APEX Scenario-Based Processing Guide

Version: 1.0 **Date:** 2025-08-22 **Author:** Mark Andrew Ray-Smith Cityline Ltd

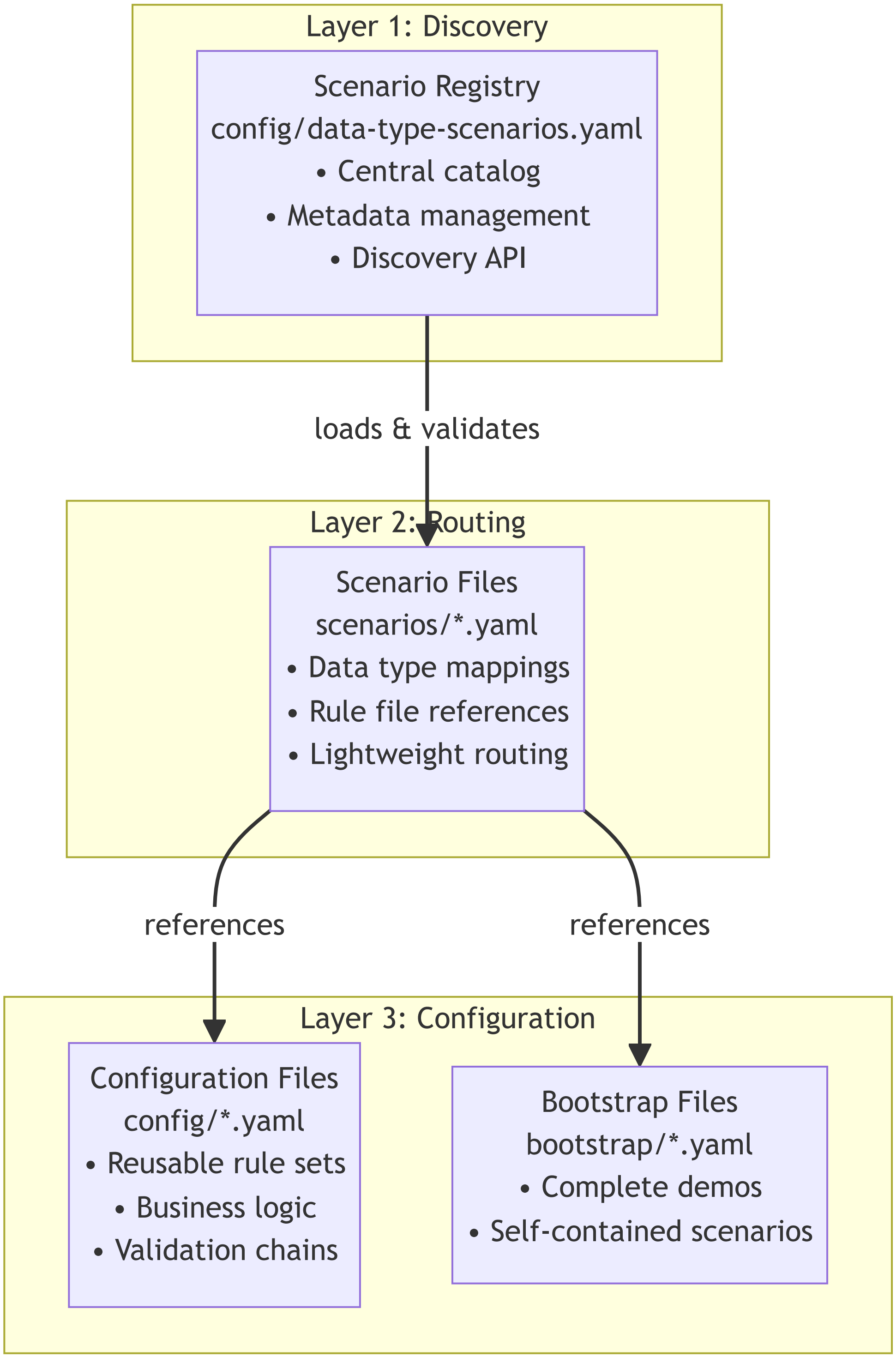
Overview

APEX's scenario-based processing system provides a sophisticated architecture for managing complex rule configurations through centralized management and intelligent routing. This system enables organizations to manage enterprise-scale configurations with type-safe routing, comprehensive dependency tracking, and automatic data type detection.

Architecture Overview

Three-Layer Architecture

APEX scenario-based processing uses a three-layer architecture that separates concerns and provides maximum flexibility:



Key Benefits

Centralized Management

- **Single Registry**: One place to discover all available scenarios
- **Metadata Management**: Rich metadata for governance and compliance
- **Version Control**: Complete change tracking and rollback capabilities
- **Discovery API**: Programmatic access to scenario information

Type-Safe Routing

- **Automatic Detection**: Intelligent data type detection based on object structure
- **Flexible Mapping**: Support for multiple scenarios per data type
- **Fallback Handling**: Graceful degradation for unknown data types
- **Performance Optimization**: Efficient routing with minimal overhead

Lightweight Configuration

- **Separation of Concerns**: Routing logic separate from business logic
- **Reusable Components**: Rule configurations can be shared across scenarios
- **Easy Maintenance**: Simple scenario files that are easy to understand and modify
- **Scalable Architecture**: Supports large numbers of scenarios and data types

Core Components

1. Scenario Registry

The scenario registry (`config/data-type-scenarios.yaml`) serves as the central catalog for all available scenarios:

```yaml
metadata:
  name: "APEX Data Type Scenarios Registry"
  version: "1.0.0"
  description: "Central registry for all data type processing scenarios"
  type: "scenario-registry"
  created-date: "2025-08-22"
  created-by: "system.admin@company.com"

scenarios:
  - scenario-id: "otc-options-standard"
    name: "OTC Options Standard Processing"
    description: "Complete validation and enrichment pipeline for OTC Options"
    data-types: ["OtcOption", "dev.mars.apex.demo.data.OtcOption"]
    scenario-file: "scenarios/otc-options-standard.yaml"
    business-domain: "Derivatives Trading"
    risk-category: "Medium"
    enabled: true

  - scenario-id: "commodity-swaps-standard"
    name: "Commodity Swaps Standard Processing"
    description: "Multi-layered validation for commodity derivatives"
    data-types: ["CommodityTotalReturnSwap", "dev.mars.apex.demo.data.CommodityTotalReturnSwap"]
    scenario-file: "scenarios/commodity-swaps-standard.yaml"
    business-domain: "Commodities Trading"
    risk-category: "High"
    enabled: true

  - scenario-id: "settlement-auto-repair"
    name: "Settlement Auto-Repair"
    description: "Intelligent auto-repair for failed settlement instructions"
    data-types: ["SettlementInstruction", "dev.mars.apex.demo.data.SettlementInstruction"]
    scenario-file: "scenarios/settlement-auto-repair.yaml"
    business-domain: "Post-Trade Settlement"
    risk-category: "High"
    enabled: true
```

2. Scenario Files

Individual scenario files (`scenarios/*.yaml`) provide lightweight routing between data types and rule configurations:

```yaml
metadata:
  name: "OTC Options Standard Processing Scenario"
  version: "1.0.0"
  description: "Associates OTC Options with existing rule configurations"
  type: "scenario"
  business-domain: "Derivatives Trading"
  owner: "derivatives.team@company.com"

scenario:
  scenario-id: "otc-options-standard"
  data-types:
    - "OtcOption"
    - "dev.mars.apex.demo.data.OtcOption"

  processing-pipeline:
    validation-config: "config/otc-options-validation.yaml"
    enrichment-config: "config/otc-options-enrichment.yaml"

  routing-rules:
    - condition: "#data.optionType == 'Call'"
      config-override: "config/call-options-specific.yaml"
    - condition: "#data.underlyingAsset.assetClass == 'Energy'"
      enrichment-override: "config/energy-commodities-enrichment.yaml"
```

3. Configuration Files

Rule configuration files (`config/*.yaml`) contain the actual business logic and can be reused across multiple scenarios:

```yaml
metadata:
  name: "OTC Options Validation Rules"
  version: "1.0.0"
  description: "Comprehensive validation rules for OTC Options"
  type: "rule-config"

rules:
  - id: "option-type-validation"
    name: "Option Type Validation"
    condition: "#optionType == 'Call' || #optionType == 'Put'"
    message: "Option type must be either 'Call' or 'Put'"

  - id: "strike-price-validation"
    name: "Strike Price Validation"
    condition: "#strikePrice != null && #strikePrice > 0"
    message: "Strike price must be positive"

  - id: "expiration-date-validation"
    name: "Expiration Date Validation"
    condition: "#expirationDate != null && #expirationDate.isAfter(T(java.time.LocalDate).now())"
    message: "Expiration date must be in the future"

enrichments:
  - id: "underlying-asset-enrichment"
    type: "lookup-enrichment"
    condition: "#underlyingAsset != null"
    lookup-config:
      lookup-dataset:
        type: "inline"
        key-field: "assetName"
        data:
          - assetName: "Natural Gas"
            assetClass: "Energy"
            exchange: "NYMEX"
            quoteCurrency: "USD"
          - assetName: "Brent Crude Oil"
            assetClass: "Energy"
            exchange: "ICE"
            quoteCurrency: "USD"
```

Data Type Detection and Routing

Automatic Data Type Detection

APEX automatically detects data types using multiple strategies:

1. Class Name Detection

```
// Direct class name matching
if (data.getClass().getSimpleName().equals("OtcOption")) {
    return getScenario("otc-options-standard");
}
```

2. Fully Qualified Class Name Detection

```
// Full package and class name matching
if (data.getClass().getName().equals("dev.mars.apex.demo.data.OtcOption")) {
    return getScenario("otc-options-standard");
}
```

3. Interface-Based Detection

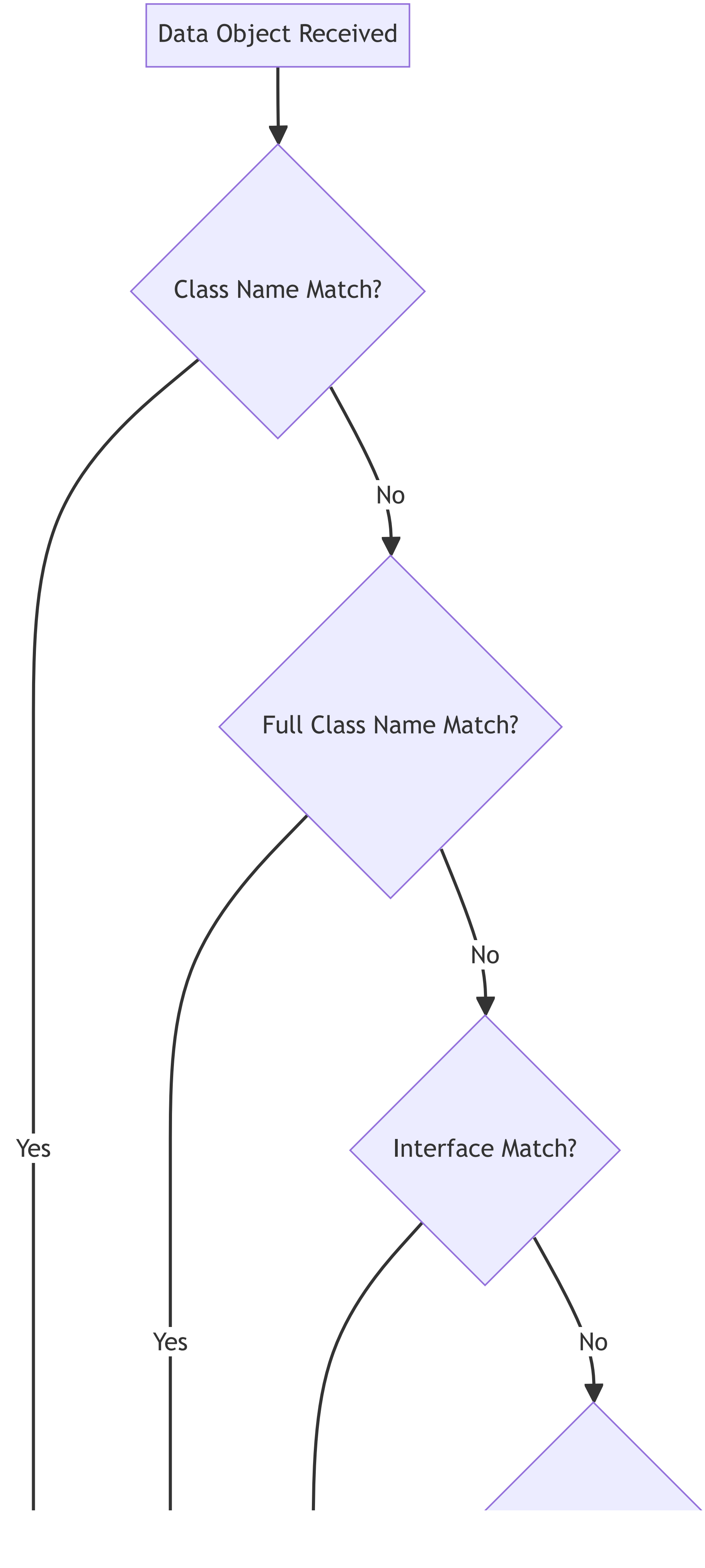
```
// Interface implementation detection
if (data instanceof FinancialInstrument) {
    return getScenarioForInterface("FinancialInstrument");
}
```

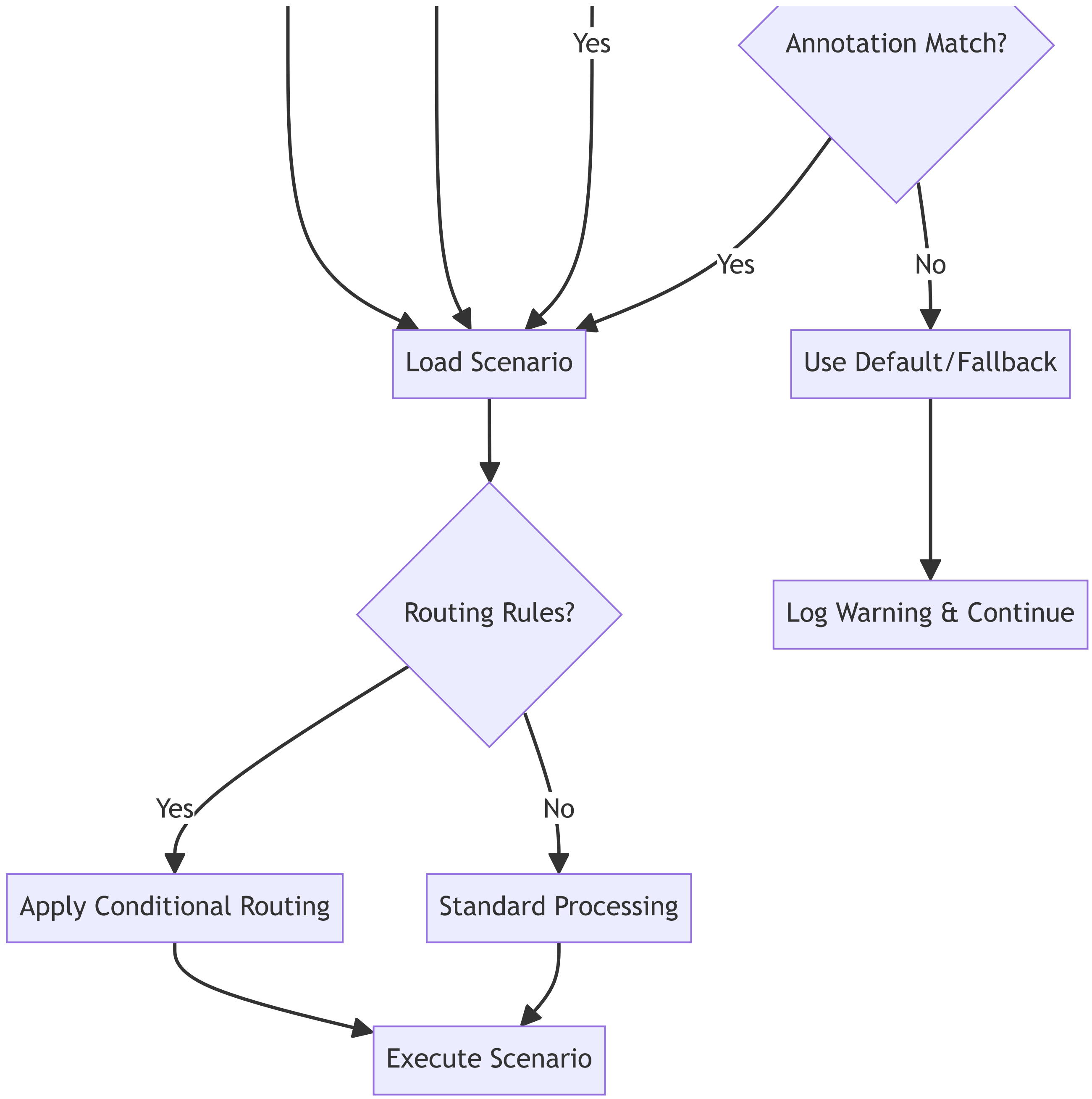
4. Annotation-Based Detection

```
// Custom annotation detection
@ScenarioMapping("otc-options-standard")
public class OtcOption {
    // Class implementation
}
```

Routing Logic

The routing engine follows this decision tree:


Data Object Received
Class Name Match?
No
Yes
Full Class Name Match?
No
Yes
Interface Match?
No



Conditional Routing

Scenarios can include conditional routing rules that modify processing based on data content:

```yaml
routing-rules:
  - condition: "#data.notionalAmount > 10000000"
    config-override: "config/high-value-validation.yaml"
    enrichment-override: "config/enhanced-enrichment.yaml"

  - condition: "#data.counterparty.riskRating == 'HIGH'"
    validation-override: "config/high-risk-validation.yaml"

  - condition: "#data.jurisdiction == 'US'"
    compliance-config: "config/us-regulatory-compliance.yaml"
```

Implementation Patterns

1. Service-Based Implementation

```
@Service
public class DataTypeScenarioService {

    private final ScenarioRegistry scenarioRegistry;
    private final ConfigurationLoader configurationLoader;

    public ScenarioConfiguration getScenarioForData(Object data) {
        String dataType = detectDataType(data);
        ScenarioRegistryEntry entry = scenarioRegistry.getScenarioForDataType(dataType);

        if (entry != null && entry.isEnabled()) {
            return loadScenarioConfiguration(entry);
        }

        return getDefaultScenario();
    }

    private String detectDataType(Object data) {
        // Try class name first
        String className = data.getClass().getSimpleName();
        if (scenarioRegistry.hasDataType(className)) {
            return className;
        }

        // Try full class name
        String fullClassName = data.getClass().getName();
        if (scenarioRegistry.hasDataType(fullClassName)) {
            return fullClassName;
        }

        // Try interfaces
        for (Class<?> iface : data.getClass().getInterfaces()) {
            if (scenarioRegistry.hasDataType(iface.getSimpleName())) {
                return iface.getSimpleName();
            }
        }

        return "Unknown";
    }
}
```

2. Configuration-Driven Processing

```
@Component
public class ScenarioProcessor {

    public ProcessingResult processData(Object data, ScenarioConfiguration scenario) {
        ProcessingResult result = new ProcessingResult();

        // Apply validation rules
        if (scenario.getValidationConfig() != null) {
            ValidationResult validation = validateData(data, scenario.getValidationConfig());
            result.setValidationResult(validation);
        }
        // Apply enrichments
        if (scenario.getEnrichmentConfig() != null) {
            Object enrichedData = enrichData(data, scenario.getEnrichmentConfig());
            result.setEnrichedData(enrichedData);
        }

        // Apply conditional routing
        for (RoutingRule rule : scenario.getRoutingRules()) {
            if (evaluateCondition(rule.getCondition(), data)) {
                applyRoutingOverrides(result, rule);
            }
        }

        return result;
    }
}
```

3. Registry Management

```
@Component
public class ScenarioRegistry {

    private final Map<String, ScenarioRegistryEntry> scenarios = new ConcurrentHashMap<>();
    private final Map<String, List<String>> dataTypeToScenarios = new ConcurrentHashMap<>();

    @PostConstruct
    public void loadRegistry() {
        YamlConfigurationLoader loader = new YamlConfigurationLoader();
        ScenarioRegistryConfiguration config = loader.loadFromClasspath("config/data-type-scenarios.yaml");

        for (ScenarioRegistryEntry entry : config.getScenarios()) {
            scenarios.put(entry.getScenarioId(), entry);

            for (String dataType : entry.getDataTypes()) {
                dataTypeToScenarios.computeIfAbsent(dataType, k -> new ArrayList<>())
                                  .add(entry.getScenarioId());
            }
        }
    }

    public ScenarioRegistryEntry getScenarioForDataType(String dataType) {
        List<String> scenarioIds = dataTypeToScenarios.get(dataType);
        if (scenarioIds != null && !scenarioIds.isEmpty()) {
            // Return first enabled scenario
            return scenarioIds.stream()
                             .map(scenarios::get)
                             .filter(ScenarioRegistryEntry::isEnabled)
                             .findFirst()
                             .orElse(null);
        }
        return null;
    }
}
```

Best Practices

1. Scenario Organization

Keep Scenarios Lightweight

- Scenario files should only contain routing logic and references
- Business logic belongs in configuration files
- Avoid duplicating rules across scenarios

Use Meaningful Names

- Scenario IDs should be descriptive and follow naming conventions
- Include business domain and processing type in names
- Use consistent naming patterns across related scenarios

Organize by Business Domain

```
scenarios/
├── derivatives/
│   ├── otc-options-standard.yaml
│   ├── commodity-swaps-standard.yaml
│   └── interest-rate-swaps-standard.yaml
├── settlement/
│   ├── settlement-auto-repair.yaml
│   ├── settlement-validation.yaml
│   └── settlement-enrichment.yaml
└── regulatory/
    ├── mifid-compliance.yaml
    ├── emir-reporting.yaml
    └── dodd-frank-compliance.yaml
```

2. Configuration Management

Version Control

- Use semantic versioning for all scenario and configuration files
- Maintain compatibility matrices between scenarios and configurations
- Document breaking changes and migration paths

Environment Management

```yaml
environments:
  development:
    scenarios:
      - scenario-id: "otc-options-standard"
        enabled: true
        config-overrides:
          validation-config: "config/dev/otc-options-validation.yaml"

  production:
    scenarios:
      - scenario-id: "otc-options-standard"
        enabled: true
        config-overrides:
          validation-config: "config/prod/otc-options-validation.yaml"
```

Metadata Standards

- Include comprehensive metadata in all files
- Use consistent field names and formats
- Document business purpose and ownership

3. Performance Optimization

Caching Strategy

```
@Service
public class CachedScenarioService {

    @Cacheable("scenarios")
    public ScenarioConfiguration getScenario(String scenarioId) {
        return loadScenarioConfiguration(scenarioId);
    }

    @CacheEvict(value = "scenarios", allEntries = true)
    public void refreshScenarios() {
        // Refresh all cached scenarios
    }
}
```

Lazy Loading

- Load scenario configurations on-demand
- Cache frequently used scenarios
- Implement background refresh for cache warming

Monitoring and Metrics

```
@Component
public class ScenarioMetrics {

    private final MeterRegistry meterRegistry;

    public void recordScenarioExecution(String scenarioId, long duration, boolean success) {
        Timer.Sample sample = Timer.start(meterRegistry);
        sample.stop(Timer.builder("scenario.execution")
                        .tag("scenario", scenarioId)
                        .tag("success", String.valueOf(success))
                        .register(meterRegistry));
    }
}
```

4. Error Handling

Graceful Degradation

```
public ScenarioConfiguration getScenarioWithFallback(Object data) {
    try {
        ScenarioConfiguration scenario = getScenarioForData(data);
        if (scenario != null) {
            return scenario;
        }
    } catch (Exception e) {
        logger.warn("Failed to load scenario for data type: {}", data.getClass().getName(), e);
    }

    // Return default scenario
    return getDefaultScenario();
}
```

Validation and Recovery

- Validate all scenario configurations at startup
- Provide clear error messages for configuration issues
- Implement circuit breaker patterns for external dependencies
- Log all routing decisions for debugging and audit

Integration Examples

Spring Boot Integration

```java
@RestController
@RequestMapping("/api/scenarios")
public class ScenarioController {

    private final DataTypeScenarioService scenarioService;
    private final ScenarioProcessor processor;

    @PostMapping("/process")
    public ResponseEntity<ProcessingResult> processData(@RequestBody Object data) {
        ScenarioConfiguration scenario = scenarioService.getScenarioForData(data);
        ProcessingResult result = processor.processData(data, scenario);
        return ResponseEntity.ok(result);
    }

    @GetMapping("/registry")
    public ResponseEntity<List<ScenarioRegistryEntry>> getScenarios() {
        return ResponseEntity.ok(scenarioService.getAllScenarios());
    }
}
```

Batch Processing Integration

```java
@Component
public class ScenarioBatchProcessor {

    @Async
    public CompletableFuture<BatchProcessingResult> processBatch(List<Object> dataItems) {
        Map<String, List<Object>> groupedByScenario = dataItems.stream()
            .collect(Collectors.groupingBy(this::getScenarioId));

        List<CompletableFuture<ProcessingResult>> futures = groupedByScenario.entrySet()
            .stream()
            .map(entry -> processScenarioGroup(entry.getKey(), entry.getValue()))
            .collect(Collectors.toList());

        return CompletableFuture.allOf(futures.toArray(new CompletableFuture[0]))
                               .thenApply(v -> aggregateResults(futures));
    }
}
```

Monitoring and Observability

Key Metrics

Scenario Usage Metrics

- Scenario execution frequency
- Processing times per scenario
- Success/failure rates
- Data type distribution

Performance Metrics

- Routing decision time
- Configuration loading time
- Cache hit/miss rates
- Memory usage patterns

Business Metrics

- Processing volume by business domain
- Error rates by scenario type
- Compliance processing statistics
- SLA adherence metrics

Logging Strategy

```java
@Component
public class ScenarioAuditLogger {

    public void logScenarioExecution(String scenarioId, Object data, ProcessingResult result) {
        AuditEvent event = AuditEvent.builder()
            .timestamp(Instant.now())
            .scenarioId(scenarioId)
            .dataType(data.getClass().getName())
            .success(result.isSuccess())
            .processingTime(result.getProcessingTime())
            .build();

        auditLogger.info("Scenario execution: {}", event);
    }
}
```

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This comprehensive guide provides everything needed to understand, implement, and maintain APEX's scenario-based processing system. The architecture enables scalable, maintainable, and flexible rule processing for complex enterprise environments.