale

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Figure 11-18. Monitoring WebSphere eXtreme Scale

## WebSphere eXtreme Scale: xscmd

- The `xscmd` utility displays textual information about the grid topology
  - Make sure that catalog servers and container servers are started before using this tool
  - If your catalog servers are set up with majority quorum enabled, at least two catalog servers must be started

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Figure 11-19. WebSphere eXtreme Scale: `xscmd`

With `xscmd`, you can display textual information about your Decision Server Insights WebSphere eXtreme Scale grid topology.

You can use a number of tools and techniques to determine what is happening in an eXtreme Scale environment during run time.

As mentioned earlier, you want to monitor the JVM and ThreadPool, especially when you have a large number of partitions that are on a single host server to avoid resource contention.

## Obtaining a grid map sizes report

- Use the `xscmd showMapSizes` command to get a report of the number, distribution, and size of objects in the WebSphere eXtreme Scale maps
- Run the following command from the `/wlp/bin` directory:

```
xscmd -c showMapSizes -cep localhost:2810 -user
admin -pwd ins1ghts -ts
C:\IBM\ODMInsights810\runtime\wlp\usr\servers\
cisCatalog1\resources\security\key.jks -tsp ins1ghts
> out.txt
```

- Hostname and port are specific to the catalog server
- The default is localhost:2809
- On Linux, use `xscmd.sh`

Figure 11-20. Obtaining a grid map sizes report

The `xscmd showMapSizes` command generates a report that is important for problem diagnosis, memory sizing, and understanding the distribution of data in the grid, so it's helpful to use this tool early in the solution development process.

The `showMapSizes` report includes the number, distribution, and size of objects in the eXtreme Scale maps. Map data can be useful to identify artifacts that use large amounts of memory or an uneven distribution of artifacts due to hot entities. This data is also useful for memory sizing. During solution development, you can use map data to get an early idea of the size and number of entities, events, and scheduled events.

## Monitoring that containers and catalogs are communicating

- To verify whether the catalogs are running, use the `xscmd routetable` command
- Example:

```
xscmd -c routetable -cep localhost:2810 -user admin -pwd
insights -ts
C:\IBM\ODMInsights810\runtime\wlp\usr\servers\cisCatalog1\
resources\
security\key.jks -tsp insights > out.txt
```

- This command returns the list of containers that are associated with the catalog service and the route table of partitions

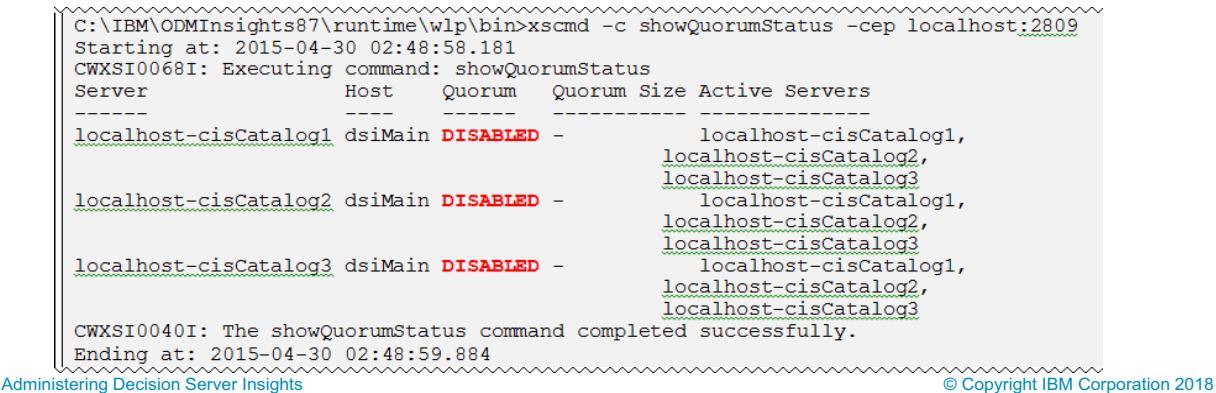
Figure 11-21. Monitoring that containers and catalogs are communicating

You can use the extreme scale `xscmd` utility to verify that all your servers are running.

As you see here, you can use the `routetable` command to verify that the catalogs and containers are communicating. This command also lists all the partitions on the container servers.

## Monitoring the status of quorum (1 of 2)

- To verify the status of your catalogs, use the `xscmd showQuorumStatus` command
  - Example:
- ```
xscmd -c showQuorumStatus -cep localhost:2810 -user admin
-pwd insights -ts C:\IBM\ODMInsights810\runtime\wlp\usr\
servers\cisCatalog1\resources\security\key.jks -tsp
insights > out.txt
```
- This command returns the status of the catalogs that are associated with the catalog service



```
C:\IBM\ODMInsights87\runtime\wlp\bin>xscmd -c showQuorumStatus -cep localhost:2809
Starting at: 2015-04-30 02:48:58.181
CWXSI0068I: Executing command: showQuorumStatus
Server          Host   Quorum  Quorum Size Active Servers
-----
localhost-cisCatalog1  dsiMain DISABLED -      localhost-cisCatalog1,
localhost-cisCatalog2, 
localhost-cisCatalog3
localhost-cisCatalog2, 
localhost-cisCatalog3
localhost-cisCatalog3, 
localhost-cisCatalog1,
localhost-cisCatalog2,
localhost-cisCatalog3
CWXSI0040I: The showQuorumStatus command completed successfully.
Ending at: 2015-04-30 02:48:59.884
```

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Figure 11-22. Monitoring the status of quorum (1 of 2)

Here, you see an example of running the eXtreme Scale utility to check quorum status. The `showQuorumStatus` command returns the status of all catalogs that are associated with this catalog service.

In this example, three catalogs are in the service, but quorum is disabled.

Monitoring the status of quorum (2 of 2)

- Quorum includes these statuses:

| Status | Descriptions |
|-------------|--|
| TRUE | The server has quorum enabled and the system is working normally.
Quorum is met. |
| FALSE | The server has quorum enabled, but quorum is lost. The catalog servers do not allow changes to the catalog service domain. |
| UNAVAILABLE | The server cannot be contacted. It is either not running, or the server cannot be reached because of a network problem. |
| DISABLED | The server does not have quorum enabled. |

Figure 11-23. Monitoring the status of quorum (2 of 2)

This slide shows a list of quorum statuses that you can expect to see for your catalog servers. Later, during the exercises, you learn how to enable majority quorum.

11.4. Using Insight Monitor

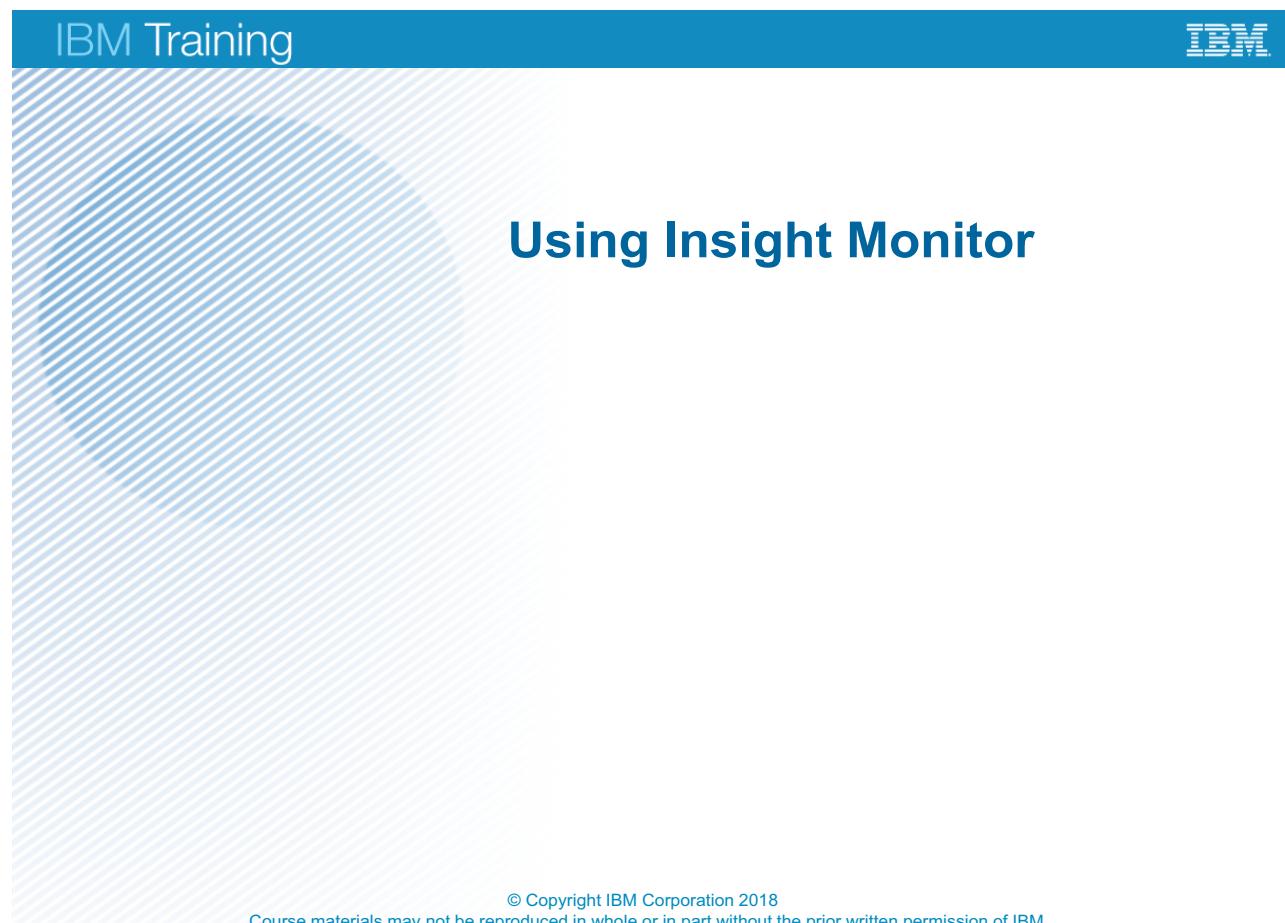
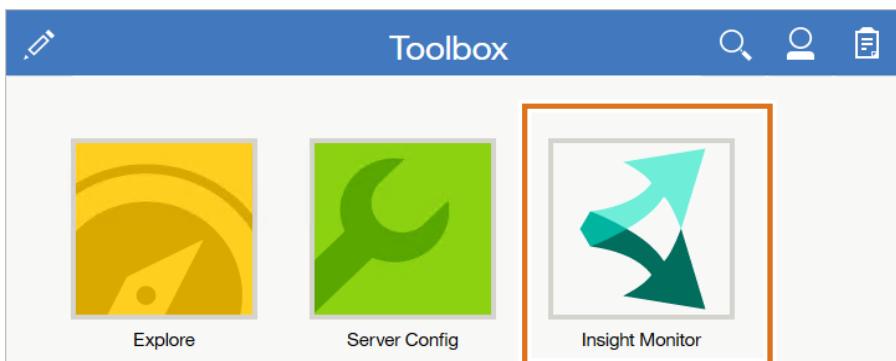


Figure 11-24. Using Insight Monitor



Overview

- Web interface for administrators
 - View event rates
 - Monitor CPU and memory usage on all runtime servers
 - Check system health
- Implemented as a tool in the Liberty admin center



- Launch URL: <http://hostname:port/adminCenter>

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Figure 11-25. Overview

Insight Monitor provides a browser-based interface for administrators to monitor event activity and system health.

Insight Monitor is implemented as a tool in the Liberty Admin Center.

Enabling Insight Monitor

- Not enabled by default
- Enable Liberty admin center feature on catalog server by adding feature to `server.xml`

```
<feature>ia:iaAdminCenter-8.10.0</feature>
```

- Enable Liberty monitor feature on each container server by adding feature to `server.xml`

```
<feature>monitor-1.0</feature>
```

Figure 11-26. Enabling Insight Monitor

Insight Monitor is not enabled by default, but requires manual setup. You enable the admin center on the primary catalog server by adding the `adminCenter` feature to the `server.xml` file.

You enable monitoring of each of the runtime servers by adding the `monitor` feature to the `server.xml` files for the container servers, the remaining catalog servers, and the inbound and outbound servers.

Authentication between catalog and container servers

- Certificate-based authentication
 - Use keytool
 - Export certificate from catalog/container server
 - Import certificate to each container/catalog server
 - Add `clientAuthenticationSupported="true"` attribute to the `<ssl>` tag to each catalog and container server
- User name and password authentication
 - Set in `server.xml` of catalog server
 - Add `<ia_admincenter>` tag

```
<ia_admincenter
    http.ssl.config="defaultSSLConfig"
    user="tester"
    password="tester" />
```

- You can also use this tag to set non-default port values

Figure 11-27. Authentication between catalog and container servers

To enable authentication between the catalog and container servers, you can use these methods:

- Certificate-based authentication, by using the Java keytool
- User name and password by using the `ia_admincenter` tag

When you use the `ia_admincenter` tag to define the user name and password authentication, these properties are required:

- `http.ssl.config`
- `user`
- `password`

You can also use the `ia_admincenter` tag to define other properties, such as non-default port values. For example:

```
<ia_admincenter
    http.ssl.config="defaultSSLConfig"
    user="tester"
    password="tester"
    alternate.ports="serverX:9443,serverY:9442" />
```

IBM Training



Monitoring events

- Monitor event distribution, count, or rates of occurrence

Insight Monitor

Event Memory CPU

Total Count ▼

Event Types: All ▾

Accumulated count of events processed since the server was started.

| Server | Event Type | Count |
|--------------------------|---|-------|
| All Servers | TranslationAgent | 10 |
| All Servers | ProductRecommendation | 2 |
| All Servers | banking_scenario_agent_fraud_detection | 3 |
| All Servers | CheckAccountEvent | 3 |
| All Servers | banking_scenario_agent_product_recom... | 5 |
| All Servers | CheckAccountEvent | 3 |
| All Servers | ProductRecommendation | 2 |
| container1-cisContainer1 | TranslationAgent | 10 |
| container1-cisContainer1 | ProductRecommendation | 2 |
| container1-cisContainer1 | banking_scenario_agent_fraud_detection | 3 |
| container1-cisContainer1 | CheckAccountEvent | 3 |
| container1-cisContainer1 | banking_scenario_agent_product_recom... | 5 |
| container1-cisContainer1 | CheckAccountEvent | 3 |
| container1-cisContainer1 | ProductRecommendation | 2 |

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Figure 11-28. Monitoring events

The Events pages display event totals from when the runtime server was started. If a server is restarted, the event count is reset. The event count also includes time triggers, which the system schedules, so it can be higher than expected.

As you see in this example, the Total Count page shows the number of events that are processed per server. This count includes retries of event processing as a result of processing errors.



Monitoring runtime server memory

- Monitor memory consumption on each runtime server

A screenshot of the Insight Monitor interface. At the top, there's a navigation bar with icons for Event, Memory (which is highlighted with an orange border), and CPU. Below the navigation bar, there's a section titled "Memory" with a green icon. The main content area is titled "Memory consumption per server." and contains a table with three rows of data. The table has columns for Used (MB), Free (MB), and Total (MB).

| | Used (MB) | Free (MB) | Total (MB) |
|--------------------------|-----------|-----------|------------|
| container1-cisContainer1 | 2236.6 | 835.7 | 3072 |
| container2-cisContainer2 | 1045.2 | 2027.4 | 3072 |
| container3-cisContainer3 | 826.2 | 2246 | 3072 |

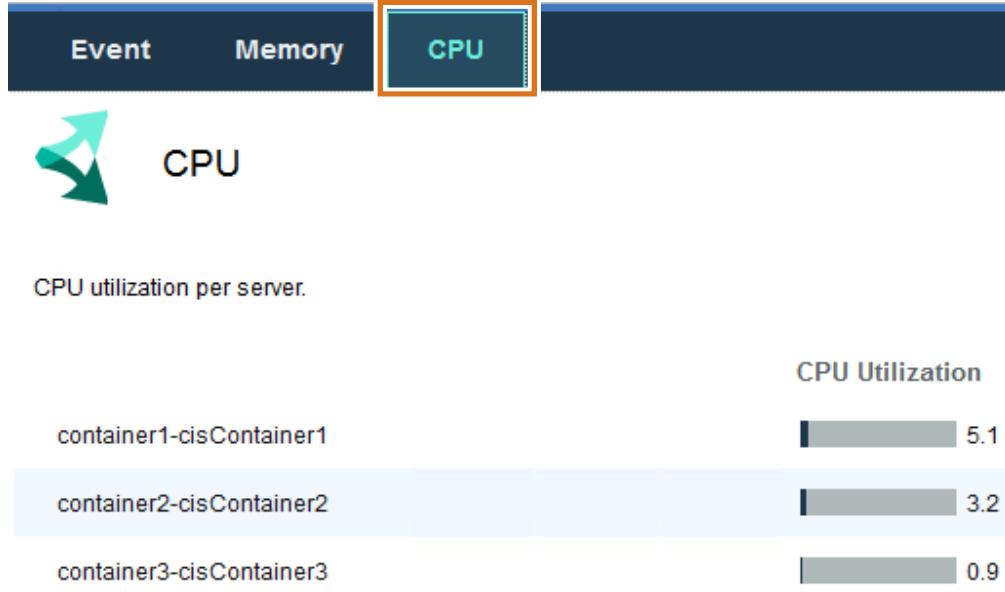
Figure 11-29. Monitoring runtime server memory

The Memory page lists the memory usage for each runtime server.

Use the information on this page to determine whether the system is running low on Java heap. If the memory usage is near the configured amount, you might want to add more RAM and increase the size of the Java virtual machines.

Monitoring CPU

- Monitor memory consumption on each runtime server



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Figure 11-30. Monitoring CPU

The CPU page shows a view of CPU utilization on each runtime server.

Use this page to determine whether the system is running efficiently. If the system has a high event rate, the CPU utilization must be near 100%, which indicates that the system is processing the backlog of events as quickly as possible.

11.5. Monitoring WebSphere MQ

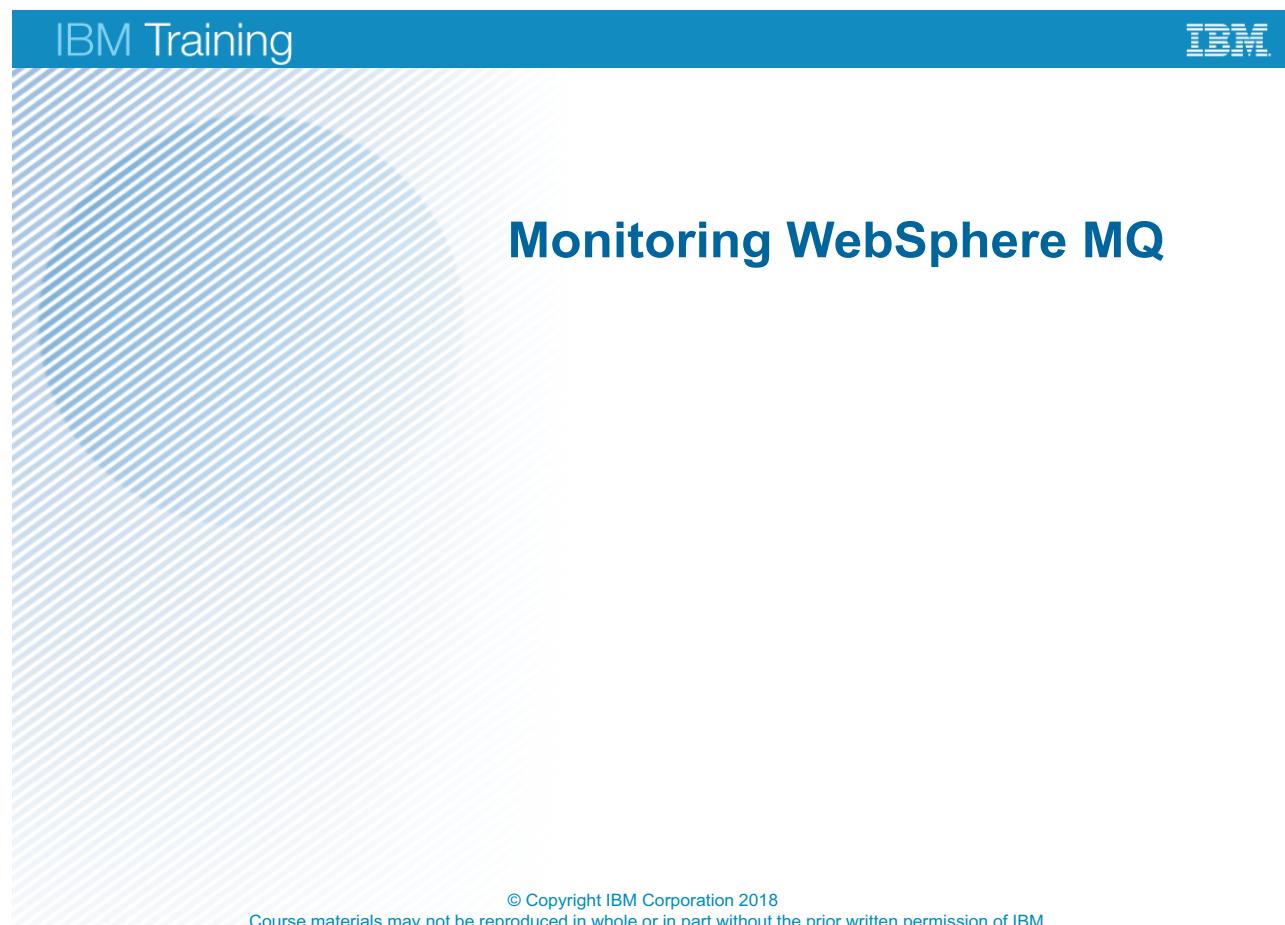


Figure 11-31. Monitoring WebSphere MQ

Tracing the WebSphere MQ resource adapter (1 of 2)

| Property | Description | Default |
|-------------------------|---|---------|
| logWriterEnabled | A flag to enable or disable the sending of a diagnostic trace to a LogWriter object provided by the application server. If the value is true, the trace is sent to a LogWriter object instead of the location that is specified by the <code>traceDestination</code> property. If the value is false, any LogWriter object that is provided by the application server is not used. | False |
| traceEnabled | A flag to enable or disable diagnostic tracing. If the value is false, tracing is turned off. If the value is true, a trace is sent to the location specified by the <code>traceDestination</code> property. | False |
| traceDestination | The location to where a diagnostic trace is sent <ul style="list-style-type: none"> If the value is <code>System.err</code>, the trace is directed to the system error stream instead of a file If the value is <code>System.out</code>, the trace is directed to the system output stream Example: <code>/tmp/wmq_jca.trace</code> <p>Note: If <code>logWriterEnabled</code> is set to True, the log redirects to the LogWriter</p> | |

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Figure 11-32. Tracing the WebSphere MQ resource adapter (1 of 2)

With the WebSphere MQ resource adapter, you can configure diagnostic trace as a property on the resource adapter. The resource adapter RAR file contains a file that is called `META-INF/ra.xml`, which contains a deployment descriptor for the resource.

To change the behavior of the log and the settings, you must change the `ra.xml` that is included in the `wmq.jmsra.rar` file.

You extract the files to locate the `ra.xml` file in the **META-INF** folder. After you make the change, you replace the `ra.xml` file back in the `wmq.jmsra.rar` file.

Tracing the WebSphere MQ resource adapter (1 of 2)

- Example

```

<config-property>
  <config-property-name>logWriterEnabled</config-property-name>
  <config-property-type>java.lang.String</config-property-type>
  <config-property-value>false</config-property-value>
</config-property>
<config-property>
  <config-property-name>traceEnabled</config-property-name>
  <config-property-type>java.lang.String</config-property-type>
  <config-property-value>true</config-property-value>
</config-property>
<config-property>
  <config-property-name>traceLevel</config-property-name>
  <config-property-type>java.lang.String</config-property-type>
  <config-property-value>6</config-property-value>
</config-property>
<config-property>
  <config-property-name>traceDestination</config-property-name>
  <config-property-type>java.lang.String</config-property-type>
  <config-property-value>/tmp/wm_jca.trace</config-property-value>
</config-property>

```

Figure 11-33. Tracing the WebSphere MQ resource adapter (1 of 2)

In the example that is shown here, the `traceDestination` property is added as the location where the log file should be stored. The `traceLevel` property is changed from 3 (error and warning messages) to 6 (error, warning, and information messages).

For more information, see the IBM Knowledge Center about enabling and changing the trace level for JMS logging and about tracing the WebSphere MQ resource adapter.

Unit summary

- Use administration scripts to monitor status and activity of your servers and grid
- Use trace files and logging to monitor Decision Server Insights
- Describe how to monitor WebSphere eXtreme Scale and WebSphere MQ

Figure 11-34. Unit summary

Review questions

1. You run the Decision Server Insights server administration scripts from which directory:
 - a. <InstallDir>\runtime\ia\bin
 - b. <InstallDir>\runtime\wlp\bin

2. **True or False:** After modifying logging properties in the `server.xml` file for your containers and catalogs, you must restart the servers.

3. **True or False:** You use `xscmd` to manage the WebSphere eXtreme Scale grid.

4. You run the `xscmd` script from which directory:
 - a. <InstallDir>\runtime\ia\bin
 - b. <InstallDir>\runtime\wlp\bin

Figure 11-35. Review questions

Write your answers here:

- 1.

- 2.

- 3.

- 4.

Review answers

1. You run the Decision Server Insights server administration scripts from which directory:
A. <InstallDir>\runtime\ia\bin
2. **True or False:** After modifying logging properties in the `server.xml` file for your containers and catalogs, you must restart the servers.
False. *Changes to the logging properties in the `server.xml` file are automatically applied without restarting the server.*
3. **True or False:** You use `xscmd` to manage the WebSphere eXtreme Scale grid.
True.
4. You run the `xscmd` script from which directory:
B. <InstallDir>\runtime\wlp\bin

Figure 11-36. Review answers

Exercise: Administering Decision Server Insights

Administering Decision Server Insights

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Figure 11-37. Exercise: Administering Decision Server Insights

Exercise introduction

- Monitor and manage the hosts in a Decision Server Insights grid



Administering Decision Server Insights

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Figure 11-38. Exercise introduction

Unit 12. Course summary

Estimated time

00:30

Overview

This unit summarizes the course and provides information for future study.

Unit objectives

- Explain how the course met its learning objectives
- Access the IBM Training website
- Identify other IBM Training courses that are related to this topic
- Locate appropriate resources for further study

[Course summary](#)

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Figure 12-1. Unit objectives

Course objectives

- Describe the Decision Server Insights programming model and architecture
- Design and create a Decision Server Insights solution
- Define the business model for the events, entities, and concepts that are relevant to your domain
- Work with aggregates for calculations across events
- Implement business logic with rule agents and rules to detect and respond to business situations
- Deploy solutions to the Insight Server runtime and test runtime behavior
- Explain Decision Server Insights integration capabilities

[Course summary](#)

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Figure 12-2. Course objectives

Course objectives

- Install, configure, and administer a Decision Server Insights grid environment

[Course summary](#)

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Figure 12-3. Course objectives

To learn more on the subject

- IBM Training website:
www.ibm.com/training
- For more information about Decision Server Insights and decision management
 - Redbooks: *Systems of Insight for Digital Transformation: Using IBM Operational Decision Manager Advanced and Predictive Analytics*
<http://www.redbooks.ibm.com/abstracts/sg248293.html?Open>
 - Redpaper: *Systems of Insight Overview*
<http://www.redbooks.ibm.com/abstracts/redp5299.html?Open>
 - DeveloperWorks tutorial: *Install and configure a Decision Server Insights reference topology*
http://www.ibm.com/developerworks/bpm/bpmjournal/1503_defreitas1/1503_defreitas1.html
 - Kolban's Book on IBM Decision Server Insights
<http://neilkolban.com/ibm/decision-server-insights>

Course summary

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Figure 12-4. To learn more on the subject

Enhance your learning with IBM resources

Keep your IBM Cloud skills up-to-date

- IBM offers resources for:
 - Product information
 - Training and certification
 - Documentation
 - Support
 - Technical information



- To learn more, see the IBM Cloud Education Resource Guide:
 - www.ibm.biz/CloudEduResources

Course summary

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Figure 12-5. Enhance your learning with IBM resources

Unit summary

- Explain how the course met its learning objectives
- Access the IBM Training website
- Identify other IBM Training courses that are related to this topic
- Locate appropriate resources for further study

[Course summary](#)

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Figure 12-6. Unit summary

IBM Training 

Course completion

You have completed this course:
Developing Solutions with IBM Decision Server Insights V8.10
Any questions?



[Course summary](#)

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Figure 12-7. Course completion

Appendix A. List of abbreviations

| | |
|-------------|-------------------------------------|
| ABRD | agile business rule development |
| API | application programming interface |
| ATM | automated teller machine |
| B2X | BOM-to-XOM mapping |
| BAL | Business Action Language |
| BEP | business event processing |
| BERL | Business Event Rule Language |
| BMD | business model definition |
| BOM | business object model |
| BPM | business process management |
| BPMN | Business Process Modeling Notation |
| BQL | Business Query Language |
| BRM | business rule management |
| BRMS | business rule management system |
| CEP | complex event processing |
| CICS | Customer Information Control System |
| CPU | central processing unit |
| CVS | Concurrent Versions System |
| Db | Database |
| DSI | Decision Server Insights |
| DVS | Decision Validation Services |
| DW | Decision Warehouse |
| EAR | enterprise archive |
| EE | Enterprise Edition (Java EE) |
| EJB | Enterprise JavaBeans |
| ERC | edition revision code |
| ESB | enterprise service bus |
| FFDC | First Failure Data Capture |
| GUI | Graphical User Interface |
| HMM | Hidden Markov Models |

| | |
|--------------|---|
| HTML | Hypertext Markup Language |
| HTDS | hosted transparent decision service |
| HTTP | Hypertext Transfer Protocol |
| IBM | International Business Machines Corporation |
| IDE | integrated development environment |
| IIB | IBM Information Bus |
| IP | Internet Protocol |
| IRL | ILOG Rule Language |
| IT | information technology |
| JAR | Java archive |
| JAXB | Java Architecture for XML Binding |
| JCA | Java EE Connector Architecture |
| JDK | Java Development Kit |
| JMS | Java Message Service |
| JMX | Java Management Extension |
| JNDI | Java Naming and Directory Interface |
| JRE | Java Runtime Environment |
| JSON | JavaScript Object Notation |
| JVM | Java virtual machine |
| KPI | key performance indicator |
| LAN | local area network |
| MBean | message bean |
| MDB | message-driven bean |
| MQ | message queue |
| MTDS | monitored transparent decision service |
| NPE | null pointer error |
| ODM | Operational Decision Manager |
| OSGi | Open Services Gateway Initiative |
| POJO | plain old Java object |
| QA | quality assurance |
| RAR | resource adapter archive |
| RES | Rule Execution Server |
| REST | Representational State Transfer |
| RMI | Remote Method Invocation |

| | |
|-------------|--|
| RQL | Rule Query Language |
| RSO | Rule Solutions for Office |
| SCA | Service Component Architecture |
| SCC | source code control |
| SDO | Service Data Object |
| SE | Standard Edition (Java SE) |
| SME | subject matter expert |
| SOA | service-oriented architecture |
| SOAP | Usage note: SOAP is not an acronym; it is a word in itself (formerly an acronym for Simple Object Access Protocol) |
| SPSS | Statistical Product and Service Solutions |
| SSP | Scenario Service Provider |
| TCP | Transmission Control Protocol |
| TRL | Technical Rule Language |
| UI | user interface |
| UML | Unified Modeling Language |
| URI | Uniform Resource Identifier |
| URL | Uniform Resource Locator |
| USB | Universal Serial Bus |
| WADL | Web Application Description Language |
| WAN | wide area network |
| WAR | web archive |
| WDT | WebSphere Developer Tools |
| WSDL | Web Services Description Language |
| WSE | Workgroup Server Edition |
| WTDS | web transparent decision service |
| XML | Extensible Markup Language |
| XOM | execution object model |
| XSD | XML Schema Definition |
| XSLT | Extensible Stylesheet Language Transformation. |
| XU | Execution Unit |
| z/OS | Z Series Operating System |



IBM Training



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