

CSV Import Support for Dynamic Attributes

Version 1.3.0-SNAPSHOT, 2026-02-23T21:00:11Z

Chapter 1. Executive Summary

This document proposes a design for importing `dynamicAttributeSets` and `dynamicAttributes` via CSV. The challenge is that dynamic attributes are schema-less, nested structures where the attribute names and types are not known at compile time, yet CSV is an inherently flat, column-based format.

Chapter 2. Background: Dynamic Attributes Data Model

2.1. Current Structure

```
// A model with dynamic attributes
public class Product extends BaseModel {
    protected String name;
    protected String sku;
    protected List<DynamicAttributeSet> dynamicAttributeSets = new ArrayList<>();
}

// Container for related attributes
public class DynamicAttributeSet {
    protected String name;                                // e.g., "logistics", "compliance"
    protected List<DynamicAttribute> attributes;
}

// Individual attribute with type and value
public class DynamicAttribute {
    protected String id;
    protected String name;                                // e.g., "weight", "hazmat_class"
    protected DynamicAttributeType type;                  // String, Integer, Boolean, Date,
etc.
    protected Object value;                             // The actual value
    protected Object defaultValue;
    protected boolean required;
    protected boolean hidden;
    // ... other metadata
}
```

2.2. Example JSON Representation

```
{
  "name": "Widget Pro",
  "sku": "WGT-001",
  "dynamicAttributeSets": [
    {
      "name": "logistics",
      "attributes": [
        { "name": "weight", "type": "Double", "value": 2.5 },
        { "name": "dimensions", "type": "String", "value": "10x5x3" },
        { "name": "hazmat", "type": "Boolean", "value": false }
      ]
    },
    {
      "name": "compliance",
      "attributes": [
        { "name": "certifications", "type": "List", "value": ["ISO9001", "GMP"] },
        { "name": "regulations", "type": "List", "value": ["FDA", "EMA"] }
      ]
    }
  ]
}
```

```
"name": "compliance",
"attributes": [
    { "name": "ce_certified", "type": "Boolean", "value": true },
    { "name": "certification_date", "type": "Date", "value": "2024-01-15" }
]
}
]
```

Chapter 3. Design Challenges

1. **Flat vs Nested:** CSV is flat; dynamic attributes are deeply nested (model → sets → attributes)
2. **Schema Variability:** Different rows may have different dynamic attributes
3. **Type Coercion:** CSV values are strings; dynamic attributes have typed values
4. **Merge Semantics:** Should import replace all attributes or merge with existing?
5. **Validation:** How to validate against DynamicAttributeSetDefinition if one exists?
6. **Performance:** Potentially many columns for dynamic attributes

Chapter 4. Proposed Design: All Three Strategies Supported

The design supports **all three import strategies**, configurable via ImportProfile. Each strategy has its use cases, and users can choose based on their data shape and tooling.

4.1. Strategy Overview

Strategy	Best For	CSV Style	Configuration
DOT_NOTATION	Spreadsheet-friendly, sparse attributes	<code>dyn.setName.attrName</code> columns	<code>dynamicAttributeStrategy: DOT_NOTATION</code>
JSON_COLUMN	Complex structures, programmatic generation	Single <code>dynamicAttributes</code> JSON column	<code>dynamicAttributeStrategy: JSON_COLUMN</code>
VERTICAL	Attribute-centric imports, bulk attribute loading	Multiple rows per entity	<code>dynamicAttributeStrategy: VERTICAL</code>

4.2. Strategy 1: DOT_NOTATION (Header Convention)

Use a special header prefix and dot notation to map CSV columns to dynamic attributes.

4.2.1. Header Format

```
dyn.<setName>.<attributeName>
dyn.<setName>.<attributeName>:type
```

4.2.2. Example CSV

```
name,sku,dyn.logistics.weight,dyn.logistics.dimensions,dyn.logistics.hazmat,dyn.compliance.ce_certified,dyn.compliance.certification_date
"Widget Pro","WGT-001",2.5,"10x5x3",false,true,"2024-01-15"
"Gadget X","GDG-002",1.2,"5x5x2",false,true,"2024-03-20"
```

4.2.3. Type Inference

Types can be inferred or explicitly specified:

Method	Header	Notes
Inferred from value	<code>dyn.logistics.weight</code>	Parser attempts: Boolean → Integer → Long → Double → Date → String

Method	Header	Notes
Explicit type suffix	<code>dyn.logistics.weight:Double</code>	Forces specific type
From DynamicAttribute SetDefinition	<code>dyn.logistics.weight</code>	Looks up type from definition if exists
From ImportProfile	Configured in profile	Type specified in column mapping

4.2.4. Best For

- Spreadsheet editing (Excel, Google Sheets)
- Human-readable CSV files
- Sparse attributes (some rows have attributes, others don't)
- When attribute names are known upfront

4.3. Strategy 2: JSON_COLUMN (JSON-in-Cell)

Store the entire dynamic attributes structure as JSON in a dedicated CSV column.

4.3.1. Column Format

The column name is configurable (default: `dynamicAttributes`). The value is a JSON object:

```
{
  "setName": {
    "attrName": value,
    "attrName2": value2
  },
  "setName2": {
    "attrName": value
  }
}
```

4.3.2. Example CSV

```
name,sku,dynamicAttributes
"Widget Pro","WGT-001","{
  ""logistics"": {
    ""weight"": 2.5,
    ""dimensions"": "10x5x3",
    ""hazmat"": false
  },
  ""compliance"": {
    ""ce_certified"": true,
    ""certification_date"": "2024-01-15"
  }
}"
"Gadget X","GDG-002","{
  ""logistics"": {
    ""weight"": 1.2,
    ""dimensions"": "5x5x2"
  }
}"
```

4.3.3. Alternative: Relaxed JSON Format

For easier editing, support a relaxed format with single quotes or unquoted keys:

```
name,sku,dynamicAttributes
"Widget Pro","WGT-
001","{'logistics':{'weight':2.5,'hazmat':false},'compliance':{'ce_certified':true}}"
```

4.3.4. Full Structure JSON (Optional)

For complete control, support full DynamicAttributeSet structure:

```
name,sku,dynamicAttributeSets
"Widget Pro","WGT-
001", [{"name":"logistics", "attributes": [{"name":"weight", "type":"Double", "value":2.5}]}]
```

4.3.5. Best For

- Programmatically generated CSV files
- Complex attribute structures
- When attributes vary significantly between rows
- Integration with systems that export JSON

4.4. Strategy 3: VERTICAL (Multiple Rows per Entity)

One row per attribute, with a parent identifier to group rows into entities.

4.4.1. Column Format

Required columns:

Column	Description
_entityKey	Unique identifier to group rows (e.g., SKU, refName)
_attrSet	Dynamic attribute set name
_attrName	Attribute name within the set
_attrType	Attribute type (optional, can be inferred)
_attrValue	The attribute value

Column names are configurable in ImportProfile.

4.4.2. Example CSV

```
_entityKey,_attrSet,_attrName,_attrType,_attrValue
"WGT-001","logistics","weight","Double","2.5"
"WGT-001","logistics","dimensions","String","10x5x3"
"WGT-001","logistics","hazmat","Boolean","false"
"WGT-001","compliance","ce_certified","Boolean","true"
"WGT-001","compliance","certification_date","Date","2024-01-15"
"GDG-002","logistics","weight","Double","1.2"
"GDG-002","logistics","dimensions","String","5x5x2"
```

4.4.3. With Entity Fields

Include entity fields on each row (redundant but allows single-pass processing):

```
sku,name,_attrSet,_attrName,_attrType,_attrValue
"WGT-001","Widget Pro","logistics","weight","Double","2.5"
"WGT-001","Widget Pro","logistics","dimensions","String","10x5x3"
"WGT-001","Widget Pro","compliance","ce_certified","Boolean","true"
"GDG-002","Gadget X","logistics","weight","Double","1.2"
```

4.4.4. Best For

- Bulk attribute imports (adding many attributes to existing entities)
- Attribute-focused workflows
- When entity already exists and you're just updating attributes
- Exports from attribute management systems

4.5. Hybrid Mode: Combining Strategies

Enable multiple strategies in a single import by setting `dynamicAttributeStrategy: HYBRID`:

```
name,sku,dyn.logistics.weight,dynamicAttributes
"Widget Pro","WGT-001",2.5,"{""compliance"":{""ce_certified"":true}}"
"Gadget X","GDG-002",1.2,"{""compliance"":{""rohs"":true}}"
```

Processing order: 1. DOT_NOTATION columns processed first 2. JSON_COLUMN merged/overlaid 3. Explicit ColumnMappings applied last (highest priority)

Chapter 5. Detailed Design: Dot Notation Approach

5.1. Configuration in ImportProfile

5.1.1. New Enums

```
/*
 * Strategy for importing dynamic attributes from CSV.
 */
public enum DynamicAttributeImportStrategy {
    /**
     * Disable dynamic attribute import.
     */
    NONE,

    /**
     * Use dot-notation headers: dyn.setName.attrName[:type]
     * Best for spreadsheet-friendly imports.
     */
    DOT_NOTATION,

    /**
     * Use a single JSON column containing all dynamic attributes.
     * Best for programmatic imports.
     */
    JSON_COLUMN,

    /**
     * Use vertical format with multiple rows per entity.
     * Best for attribute-centric imports.
     */
    VERTICAL,

    /**
     * Support both DOT_NOTATION and JSON_COLUMN in same import.
     * DOT_NOTATION processed first, JSON_COLUMN merged on top.
     */
    HYBRID
}

/*
 * Strategy for merging imported dynamic attributes with existing.
 */
public enum DynamicAttributeMergeStrategy {
    /**
     * Remove all existing attributes, replace with imported.
     */
}
```

```

*/
REPLACE,
/*
 * Keep existing attributes, update matching, add new.
 */
MERGE,

/*
 * Keep existing attributes, only add new (no updates to existing).
 */
APPEND
}

```

5.1.2. DynamicAttributeMapping

```

@Data
@NoArgsConstructor
@AllArgsConstructor
@Builder
@Entity
public class DynamicAttributeMapping {
    /**
     * The CSV column name or pattern.
     * For DOT_NOTATION: can use "dyn.{setName}.{attrName}" for auto-discovery.
     * For JSON_COLUMN: the column containing JSON.
     * For VERTICAL: not used (uses verticalConfig).
     */
    private String sourceColumn;

    /**
     * Target attribute set name. If null, extracted from header.
     */
    private String targetSetName;

    /**
     * Target attribute name. If null, extracted from header.
     */
    private String targetAttributeName;

    /**
     * Force a specific type. If null, inferred.
     */
    private DynamicAttributeType type;

    /**
     * Date/time format for Date/DateTime types.
     */
    private String dateFormat;
}

```

```

/**
 * Reference to DynamicAttributeSetDefinition for validation.
 */
private String definitionRefName;
}

```

5.1.3. VerticalFormatConfig

```

@Data
@NoArgsConstructor
@AllArgsConstructor
@Builder
@Entity
public class VerticalFormatConfig {
    /**
     * Column containing the entity key for grouping rows.
     * Default: "_entityKey"
     */
    @Builder.Default
    private String entityKeyColumn = "_entityKey";

    /**
     * Field on the entity that matches entityKeyColumn values.
     * Used for lookups when updating existing entities.
     * Default: "refName"
     */
    @Builder.Default
    private String entityKeyField = "refName";

    /**
     * Column containing the attribute set name.
     * Default: "_attrSet"
     */
    @Builder.Default
    private String setNameColumn = "_attrSet";

    /**
     * Column containing the attribute name.
     * Default: "_attrName"
     */
    @Builder.Default
    private String attrNameColumn = "_attrName";

    /**
     * Column containing the attribute type (optional).
     * Default: "_attrType"
     */
    @Builder.Default

```

```

private String attrTypeColumn = "_attrType";

/**
 * Column containing the attribute value.
 * Default: "_attrValue"
 */
@Builder.Default
private String attrValueColumn = "_attrValue";

/**
 * If true, entity fields can be included on each row.
 * First occurrence of each field value is used.
 * Default: false
 */
@Builder.Default
private boolean allowEntityFieldsOnRows = false;

/**
 * Columns to exclude from entity field processing.
 * Typically the attribute columns themselves.
 */
private List<String> excludeFromEntityFields;
}

```

5.1.4. JsonColumnConfig

```

@Data
@NoArgsConstructor
@AllArgsConstructor
@Builder
@Entity
public class JsonColumnConfig {
    /**
     * The CSV column name containing JSON dynamic attributes.
     * Default: "dynamicAttributes"
     */
    @Builder.Default
    private String columnName = "dynamicAttributes";

    /**
     * JSON format style.
     * COMPACT: {"setName": {"attrName": value}} - values only, types inferred
     * FULL:
     * [{"name": "setName", "attributes": [{"name": "attrName", "type": "String", "value": "x"}]}]
     */
    @Builder.Default
    private JsonFormatStyle formatStyle = JsonFormatStyle.COMPACT;

    /**

```

```

        * Allow relaxed JSON parsing (single quotes, unquoted keys).
        * Default: true
        */
    @Builder.Default
    private boolean relaxedParsing = true;
}

public enum JsonFormatStyle {
    /**
     * Compact format: {"setName": {"attrName": value, ...}, ...}
     * Types are inferred from JSON value types.
     */
    COMPACT,

    /**
     * Full structure matching DynamicAttributeSet model:
     *
     [{"name": "setName", "attributes": [{"name": "attrName", "type": "Type", "value": val}]}]
     */
    FULL
}

```

5.1.5. Updated ImportProfile

```

public class ImportProfile extends BaseModel {
    // ... existing fields ...

    //

    // DYNAMIC ATTRIBUTE CONFIGURATION
    //

    //

    /**
     * Strategy for importing dynamic attributes.
     * Default: NONE (disabled)
     */
    @Builder.Default
    private DynamicAttributeImportStrategy dynamicAttributeStrategy =
        DynamicAttributeImportStrategy.NONE;

    /**
     * Strategy for merging imported dynamic attributes with existing.
     * Default: MERGE
     */
    @Builder.Default
    private DynamicAttributeMergeStrategy dynamicAttributeMergeStrategy =

```

```

DynamicAttributeMergeStrategy.MERGE;

// --- DOT_NOTATION Configuration ---

/**
 * Prefix for auto-discovery of dynamic attribute columns.
 * Only used when strategy is DOT_NOTATION or HYBRID.
 * Default: "dyn."
 */
@Builder.Default
private String dynamicAttributePrefix = "dyn.";

/**
 * Enable auto-discovery of dynamic attribute columns by prefix.
 * If false, only explicitly mapped columns are processed.
 */
@Builder.Default
private boolean enableDynamicAttributeDiscovery = true;

// --- JSON_COLUMN Configuration ---

/**
 * Configuration for JSON column strategy.
 * Only used when strategy is JSON_COLUMN or HYBRID.
 */
private JsonColumnConfig jsonColumnConfig;

// --- VERTICAL Configuration ---

/**
 * Configuration for vertical format strategy.
 * Only used when strategy is VERTICAL.
 */
private VerticalFormatConfig verticalFormatConfig;

// --- Common Configuration ---

/**
 * Explicit mappings for dynamic attribute columns.
 * Used for DOT_NOTATION when auto-discovery is disabled,
 * or to override inferred types/settings.
 */
private List<DynamicAttributeMapping> dynamicAttributeMappings;

/**
 * Reference to DynamicAttributeSetDefinition for type/validation lookup.
 * If specified, validates imported attributes against this definition.
 */
private String dynamicAttributeDefinitionRefName;

/**

```

```

    * If true, only allow attributes defined in the DynamicAttributeSetDefinition.
    * Unknown attributes will cause validation errors.
    * Default: false (allow any attributes)
    */
@Builder.Default
private boolean strictDynamicAttributeValidation = false;

/**
 * Default type when type cannot be inferred.
 * Default: String
 */
@Builder.Default
private DynamicAttributeType defaultDynamicAttributeType =
    DynamicAttributeType.String;

/**
 * Date format for parsing Date type attributes.
 * Default: "yyyy-MM-dd"
 */
@Builder.Default
private String dynamicAttributeDateFormat = "yyyy-MM-dd";

/**
 * DateTime format for parsing DateTime type attributes.
 * Default: "yyyy-MM-dd'T'HH:mm:ss"
 */
@Builder.Default
private String dynamicAttributeDateTimeFormat = "yyyy-MM-dd'T'HH:mm:ss";
}

```

5.2. Processing Pipeline

5.2.1. Overall Flow



5.2.2. DOT_NOTATION Processing Pipeline

CSV Row



- ```
| 1. Header Parsing (once per import)
| - Identify columns with "dyn." prefix
| - Parse: dyn.<setName>.<attrName>[:type]
| - Build column → (setName, attrName, type) mapping
| - Validate header format
```



- ```
| 2. Regular Column Processing  
|   - Process non-dynamic columns as before  
|   - Apply existing transformations
```



- ```
| 3. Dynamic Attribute Extraction
| - For each dyn.* column with non-empty value:
| a. Get parsed header info (setName, attrName)
| b. Determine type (explicit > definition > inferred)
| c. Convert string value to typed value
| d. Create DynamicAttribute object
| - Group attributes by set name
```



- ```
| 4. Set Assembly  
|   - Create DynamicAttributeSet for each set name  
|   - Populate with collected attributes
```



[Merge & Validate] ——□ Bean with dynamicAttributeSets

5.2.3. JSON_COLUMN Processing Pipeline

CSV Row

|
|
|

- | 1. Locate JSON Column
| - Find column by name (default: "dynamicAttributes")
| - Skip if empty/null

|
|
|

- | 2. Parse JSON
| - If COMPACT format:
| Parse {"setName": {"attrName": "value", ...}, ...}
| Infer types from JSON value types
| - If FULL format:
| Parse as List<DynamicAttributeSet>
| Use explicit types from structure
| - Handle relaxed JSON if enabled

|
|

- | 3. Build Attribute Sets
| - Create DynamicAttributeSet for each entry
| - Create DynamicAttribute for each nested entry
| - Map JSON types to DynamicAttributeType

|
|

[Merge & Validate] ——□ Bean with dynamicAttributeSets

5.2.4. VERTICAL Processing Pipeline

CSV File (grouped by entity)

|
|
|

1. Group Rows by Entity Key
 - Read all rows
 - Group by `_entityKey` column value
 - Each group becomes one entity

|
|
|

2. For Each Entity Group

|

- a. Extract entity fields (if `allowEntityFieldsOnRows`)
 - Use first row's values for non-attribute columns

|

- b. Collect attributes from all rows in group
 - Read `_attrSet`, `_attrName`, `_attrType`, `_attrValue`
 - Group by set name

|

- c. Build DynamicAttributeSets
 - Create set for each unique `_attrSet` value
 - Add attributes to appropriate set

|
|

3. Entity Resolution
 - If entity exists (lookup by `entityKeyField`):
 Apply merge strategy with existing
 - If entity is new:
 Create with collected attributes

[Validate] —— Entity with dynamicAttributeSets

5.2.5. HYBRID Processing Pipeline

CSV Row

|
|
|

- ```
| 1. Process DOT_NOTATION columns first
| - Extract dyn.* columns
| - Build initial attribute sets
```

|  
|  
|

- ```
| 2. Process JSON_COLUMN  
|   - Parse JSON column  
|   - Merge with DOT_NOTATION results:  
|     * Same set+attr: JSON value overwrites  
|     * New attrs: Added to sets  
|     * New sets: Added to list
```

|
|

[Merge & Validate] —— Bean with dynamicAttributeSets

5.2.6. Common: Merge & Validate Stage

Collected Dynamic Attributes

|
|
|

- ```
| Merge with Existing (if updating)
| - REPLACE: Clear existing sets, add new
| - MERGE: Update existing attrs, add new attrs/sets
| - APPEND: Only add attrs that don't exist
```

|  
|  
|

```

| Validation
| - If DynamicAttributeSetDefinition exists:
| a. Validate required attributes are present
| b. Validate types match definition
| c. Validate Select/MultiSelect values are allowed
| - If strictDynamicAttributeValidation:
| d. Reject unknown attributes not in definition

```

|  
□  
Bean with populated dynamicAttributeSets

## 5.3. New SPI: DynamicAttributeProcessor

```

package com.e2eq.framework.imports.spi;

/**
 * Processes dynamic attribute columns during CSV import.
 */
@ApplicationScoped
public class DynamicAttributeProcessor {

 @Inject
 DynamicAttributeSetDefinitionRepo definitionRepo;

 /**
 * Parse a dynamic attribute header.
 *
 * @param header the CSV header (e.g., "dyn.logistics.weight:Double")
 * @param prefix the dynamic attribute prefix (default "dyn.")
 * @return parsed header info, or null if not a dynamic attribute column
 */
 public ParsedDynamicHeader parseHeader(String header, String prefix) {
 if (!header.startsWith(prefix)) {
 return null;
 }

 String remainder = header.substring(prefix.length());
 // Parse: setName.attrName[:type]
 int typeIdx = remainder.lastIndexOf(':');
 String path;
 DynamicAttributeType explicitType = null;

 if (typeIdx > 0) {
 path = remainder.substring(0, typeIdx);
 String typeStr = remainder.substring(typeIdx + 1);
 try {

```

```

 explicitType = DynamicAttributeType.fromValue(typeStr);
 } catch (IllegalArgumentException e) {
 // Invalid type, treat as part of name
 path = remainder;
 }
} else {
 path = remainder;
}

int dotIdx = path.indexOf('.');
if (dotIdx <= 0 || dotIdx >= path.length() - 1) {
 return null; // Invalid format
}

String setName = path.substring(0, dotIdx);
String attrName = path.substring(dotIdx + 1);

return new ParsedDynamicHeader(header, setName, attrName, explicitType);
}

/**
 * Process dynamic attribute columns for a row.
 *
 * @param bean the target bean
 * @param rowData all column values
 * @param parsedHeaders map of column name to parsed header info
 * @param profile the import profile
 * @param context the import context
 * @return result with any errors
 */
public ProcessResult processDynamicAttributes(
 BaseModel bean,
 Map<String, Object> rowData,
 Map<String, ParsedDynamicHeader> parsedHeaders,
 ImportProfile profile,
 ImportContext context) {

 // Check if bean has dynamicAttributeSets field
 List<DynamicAttributeSet> sets = getDynamicAttributeSets(bean);
 if (sets == null) {
 return ProcessResult.skip("Bean does not support dynamic attributes");
 }

 // Load definition if specified
 DynamicAttributeSetDefinition definition = loadDefinition(profile, context);

 // Group columns by set name
 Map<String, List<AttributeValue>> bySet = new LinkedHashMap<>();

 for (Map.Entry<String, ParsedDynamicHeader> entry : parsedHeaders.entrySet())
{

```

```

 Object value = rowData.get(entry.getKey());
 if (value == null || value.toString().trim().isEmpty()) {
 continue; // Skip empty values
 }

 ParsedDynamicHeader parsed = entry.getValue();
 DynamicAttributeType type = determineType(parsed, value, definition);
 Object typedValue = convertValue(value.toString(), type, profile);

 bySet.computeIfAbsent(parsed.getSetName(), k -> new ArrayList<>())
 .add(new AttributeValue(parsed.getAttributeName(), type, typedValue));
 }

 // Apply merge strategy
 applyMergeStrategy(sets, bySet, profile.getDynamicAttributeMergeStrategy());

 // Validate against definition if present
 if (definition != null) {
 List<String> errors = validateAgainstDefinition(sets, definition);
 if (!errors.isEmpty()) {
 return ProcessResult.error(String.join("; ", errors));
 }
 }

 return ProcessResult.success();
}

// ... helper methods ...
}

@Data
@AllArgsConstructor
public class ParsedDynamicHeader {
 private String originalHeader;
 private String setName;
 private String attrName;
 private DynamicAttributeType explicitType;
}

```

## 5.4. Type Inference Logic

```

public DynamicAttributeType inferType(String value) {
 if (value == null || value.isEmpty()) {
 return DynamicAttributeType.String;
 }

 // Boolean
 if ("true".equalsIgnoreCase(value) || "false".equalsIgnoreCase(value)) {
 return DynamicAttributeType.Boolean;
 }
}

```

```

 }

 // Integer
 try {
 Integer.parseInt(value);
 return DynamicAttributeType.Integer;
 } catch (NumberFormatException e) { }

 // Long
 try {
 Long.parseLong(value);
 return DynamicAttributeType.Long;
 } catch (NumberFormatException e) { }

 // Double
 try {
 Double.parseDouble(value);
 return DynamicAttributeType.Double;
 } catch (NumberFormatException e) { }

 // Date (common formats)
 if (isDateFormat(value)) {
 return DynamicAttributeType.Date;
 }

 // DateTime
 if (isDateTimeFormat(value)) {
 return DynamicAttributeType.DateTime;
 }

 // Default to String
 return DynamicAttributeType.String;
}

```

## 5.5. Merge Strategy Implementation

```

private void applyMergeStrategy(
 List<DynamicAttributeSet> existingSets,
 Map<String, List<AttributeValue>> importedBySet,
 DynamicAttributeMergeStrategy strategy) {

 switch (strategy) {
 case REPLACE:
 existingSets.clear();
 // Fall through to add all imported
 case MERGE:
 case APPEND:
 for (Map.Entry<String, List<AttributeValue>> entry : importedBySet
 .entrySet()) {

```

```

 String setName = entry.getKey();
 List<AttributeValue> importedAttrs = entry.getValue();

 DynamicAttributeSet existingSet = findSetByName(existingSets, setName
);
 if (existingSet == null) {
 // Create new set
 existingSet = new DynamicAttributeSet();
 existingSet.setName(setName);
 existingSet.setAttributes(new ArrayList<>());
 existingSets.add(existingSet);
 }

 for (AttributeValue av : importedAttrs) {
 DynamicAttribute existing = findAttrByName(existingSet
.getAttributes(), av.name);

 if (existing == null) {
 // Add new attribute
 DynamicAttribute attr = new DynamicAttribute();
 attr.setId(UUID.randomUUID().toString());
 attr.setName(av.name);
 attr.setType(av.type);
 attr.setValue(av.value);
 existingSet.getAttributes().add(attr);
 } else if (strategy == DynamicAttributeMergeStrategy.MERGE) {
 // Update existing
 existing.setType(av.type);
 existing.setValue(av.value);
 }
 // APPEND: skip if exists
 }
 }
 break;
}
}

```

# Chapter 6. CSV Examples

## 6.1. DOT\_NOTATION Strategy Examples

### 6.1.1. Example 1: Simple Dynamic Attributes

```
refName,displayName,dyn.specs.color,dyn.specs.size,dyn.specs.weight:Double
prod-001,Red Widget,Red,Large,2.5
prod-002,Blue Gadget,Blue,Medium,1.8
```

### 6.1.2. Example 2: Multiple Attribute Sets

```
sku,name,dyn.logistics.weight:Double,dyn.logistics.hazmat:Boolean,dyn.compliance.ce_ma
rk:Boolean,dyn.compliance.rohs:Boolean
WGT-001,Widget Pro,2.5,false,true,true
GDG-002,Gadget X,1.2,false,true,false
```

### 6.1.3. Example 3: With Type Suffix

```
refName,dyn.dates.manufactured:Date,dyn.dates.expires:Date,dyn.counts.inventory:Intege
r
item-001,2024-01-15,2025-01-15,500
item-002,2024-02-20,2025-02-20,250
```

### 6.1.4. Example 4: Sparse Attributes (Optional)

```
refName,dyn.optional.note,dyn.optional.priority:Integer,dyn.optional.reviewed:Boolean
item-001,Important item,1,true
item-002,,
item-003,Standard item,,false
```

In row 2, `note`, `priority`, and `reviewed` are all empty - these attributes won't be created. In row 3, only `note` and `reviewed` are set.

## 6.2. JSON\_COLUMN Strategy Examples

### 6.2.1. Example 5: Compact JSON Format

```
refName,displayName,dynamicAttributes
prod-001,Red
Widget,"{"specs":{"color":"Red","size":"Large","weight":2.5}}"
prod-002,Blue
```

```
Gadget,"specs": {"color": "Blue", "size": "Medium"}, "compliance": {"ce_mark": true}}
```

## 6.2.2. Example 6: Relaxed JSON (Single Quotes)

With `relaxedParsing: true`:

```
refName,displayName,dynamicAttributes
prod-001,Red Widget,"specs":{'color':'Red','weight':2.5}"
prod-002,Blue Gadget,"specs":{'color':'Blue'},'compliance':{'rohs':true}}"
```

## 6.2.3. Example 7: Full Structure JSON

With `formatStyle: FULL`:

```
refName,displayName,dynamicAttributeSets
prod-001,Red
Widget,[{"name": "specs", "attributes": [{"name": "color", "type": "String", "value": "Red"}, {"name": "weight", "type": "Double", "value": 2.5}]]"
```

## 6.2.4. Example 8: Custom Column Name

With `jsonColumnConfig.columnName: "customAttrs"`:

```
refName,displayName,customAttrs
prod-001,Red Widget,"specs": {"color": "Red"}"
```

## 6.3. VERTICAL Strategy Examples

### 6.3.1. Example 9: Basic Vertical Format

```
_entityKey,_attrSet,_attrName,_attrType,_attrValue
WGT-001,logistics,weight,Double,2.5
WGT-001,logistics,dimensions,String,10x5x3
WGT-001,logistics,hazmat,Boolean,false
WGT-001,compliance,ce_mark,Boolean,true
WGT-001,compliance,certification_date,Date,2024-01-15
GDG-002,logistics,weight,Double,1.2
GDG-002,logistics,dimensions,String,5x5x2
GDG-002,compliance,ce_mark,Boolean,true
```

### 6.3.2. Example 10: Vertical with Entity Fields

With `allowEntityFieldsOnRows: true`:

```
sku,name,_attrSet,_attrName,_attrValue
WGT-001,Widget Pro,logistics,weight,2.5
WGT-001,Widget Pro,logistics,dimensions,10x5x3
WGT-001,Widget Pro,compliance,ce_mark,true
GDG-002,Gadget X,logistics,weight,1.2
GDG-002,Gadget X,compliance,ce_mark,true
```

### 6.3.3. Example 11: Vertical with Type Inference

Type column is optional when `_attrType` is omitted:

```
_entityKey,_attrSet,_attrName,_attrValue
WGT-001,specs,color,Red
WGT-001,specs,weight,2.5
WGT-001,specs,active,true
WGT-001,specs,count,42
```

Types inferred: color=String, weight=Double, active=Boolean, count=Integer

### 6.3.4. Example 12: Custom Column Names

With custom `verticalFormatConfig`:

```
product_sku,set_name,attribute,type,value
WGT-001,logistics,weight,Double,2.5
WGT-001,logistics,hazmat,Boolean,false
```

## 6.4. HYBRID Strategy Examples

### 6.4.1. Example 13: Combined DOT\_NOTATION + JSON

```
refName,displayName,dyn.specs.color,dyn.specs.size,dynamicAttributes
prod-001,Red Widget,Red,Large,"{""compliance"":{""ce_mark"":true,""rohs"":true}}"
prod-002,Blue Gadget,Blue,Medium,"{""compliance"":{""ce_mark"":true}}"
```

Result: `specs` set from DOT\_NOTATION columns, `compliance` set from JSON.

### 6.4.2. Example 14: Hybrid with Override

JSON values override DOT\_NOTATION for same attribute:

```
refName,dyn.specs.color,dynamicAttributes
prod-001,Red,"{""specs"":{""color"":""Dark Red"" , ""size"":""XL""}}"
```

Result: **color** = "Dark Red" (JSON wins), **size** = "XL" (from JSON only)

# Chapter 7. ImportProfile Configuration Examples

## 7.1. DOT\_NOTATION: Auto-Discovery Mode

```
{
 "refName": "product-import-dot-notation",
 "displayName": "Product Import with Dot Notation",
 "targetCollection": "com.example.Product",
 "dynamicAttributeStrategy": "DOT_NOTATION",
 "enableDynamicAttributeDiscovery": true,
 "dynamicAttributePrefix": "dyn.",
 "dynamicAttributeMergeStrategy": "MERGE"
}
```

## 7.2. DOT\_NOTATION: Explicit Mapping Mode

Map arbitrary column names to dynamic attributes:

```
{
 "refName": "product-import-explicit-mapping",
 "displayName": "Product Import with Explicit Mappings",
 "targetCollection": "com.example.Product",
 "dynamicAttributeStrategy": "DOT_NOTATION",
 "enableDynamicAttributeDiscovery": false,
 "dynamicAttributeMappings": [
 {
 "sourceColumn": "weight_kg",
 "targetSetName": "logistics",
 "targetAttributeName": "weight",
 "type": "Double"
 },
 {
 "sourceColumn": "is_hazmat",
 "targetSetName": "logistics",
 "targetAttributeName": "hazmat",
 "type": "Boolean"
 },
 {
 "sourceColumn": "ce_certified",
 "targetSetName": "compliance",
 "targetAttributeName": "ce_mark",
 "type": "Boolean"
 }
],
 "dynamicAttributeMergeStrategy": "REPLACE"
```

```
}
```

## 7.3. JSON\_COLUMN: Compact Format

```
{
 "refName": "product-import-json-compact",
 "displayName": "Product Import with JSON Column",
 "targetCollection": "com.example.Product",
 "dynamicAttributeStrategy": "JSON_COLUMN",
 "jsonColumnConfig": {
 "columnName": "dynamicAttributes",
 "formatStyle": "COMPACT",
 "relaxedParsing": true
 },
 "dynamicAttributeMergeStrategy": "MERGE"
}
```

## 7.4. JSON\_COLUMN: Full Structure Format

```
{
 "refName": "product-import-json-full",
 "displayName": "Product Import with Full JSON Structure",
 "targetCollection": "com.example.Product",
 "dynamicAttributeStrategy": "JSON_COLUMN",
 "jsonColumnConfig": {
 "columnName": "dynamicAttributeSets",
 "formatStyle": "FULL",
 "relaxedParsing": false
 },
 "dynamicAttributeMergeStrategy": "REPLACE"
}
```

## 7.5. VERTICAL: Basic Configuration

```
{
 "refName": "product-attributes-vertical",
 "displayName": "Product Attributes Vertical Import",
 "targetCollection": "com.example.Product",
 "dynamicAttributeStrategy": "VERTICAL",
 "verticalFormatConfig": {
 "entityKeyColumn": "_entityKey",
 "entityKeyField": "sku",
 "setNameColumn": "_attrSet",
 "attrNameColumn": "_attrName",
 "attrTypeColumn": "_attrType",
 "attrValueColumn": "_attrValue"
 }
}
```

```

 "attrValueColumn": "_attrValue",
 "allowEntityFieldsOnRows": false
},
"dynamicAttributeMergeStrategy": "MERGE"
}

```

## 7.6. VERTICAL: With Entity Fields on Rows

```

{
 "refName": "product-vertical-with-fields",
 "displayName": "Product Vertical with Entity Fields",
 "targetCollection": "com.example.Product",
 "dynamicAttributeStrategy": "VERTICAL",
 "verticalFormatConfig": {
 "entityKeyColumn": "sku",
 "entityKeyField": "sku",
 "setNameColumn": "attr_set",
 "attrNameColumn": "attr_name",
 "attrTypeColumn": "attr_type",
 "attrValueColumn": "attr_value",
 "allowEntityFieldsOnRows": true,
 "excludeFromEntityFields": ["attr_set", "attr_name", "attr_type", "attr_value"]
 },
 "dynamicAttributeMergeStrategy": "APPEND"
}

```

## 7.7. HYBRID: Combined Strategy

```

{
 "refName": "product-import-hybrid",
 "displayName": "Product Import with Hybrid Strategy",
 "targetCollection": "com.example.Product",
 "dynamicAttributeStrategy": "HYBRID",
 "dynamicAttributePrefix": "dyn.",
 "enableDynamicAttributeDiscovery": true,
 "jsonColumnConfig": {
 "columnName": "extraAttributes",
 "formatStyle": "COMPACT",
 "relaxedParsing": true
 },
 "dynamicAttributeMergeStrategy": "MERGE"
}

```

## 7.8. With Definition Validation

```
{
 "refName": "validated-product-import",
 "displayName": "Product Import with Strict Validation",
 "targetCollection": "com.example.Product",
 "dynamicAttributeStrategy": "DOT_NOTATION",
 "enableDynamicAttributeDiscovery": true,
 "dynamicAttributePrefix": "dyn.",
 "dynamicAttributeDefinitionRefName": "product-attributes-definition",
 "strictDynamicAttributeValidation": true,
 "dynamicAttributeMergeStrategy": "MERGE"
}
```

## 7.9. Complete Example with All Options

```
{
 "refName": "full-product-import-profile",
 "displayName": "Complete Product Import Profile",
 "description": "Demonstrates all dynamic attribute options",
 "targetCollection": "com.example.Product",

 "dynamicAttributeStrategy": "HYBRID",
 "dynamicAttributeMergeStrategy": "MERGE",

 "dynamicAttributePrefix": "dyn.",
 "enableDynamicAttributeDiscovery": true,

 "jsonColumnConfig": {
 "columnName": "jsonAttrs",
 "formatStyle": "COMPACT",
 "relaxedParsing": true
 },

 "dynamicAttributeMappings": [
 {
 "sourceColumn": "weight_lbs",
 "targetSetName": "logistics",
 "targetAttributeName": "weight_pounds",
 "type": "Double"
 }
],

 "dynamicAttributeDefinitionRefName": "product-attrs-def",
 "strictDynamicAttributeValidation": false,
 "defaultDynamicAttributeType": "String",
 "dynamicAttributeDateFormat": "MM/dd/yyyy",
 "dynamicAttributeDateTimeFormat": "MM/dd/yyyy HH:mm"
```

}

# Chapter 8. Processing Order Integration

The dynamic attribute processing integrates into the existing CSV import pipeline:

1. CSV parsing with CellProcessors
2. Field calculators (timestamps, UUIDs, templates)
3. RowValueResolvers (arbitrary code with full row access)
4. DynamicAttributeProcessor (dynamic attribute import)
5. Pre-validation transformers
6. Bean validation

# Chapter 9. RowValueResolver: Arc CDI Bean Integration

## 9.1. Overview

The `RowValueResolver` SPI provides a powerful mechanism for running arbitrary code during CSV import. Unlike static lookups or simple transformations, RowValueResolvers have access to:

- The entire row data (all columns)
- Full CDI injection capabilities (services, repositories, etc.)
- The import context (profile, realm, row number, session)

**Key Feature:** Since RowValueResolvers are Arc CDI beans, you can inject any other service and update multiple collections from a single CSV row.

## 9.2. Basic Implementation

```
@ApplicationScoped
public class SkuResolver implements RowValueResolver {

 @Inject
 ProductService productService;

 @Override
 public String getName() {
 return "skuResolver";
 }

 @Override
 public ResolveResult resolve(String inputValue, Map<String, Object> rowData,
 ImportContext context) {
 String category = (String) rowData.get("category");
 String vendor = (String) rowData.get("vendor");

 String resolvedSku = productService.findOrCreateSku(inputValue, category,
 vendor);

 if (resolvedSku != null) {
 return ResolveResult.success(resolvedSku);
 } else {
 return ResolveResult.error("Could not resolve SKU for: " + inputValue);
 }
 }
}
```

## 9.3. Multi-Collection Updates

Since RowValueResolvers are Arc beans, you can inject multiple repositories and update multiple collections from a single CSV row:

```
@ApplicationScoped
public class OrderLineResolver implements RowValueResolver {

 @Inject
 OrderRepo orderRepo;

 @Inject
 InventoryRepo inventoryRepo;

 @Inject
 AuditLogRepo auditLogRepo;

 @Override
 public String getName() {
 return "orderLineResolver";
 }

 @Override
 public ResolveResult resolve(String inputValue, Map<String, Object> rowData,
ImportContext context) {
 String orderId = (String) rowData.get("order_id");
 String productSku = (String) rowData.get("product_sku");
 Integer quantity = Integer.parseInt((String) rowData.get("quantity"));

 // Update inventory (different collection)
 inventoryRepo.decrementStock(productSku, quantity, context.getRealmId());

 // Create audit log entry (another collection)
 AuditLog log = AuditLog.builder()
 .action("IMPORT_ORDER_LINE")
 .entityRef(orderId)
 .details("Imported line for SKU: " + productSku)
 .build();
 auditLogRepo.save(log);

 // Return the value for the main entity being imported
 return ResolveResult.success(productSku);
 }
}
```

## 9.4. Available Injections

RowValueResolvers can inject any Arc/CDI bean:

| Injection Type       | Example                                                                  |
|----------------------|--------------------------------------------------------------------------|
| Repositories         | <code>@Inject ProductRepo productRepo;</code>                            |
| Services             | <code>@Inject EmailService emailService;</code>                          |
| Configuration        | <code>@ConfigProperty(name="app.import.threshold") int threshold;</code> |
| Other Resolvers      | <code>@Inject Instance&lt;RowValueResolver&gt; allResolvers;</code>      |
| MicroProfile Clients | <code>@Inject @RestClient ExternalApiClient client;</code>               |

## 9.5. Configuration in ImportProfile

Configure a RowValueResolver in your ColumnMapping:

```
{
 "refName": "order-import-profile",
 "targetCollection": "com.example.Order",
 "columnMappings": [
 {
 "sourceColumn": "product_code",
 "targetField": "sku",
 "rowValueResolverName": "skuResolver"
 },
 {
 "sourceColumn": "line_data",
 "targetField": "lineInfo",
 "rowValueResolverName": "orderLineResolver"
 }
]
}
```

## 9.6. Result Types

| Result                                           | Usage                                        |
|--------------------------------------------------|----------------------------------------------|
| <code>ResolveResult.success(value)</code>        | Set the field to the resolved value          |
| <code>ResolveResult.passthrough(original)</code> | Keep the original value unchanged            |
| <code>ResolveResult.nullValue()</code>           | Set the field to null                        |
| <code>ResolveResult.skip()</code>                | Skip this row (no error, just don't process) |
| <code>ResolveResult.skip(reason)</code>          | Skip with a reason (logged but not an error) |
| <code>ResolveResult.error(message)</code>        | Mark the row as an error                     |

## 9.7. ImportContext Information

The `ImportContext` provides access to:

| Method                        | Returns                         |
|-------------------------------|---------------------------------|
| <code>getProfile()</code>     | The ImportProfile configuration |
| <code>getTargetClass()</code> | The class being imported        |
| <code>getRealmId()</code>     | The realm/tenant ID             |
| <code>getRowNumber()</code>   | Current row number (1-based)    |
| <code>getSessionId()</code>   | The import session ID           |

## 9.8. Advanced: Conditional Processing

```
@ApplicationScoped
public class ConditionalResolver implements RowValueResolver {

 @Inject
 ConfigService configService;

 @Override
 public String getName() {
 return "conditionalResolver";
 }

 @Override
 public boolean appliesTo(Class<?> targetClass) {
 // Only apply to Order entities
 return Order.class.isAssignableFrom(targetClass);
 }

 @Override
 public int getOrder() {
 // Run before other resolvers (lower = earlier)
 return 50;
 }

 @Override
 public ResolveResult resolve(String inputValue, Map<String, Object> rowData,
 ImportContext context) {
 // Check configuration
 if (!configService.isFeatureEnabled("advanced-import", context.getRealmId()))
 {
 return ResolveResult.passthrough(inputValue);
 }

 // Skip certain rows based on data
 String status = (String) rowData.get("status");
 }
```

```

 if ("CANCELLED".equals(status)) {
 return ResolveResult.skip("Skipping cancelled orders");
 }

 // Process normally
 return ResolveResult.success(processValue(inputValue, rowData));
}
}

```

## 9.9. Testing RowValueResolvers

```

@QuarkusTest
class SkuResolverTest {

 @Inject
 SkuResolver resolver;

 @Test
 void testResolveSuccess() {
 Map<String, Object> rowData = Map.of(
 "category", "electronics",
 "vendor", "acme"
);
 ImportContext context = ImportContext.builder()
 .realmId("test-realm")
 .rowNumber(1)
 .build();

 RowValueResolver.ResolveResult result = resolver.resolve("PROD-001", rowData,
context);

 assertTrue(result.isSuccess());
 assertNotNull(result.getValue());
 }
}

```

# Chapter 10. Edge Cases and Error Handling

## 10.1. Empty/Null Values

- Empty string → attribute not created (sparse support)
- Explicit null marker (configurable, e.g., "NULL") → attribute created with null value

## 10.2. Type Mismatches

- If type is explicit or from definition, conversion failure → error
- If type is inferred, use String as fallback

## 10.3. Invalid Header Format

- `dyn.` with no dot after set name → warning, skip column
- `dyn.setname` with no attribute name → warning, skip column

## 10.4. Missing Required Attributes

- If DynamicAttributeSetDefinition specifies `required=true`, validate presence
- Report all missing required attributes as validation errors

## 10.5. Unknown Sets/Attributes

- By default, allow any set/attribute names (schema-less)
- If `strictMode=true` in profile, only allow defined sets/attributes

# Chapter 11. Implementation Components

## 11.1. New Model Classes

| Component                      | Package                                     | Description                                                 |
|--------------------------------|---------------------------------------------|-------------------------------------------------------------|
| DynamicAttributeImportStrategy | com.e2eq.framework.model.persistent.imports | Enum: NONE, DOT_NOTATION, JSON_COLUMN, VERTICAL, HYBRID     |
| DynamicAttributeMergeStrategy  | com.e2eq.framework.model.persistent.imports | Enum: REPLACE, MERGE, APPEND                                |
| DynamicAttributeMapping        | com.e2eq.framework.model.persistent.imports | Configuration for mapping CSV columns to dynamic attributes |
| JsonColumnConfig               | com.e2eq.framework.model.persistent.imports | Configuration for JSON_COLUMN strategy                      |
| JsonFormatStyle                | com.e2eq.framework.model.persistent.imports | Enum: COMPACT, FULL                                         |
| VerticalFormatConfig           | com.e2eq.framework.model.persistent.imports | Configuration for VERTICAL strategy                         |
| ParsedDynamicHeader            | com.e2eq.framework.imports.service          | Parsed dynamic attribute header info for DOT_NOTATION       |

## 11.2. New Service Classes

| Component                      | Package                            | Description                                        |
|--------------------------------|------------------------------------|----------------------------------------------------|
| DynamicAttributeImportService  | com.e2eq.framework.imports.service | Main orchestrator for dynamic attribute processing |
| DotNotationProcessor           | com.e2eq.framework.imports.service | Processes DOT_NOTATION strategy columns            |
| JsonColumnProcessor            | com.e2eq.framework.imports.service | Processes JSON_COLUMN strategy                     |
| VerticalFormatProcessor        | com.e2eq.framework.imports.service | Processes VERTICAL strategy with row grouping      |
| DynamicAttributeTypeInferencer | com.e2eq.framework.imports.service | Type inference from string values                  |
| DynamicAttributeMerger         | com.e2eq.framework.imports.service | Applies merge strategies (REPLACE, MERGE, APPEND)  |
| DynamicAttributeValidator      | com.e2eq.framework.imports.service | Validates against DynamicAttributeSetDefinition    |

## 11.3. Enhanced Existing Classes

| <b>Component</b>                   | <b>Package</b>                                           | <b>Description</b>                             |
|------------------------------------|----------------------------------------------------------|------------------------------------------------|
| ImportProfile<br>(enhanced)        | <code>com.e2eq.framework.model.persistent.imports</code> | New fields for dynamic attribute configuration |
| ImportProfileService<br>(enhanced) | <code>com.e2eq.framework.imports.service</code>          | Integration with DynamicAttributeImportService |
| CSVImportHelper<br>(enhanced)      | <code>com.e2eq.framework.util</code>                     | Strategy detection and processor routing       |

# Chapter 12. Future Considerations

1. **Nested Attributes:** Support for nested objects within attribute values (e.g., `dyn.address.coordinates.lat`)
2. **Multi-Value Attributes:** Support for MultiSelect with comma-separated values or JSON arrays
3. **Inheritance:** Respect `inheritable` flag when merging with parent entities
4. **Export Symmetry:** Ensure CSV export uses same conventions for round-trip imports
5. **Bulk Operations:** Streaming processor for VERTICAL strategy with very large files
6. **Mixed Entity Types:** VERTICAL format with multiple entity types in same file
7. **Attribute Templates:** Pre-defined attribute set templates for common patterns
8. **Change Detection:** Only update attributes that actually changed

# Chapter 13. Summary

## 13.1. Dynamic Attribute Import Strategies

The design supports **four import strategies** for dynamic attributes, each suited to different use cases:

| Strategy     | Description                                                                                                                                         |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| DOT_NOTATION | Spreadsheet-friendly with <code>dyn.setName.attrName[:type]</code> column headers. Best for human-edited CSV files with known attribute structures. |
| JSON_COLUMN  | Single JSON column containing all attributes. Best for programmatic imports or complex/variable attribute structures.                               |
| VERTICAL     | Multiple rows per entity with one attribute per row. Best for attribute-centric workflows or bulk attribute loading.                                |
| HYBRID       | Combines DOT_NOTATION and JSON_COLUMN. Allows spreadsheet columns for common attributes with JSON for extras.                                       |

All strategies share common features:

- **Merge Strategies:** REPLACE, MERGE, APPEND for handling existing attributes
- **Type Handling:** Explicit types, definition lookup, or inference
- **Validation:** Optional validation against DynamicAttributeSetDefinition
- **Sparse Support:** Missing/empty values handled gracefully

## 13.2. RowValueResolver: Extensible Import Logic

The `RowValueResolver` SPI enables powerful, custom import logic:

- **Arc CDI Beans:** Full dependency injection support
- **Multi-Collection Updates:** Update multiple collections from a single row
- **Full Row Access:** Read any column value, not just the mapped column
- **Context Awareness:** Access to realm, session, row number, and profile
- **Flexible Results:** Return values, skip rows, or report errors

## 13.3. Implementation Summary

The implementation includes:

### 13.3.1. Model Classes (quantum-models)

- `DynamicAttributeImportStrategy` - NONE, DOT\_NOTATION, JSON\_COLUMN, VERTICAL, HYBRID
- `DynamicAttributeMergeStrategy` - REPLACE, MERGE, APPEND

- `JsonColumnConfig` - Configuration for JSON\_COLUMN strategy
- `VerticalFormatConfig` - Configuration for VERTICAL strategy
- `DynamicAttributeMapping` - Explicit column-to-attribute mappings
- `ParsedDynamicHeader` - Parsed header info for DOT\_NOTATION
- `DynamicAttributeSupport` - Interface for models supporting dynamic attributes

### 13.3.2. Service Classes (`quantum-framework`)

- `DynamicAttributeImportService` - Main orchestrator
- `DotNotationProcessor` - DOT\_NOTATION strategy processor
- `JsonColumnProcessor` - JSON\_COLUMN strategy processor
- `VerticalFormatProcessor` - VERTICAL strategy processor
- `DynamicAttributeTypeInferer` - Type inference from string values
- `DynamicAttributeMerger` - Merge strategy implementation

### 13.3.3. Integration Points

- `ImportProfile` - Extended with dynamic attribute configuration
- `CSVImportHelper` - Integrated for automatic processing
- `RowValueResolver` - Arc CDI bean SPI for custom logic