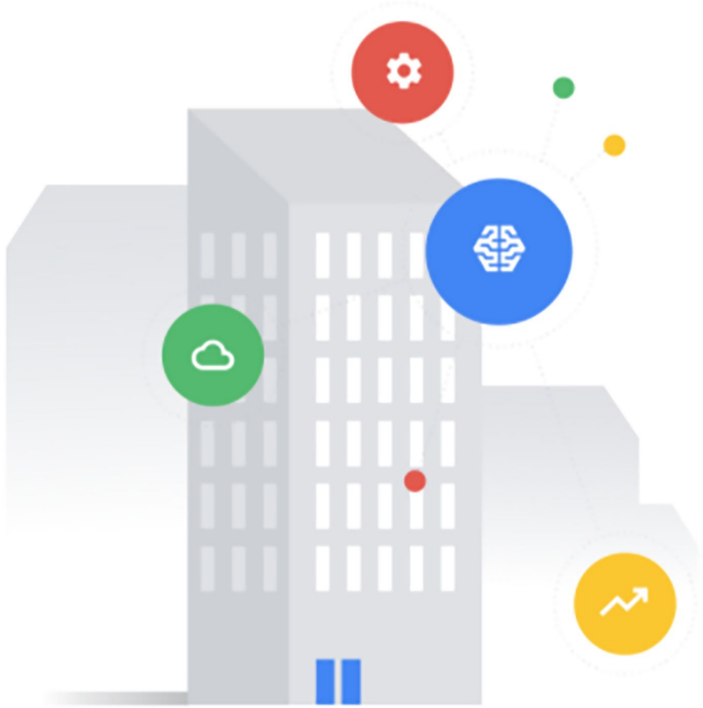
Google

Module 1 | **Lesson 4**

Master Systems Integrator (MSI) onboarding



Before you get started

This onboarding deck has interactive features and activities that enable a self-guided learning experience. To help you get started, here are two tips for viewing and navigating through the deck.

1 View this deck in presentation mode.

- To enter presentation mode, you can either:
  - Click the **Present** or **Slideshow** button in the top-right corner of this page.
  - Press **Ctrl+F5** (Windows), **Cmd+Enter** (macOS), or **Ctrl+Search+5** (Chrome OS) on your keyboard.
- To exit presentation mode, press the **Esc** key on your keyboard.

2 Navigate by clicking the buttons and links.

- Click the **Back** or **Next** buttons to go backward or forward in the deck. Moving forward, you'll find them in the bottom corners of every slide.
- Click blue text to go to another slide in this deck or open a new page in your browser.
- For the best learning experience, using your keyboard or mouse wheel to navigate is discouraged.

Ready to get started? Let's go!

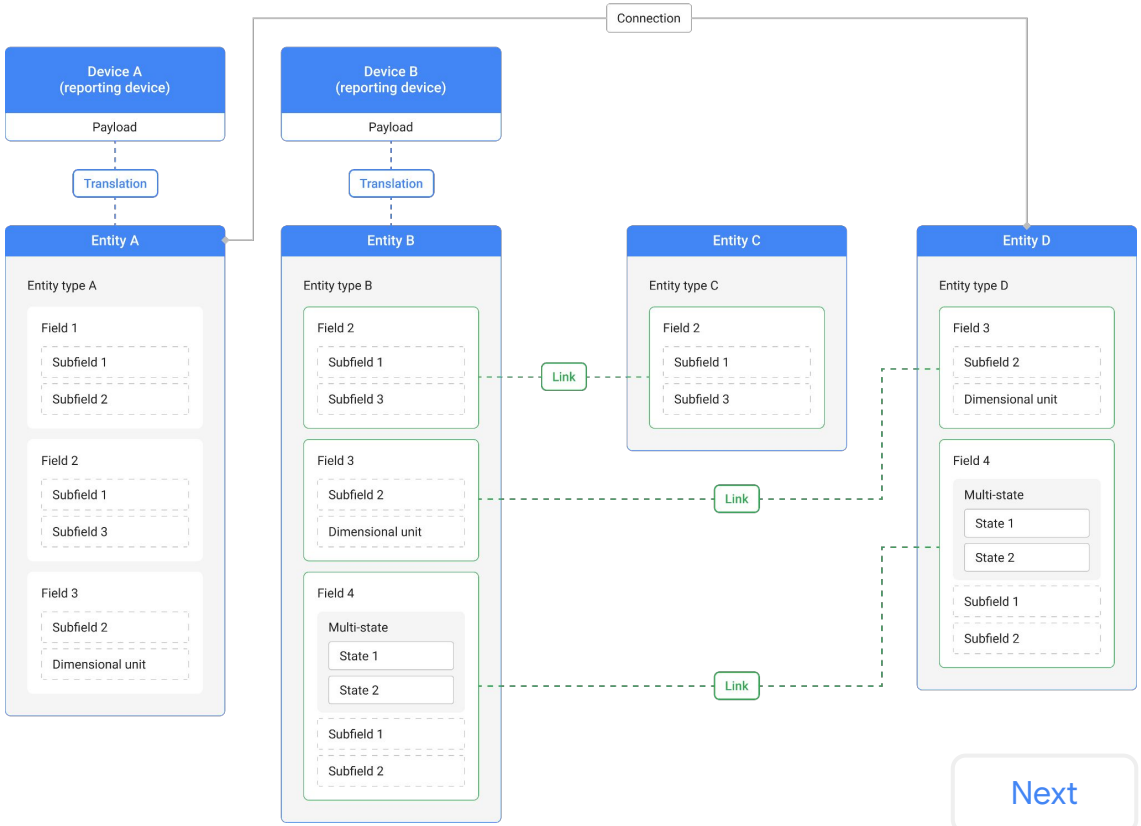
Conceptual model revisited

Here's another look at the DBO conceptual model from Lesson 2.

In this lesson, you'll explore one modeling concept from the abstract model. Remember, abstract modeling concepts are used to describe the properties of an entity. Abstract concepts include:

- Subfields
- Fields
- States and multi-states
- Entity types

Do you see these concepts in the diagram?



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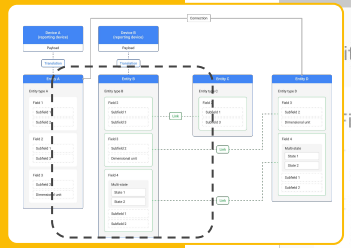
Fields



What you'll learn about:

- Fields
- Field construction syntax
- Field constraints
- Field enumeration

By the end of this lesson, you'll be able to:

- Describe the concept of a field.
- Identify a field in source code.
- Construct a field using the correct syntax.
- Recognize when enumeration is applied to a field.

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Entity A

ity type A

ield 1

Subfield 1

Subfield 2

Field 2

Subfield 1

Subfield 3

Field 3

Subfield 2

Dimensional unit

Entity B

Entity type B

Field 2

Subfield 1

Subfield 3

Field 3

Subfield 2

Dimensional unit

Field 4

Multi-state

State 1

State 2

Subfield 1

Subfield 2

Link

Entity typ

Field 2

Subfi

Subfi

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What's a field?

A field is a grouping of subfields in a structured way to define a concept semantically.

Each field consists of a string of subfields. Fields are self-descriptive, and you should be able to read it naturally.

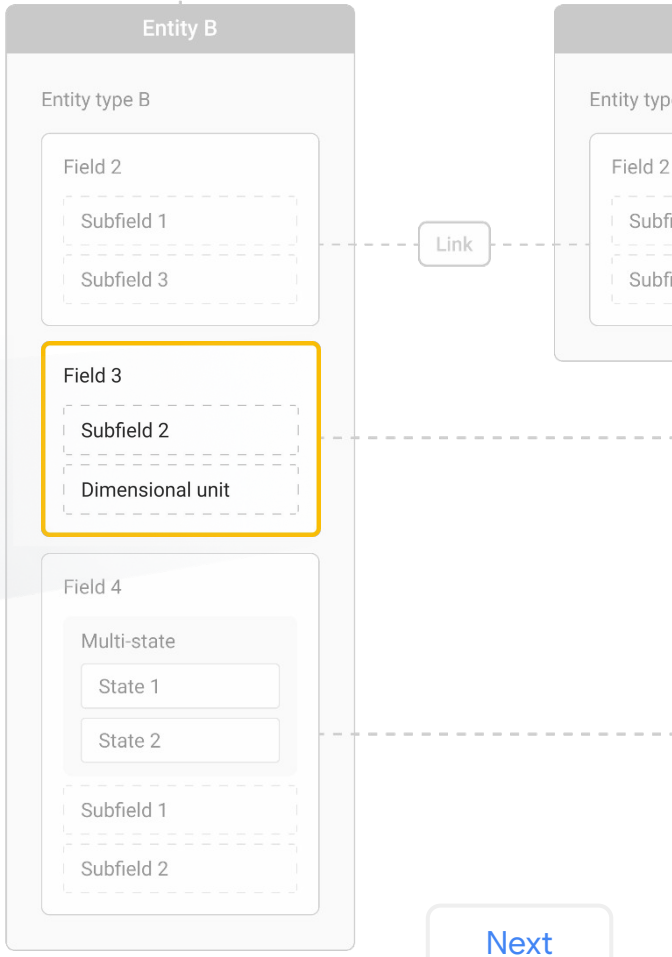
Examples

In the below examples, each individual word is a subfield and separated by underscores.

`zone_air_temperature_sensor`

`supply_fan_run_command`

See digitalbuildings / ... / resources / fields in the Digital Buildings Project GitHub repo for a list of all available telemetry and metadata fields.



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Field construction syntax

Fields are constructed by combining a point type and at least one other subfield in a very specific order:

`(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?<PointType>(_<num> )*`

Order of subfields

Subfields should be combined in this specific order:

1. **`(<Agg_Desc>_)?`** – Aggregation descriptor subfield; optional; can only be used once in conjunction with an aggregation subfield
2. **`(<Agg>_)?`** – Aggregation subfield; optional; can only be used once
3. **`(<descr>_)*`** – Descriptor subfield; optional; can be used multiple times
4. **`(<component>_)?`** – Component subfield; optional; can only be used once
5. **`(<meas. descr>_)?`** – Measurement descriptor subfield; optional; can only be used once
6. **`(<meas>_)?`** – Measurement subfield; optional; can only be used once
7. **`<PointType>`** – Point type subfield; required; can only be used once

In practice, a combination of a point type and at least one other subfield will always be used to contextualize a field properly.

Example

Here's a sample field:

`max_discharge_air_temperature_setpoint`

It has combined the following subfields:

1. **`max`** – Aggregation subfield
2. **`discharge`** – Descriptor subfield
3. **`air`** – Descriptor subfield
4. **`temperature`** – Measurement subfield
5. **`setpoint`** – Point type subfield

The following subfields weren't used:

- Aggregation descriptor, because `max` isn't a time-related aggregation.
- Component, because `air_temperature` doesn't apply to a specific subcomponent of the entity.
- Measurement descriptor, because we can safely assume this `temperature` field describes a dry-bulb temperature per precedent. A wet-bulb temperature would need a measurement descriptor.

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Note: Field construction syntax is written in regular expression syntax! Need help with regex?
Visit RegexOne for more info or regex101 for a tool to test patterns.

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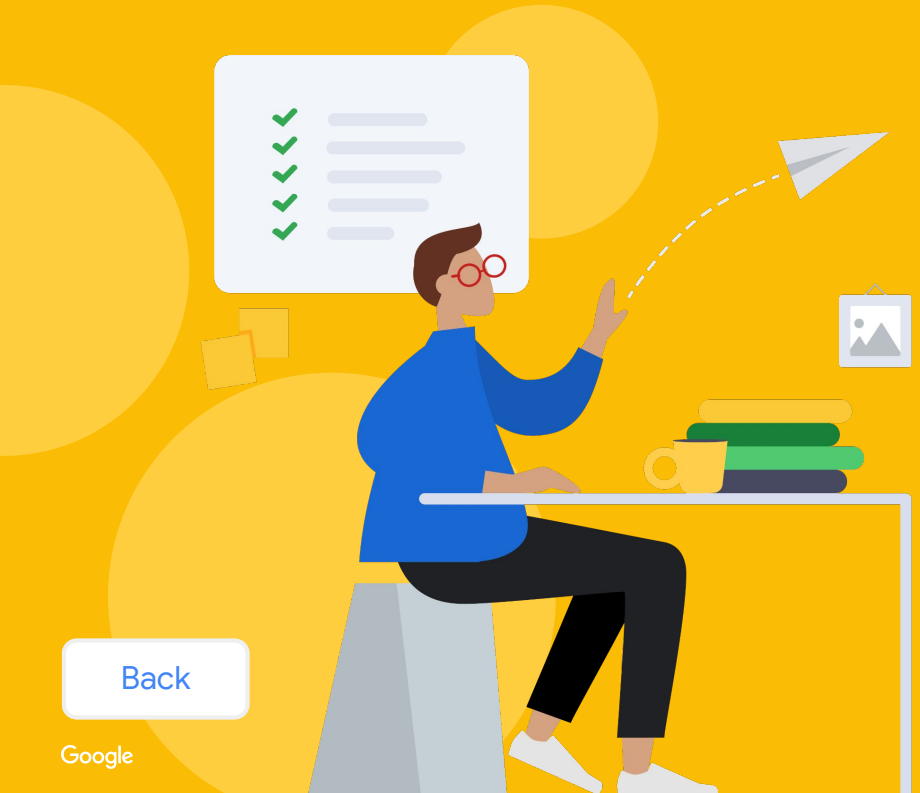
Practice



Let’s take a moment to try to construct a field.

- The next slide will have several subfields that need to be grouped into a field.
- Recall the proper field syntax and select the correct order of subfields.

You won’t be able to move forward until the correct answer is selected.

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*Click **Next** when you’re ready to begin.*

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Practice

To the right are several subfields that are needed to construct a field.

`?_?_?_?_?`

Which subfield should come first?

Select the best answer from the options listed below.

- `sensor` - Point type
- `water` - Descriptor
- `secondary` - Descriptor
- `temperature` - Measurement
- `return` - Descriptor

- `sensor` - Point type subfield
- `water` - Descriptor subfield
- `secondary` - Descriptor subfield
- `temperature` - Measurement subfield
- `return` - Descriptor subfield

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Note: More than one option may apply. If so, select only one option.

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Practice

To the right are several subfields that are needed to construct a field.

`sensor_?_?_?_?`

Which subfield should come first?

Select the best answer from the options listed below.

- **`sensor`** - Point type
- `water` - Descriptor
- `secondary` - Descriptor
- `temperature` - Measurement
- `return` - Descriptor

Hmm, that's not right! 🤔

Remember, a field shouldn't begin with a point type subfield.

Try again

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Practice

To the right are several subfields that are needed to construct a field.

`secondary_return_water_?_?`

Which subfield should come first?

Select the best answer from the options listed below.

`sensor` - Point type

`water` - Descriptor

`secondary` - Descriptor

`temperature` - Measurement

`return` - Descriptor

Good job! 🎉

Any of the descriptor subfields would work here, since the order of descriptors isn't strictly enforced.

Remember, descriptor subfields are used to specify the exact function of the field within the context of the entity. Descriptors can be used multiple times in a field, but you should use as few descriptors as possible.

Although the order of descriptors is not strictly enforced, you should always rely on readability and precedent to determine ordering. In this case, **`secondary_return_water_...`** is preferred because it is more intuitive to read than **`return_secondary_water_...`**, **`water_return_secondary_...`**. Plus, there's already a precedent set in the ontology for it, which should be adhered to as much as possible.

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Practice

To the right are several subfields that are needed to construct a field.

`temperature_?_?_?_?`

Which subfield should come first?

Select the best answer from the options listed below.

- `sensor` - Point type
- `water` - Descriptor
- `secondary` - Descriptor
- **`temperature` - Measurement**
- `return` - Descriptor

Hmm, that's not right! 🤔

Remember, a measurement subfield shouldn't come before a descriptor.

Try again

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Practice

To the right are several subfields that are needed to construct a field.

`secondary_return_water_?_?`

Which subfield should come next?

Select the best answer from the options listed below.

- **`sensor`** - Point type
- **`temperature`** - Measurement

- **`sensor`** - Point type subfield
- **`water`** - Descriptor subfield
- **`secondary`** - Descriptor subfield
- **`temperature`** - Measurement subfield
- **`return`** - Descriptor subfield

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Practice

To the right are several subfields that are needed to construct a field.

`secondary_return_water_sensor_?`

Which subfield should come next?

Select the best answer from the options listed below.

`sensor` - Point type

`temperature` - Measurement

Hmm, that's not right! 🤔

Remember, a point type subfield shouldn't come before a measurement subfield.

Try again

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Practice

To the right are several subfields that are needed to construct a field.

`secondary_return_water_temperature_?`

Which subfield should come next?

Select the best answer from the options listed below.

`sensor` - Point type

`temperature` - Measurement

Good job! 🎉

The measurement subfield should come before the point type subfield.

Remember, the measurement subfield serves a few purposes like identifying the type of measurement being performed and the field's dimensional unit.

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Practice

To the right are several subfields that are needed to construct a field.

`secondary_return_water_temperature?`

There's only one subfield left.

Select the final option.

`sensor` - Point type

`sensor` - Point type subfield

`water` - Descriptor subfield

`secondary` - Descriptor subfield

`temperature` - Measurement subfield

`return` - Descriptor subfield

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Practice

To the right are several subfields that are needed to construct a field.

`secondary_return_water_temperature_sensor`

There's only one subfield left.

Select the final option.

`sensor` - Point type

You did it! 🎉

The point type subfield should always be the last subfield.

Remember, point types are the only subfield that's required for field construction since it identifies a point's function. However, it must be combined with at least one other subfield to contextualize a field.

In this practice exercise, the aggregation, component, and measurement descriptor subfields weren't used because they're optional subfields.

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Field constraints

Remember the following constraints when working with fields.

Fields should always:

- Use a minimum of two subfields.
- Follow the construction syntax to combine subfields in the correct order.
- Use a measurement subfield for numeric values unless the point type subfield is `count` or `counter`.
- Use the minimum number of descriptor subfields needed to uniquely define the field within the context of your desired entity type.

Fields should normally:

- Be defined in the global namespace.
- Be as specific as the context dictates.

Fields should never:

- Use the same subfield more than once.
- Have the same set of subfields as another field with different ordering.
- Use an excessive amount of descriptors.
- Be identical to another field in a different namespace.

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Note: You'll learn about namespaces in Lesson 9 of this module.

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Field enumeration

The same field can be used more than once:

`(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?<PointType> (_<num> )*`

Sometimes, an entity may be made of several of the same parts with identical functions. If this occurs, the field for each part needs to be numbered to differentiate between them.

Use case

A device has two zone temperature sensors that function identically.

To distinguish between the two sensors, one sensor uses the field **<field>_1**, and the other sensor uses **<field>_2**.

Subgrouping

Subgrouping is allowed and indicated by using multiple increments of enumeration: **<field>_1_2**, **<field>_1_3**, and so on.

Example

Here's an AHU that requires field enumeration.

```
AHU_US_MTV_2171_3:
  id: "11391598658907537408"
  description: "Non-standard type for 2171"
  implements:
  - AHU_BYPSSPC2X_DX2SC_ECON_HT2SC_SFSS
  - INCOMPLETE
  uses:
  - supply_air_static_pressure_sensor1
  - supply_air_static_pressure_sensor2
```

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Numeric fields

Certain fields send numeric values. When the value is expected to be numeric, it's also required to set boundaries around which values the field will send, in order to judge data quality over time.

Which fields are numeric?

It's usually pretty obvious if the field should be numeric, but we can also tell by whether they meet one of the following conditions:

1. The field uses a **`measurement`** subfield.
2. The field's point type is **`count`** or **`counter`**.

Flexible vs. Fixed boundaries

Each numeric field requires a min and max. Each boundary can be one of two types:

- **Fixed:** the boundary should not be adjusted from device to device, nor change over time.
- **Flexible:** the boundary may (and probably will) be adjusted from device to device, and may vary with time (e.g., seasonally).

Range values

Make sure the ranges are stored as doubles (with a decimal point). Also make sure to set them as the widest possible values for all fields of that type.

Example: Fixed Usage

In this example, the damper can't be outside 0% or 100%. Anything outside that range wouldn't be physically meaningful.

```
outside_air_damper_percentage_command:
  fixed_min: 0.0
  fixed_max: 100.0
```

Example: Flexible Usage

In this example, the outside temperature will vary from sensor to sensor (e.g. Singapore and Seattle have very different expected ranges). Here we can note the typical expected range for all sensors and refine later, field-by-field.

```
outside_air_temperature_sensor:
  flexible_min: 248.15
  flexible_max: 318.15
```

Example: Mixed Usage

In this example, power should always be lower-bounded at 0, but the upper bound is flexible and will be different for individual devices.

```
power_sensor:
  fixed_min: 0
  flexible_max: 318000
```

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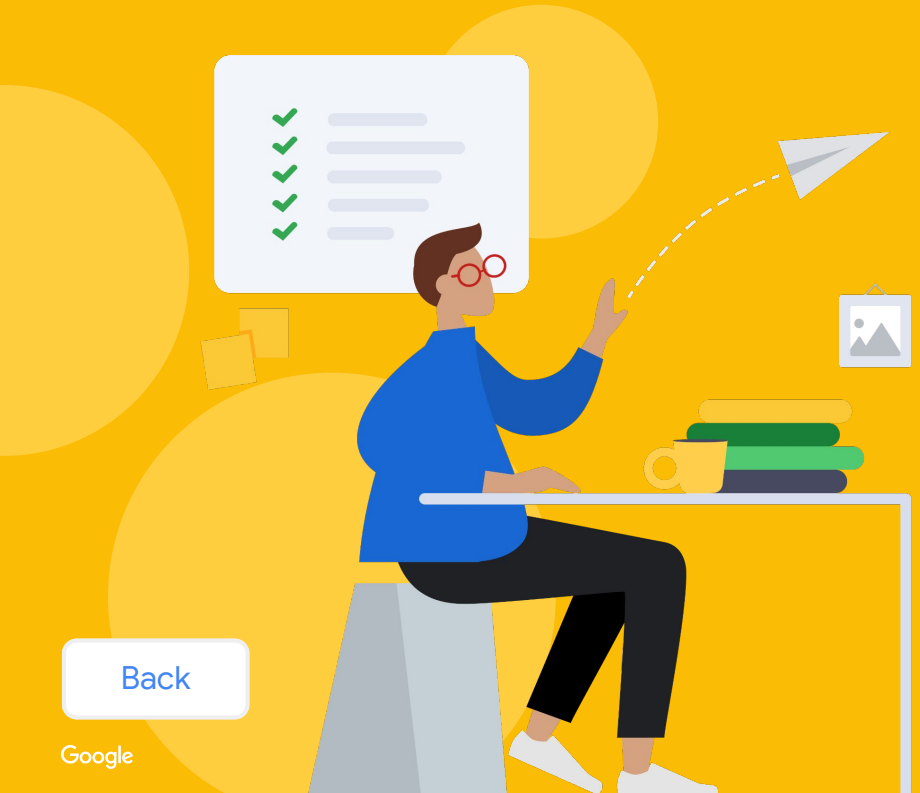
Lesson 4

Knowledge check



Let’s take a moment to reflect on what you’ve learned so far.

- The next slides will have questions about the concepts that were introduced in this lesson.
- Review each question and select the correct response.

If there are more than two answer options, you won’t be able to move forward until the correct answer is selected.

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*Click **Next** when you’re ready to begin.*

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Knowledge check 1

A field is a grouping of _____ in a structured way to define concepts semantically.

Fill in the blank.

Select the best answer from the options listed below.

- points
- tags
- subfields
- components

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Knowledge check 1

A field is a grouping of _____ in a structured way to define concepts semantically.

Fill in the blank.

Select the best answer from the options listed below.

points

tags

subfields

components

Hmm, that's not right! 🤔

Try again

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Knowledge check 1

A field is a grouping of _____ in a structured way to define concepts semantically.

Fill in the blank.

Select the best answer from the options listed below.

points

tags

subfields

components

Hmm, that's not right! 🤔

Try again

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Knowledge check 1

A field is a grouping of _____ in a structured way to define concepts semantically.

Fill in the blank.

Select the best answer from the options listed below.

points

tags

subfields

components

That's right! 🎉

Fields consist of a string of subfields in very particular order.

Brevity is key with fields, so only the minimum number of subfields should be used to uniquely define a field.

Examples

```
zone_air_temperature_sensor
supply_fan_run_command
```

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Knowledge check 1

A field is a grouping of _____ in a structured way to define concepts semantically.

Fill in the blank.

Select the best answer from the options listed below.

points | tags

subfields | components

Hmm, that's not right! 🤔

Try again

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Knowledge check 2

Fields are constructed by grouping subfields in a very specific order.

What's the correct order of subfields?

Select the best answer from the options listed below.

- `<PointType>(_<num> )*(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?(<Agg_Desc>_)?(<Agg>_)?`
- `(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas>_)?(<meas. descr>_)?<PointType>(_<num> )*`
- `(<Agg_Desc>_)?(<Agg>_)?(<meas. descr>_)?(<meas>_)?(<descr>_)*(<component>_)?<PointType>(_<num> )*`
- `(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?<PointType>(_<num> )*`

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Knowledge check 2

Fields are constructed by grouping subfields in a very specific order.

Close... but not quite right! 🤔

Try again

What's the correct order of subfields?

Select the best answer from the options listed below.

<PointType>(_<num>)*(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?(<Agg_Desc>_)?(<Agg>_)?

(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas>_)?(<meas. descr>_)?<PointType>(_<num>)*

(<Agg_Desc>_)?(<Agg>_)?(<meas. descr>_)?(<meas>_)?(<descr>_)*(<component>_)?<PointType>(_<num>)*

(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?<PointType>(_<num>)*

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Knowledge check 2

Fields are constructed by grouping subfields in a very specific order.

Close... but not quite right! 🤔

Try again

What's the correct order of subfields?

Select the best answer from the options listed below.

<PointType>(_<num>)*(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?(<Agg_Desc>_)?(<Agg>_)?

(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas>_)?(<meas. descr>_)?<PointType>(_<num>)*

(<Agg_Desc>_)?(<Agg>_)?(<meas. descr>_)?(<meas>_)?(<descr>_)*(<component>_)?<PointType>(_<num>)*

(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?<PointType>(_<num>)*

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Knowledge check 2

Fields are constructed by grouping subfields in a very specific order.

What's the correct order of subfields?

Select the best answer from the options listed below.

<PointType>(_<num>)*(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?(<Agg_Desc>_)?(<Agg>_)?

(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas>_)?(<meas. descr>_)?<PointType>(_<num>)*

(<Agg_Desc>_)?(<Agg>_)?(<meas. descr>_)?(<meas>_)?(<descr>_)*(<component>_)?<PointType>(_<num>)*

(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?<PointType>(_<num>)*

Close... but not quite right! 🤔

Try again

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Knowledge check 2

Fields are constructed by grouping subfields in a very specific order.

What's the correct order of subfields?

Select the best answer from the options listed below.

`<PointType>(_<num> )*(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?(<Agg_Desc>_)?(<Agg>_)?`

`(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas>_)?(<meas. descr>_)?<PointType>(_<num> )*`

`(<Agg_Desc>_)?(<Agg>_)?(<meas. descr>_)?(<meas>_)?(<descr>_)*(<component>_)?<PointType>(_<num> )*`

`(<Agg_Desc>_)?(<Agg>_)?(<descr>_)*(<component>_)?(<meas. descr>_)?(<meas>_)?<PointType>(_<num> )*`

That's right! 🎉

It's important to follow this syntax when constructing a field.

In addition to the order of subfields, remember that most of them are optional and can only be used once:

1. **`(<Agg_Desc>_)?`** – Aggregation descriptor subfield
   Optional; can only be used once in conjunction with an aggregation.
2. **`(<Agg>_)?`** – Aggregation subfield
   Optional; can only be used once.
3. **`(<descr>_)*`** – Descriptor subfield
   Optional; can be used multiple times.
4. **`(<component>_)?`** – Component subfield
   Optional; can only be used once.
5. **`(<meas. descr>_)?`** – Measurement descriptor subfield
   Optional; can only be used once.
6. **`(<meas>_)?`** – Measurement subfield
   Optional; can only be used once.
7. **`<PointType>`** – Point type subfield
   Required; can only be used once.

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Knowledge check 3

The same subfield can be used more than once.

`secondary_secondary_return_water_temperature_sensor`

Is this statement true or false?

Select the best answer from the options listed below.

True

False

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Knowledge check 3

The same subfield can be used more than once.

`secondary_secondary_return_water_temperature_sensor`

Is this statement true or false?

Select the best answer from the options listed below.

True

False

Hmm, that's not right! 🤔

Subfields should never be used more than once in a field.
The second secondary subfield should be removed, like so:

`secondary_return_water_temperature_sensor`

Also, fields should never use the same set of subfields as another field with a different ordering. These wouldn't be valid:

`secondary_return_water_temperature_sensor`

`secondary_water_return_temperature_sensor`

A field, however, can be used more than once.

Sometimes, an entity may be made of several of the same parts with identical functions. When this occurs, then fields need to be reused and enumerated to differentiate between each part (e.g., **`<field>_1`** and **`<field>_2`**).

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Knowledge check 3

The same subfield can be used more than once.

`secondary_secondary_return_water_temperature_sensor`

Is this statement true or false?

Select the best answer from the options listed below.

True

False

That's right! 🎉

Subfields should never be used more than once in a field.
The second secondary subfield should be removed, like so:

`secondary_return_water_temperature_sensor`

Also, fields should never use the same set of subfields as another field with a different ordering. These wouldn't be valid:

`secondary_return_water_temperature_sensor`

`secondary_water_return_temperature_sensor`

A field, however, can be used more than once.

Sometimes, an entity may be made of several of the same parts with identical functions. When this occurs, then fields need to be reused and enumerated to differentiate between each part (e.g., `<field>_1` and `<field>_2`).

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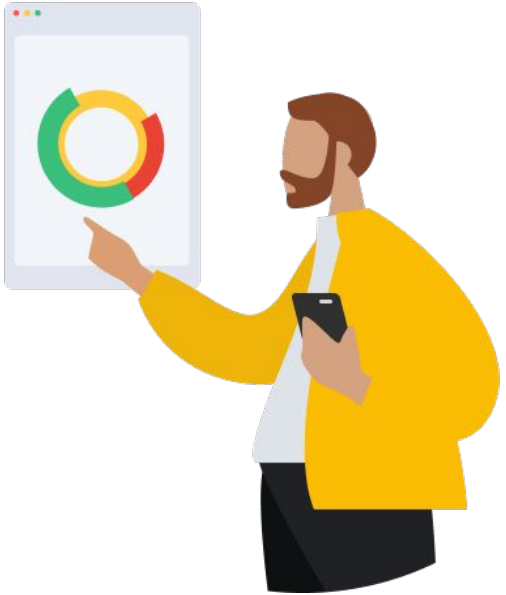
Lesson 4 summary

Let's review what you learned about:

- Fields
- Field construction syntax
- Field constraints
- Field enumeration

Now you should be able to:

- Describe the concept of a field.
- Identify a field in source code.
- Construct a field using the correct syntax.
- Recognize when enumeration is applied to a field.



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You completed Lesson 4!

Now's a great time to take a quick break before starting Lesson 5.

Ready for Lesson 5?

Let's go!

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*Press the **Esc** key on your keyboard to exit presentation mode.*

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Have questions?

For future reference, keep these contacts and resources easily accessible for technical and procedural questions.

Key contacts

- For project-related questions: Your project's TPM or DBC
- For DBO questions: Trevor (tsodorff@) or Digital Buildings Discussions

Helpful resources

Bookmark these resources for future reference.

- digitalbuildings / ontology / yaml / resources / fields
  Contains all of the available metadata and telemetry fields.
- digitalbuildings / ontology
  Contains the documentation and configuration files for the DBO.
- digitalbuildings / ontology / docs / ontology.md
  Provides an overview of the structure and principles of the ontology.
- digitalbuildings / ontology / docs / model.md
  Describes the conventions used in the DBO abstract model.
- Digital Buildings Project GitHub
  Contains source code, tooling, and documentation for the DBO.