Navigate the Bill of Materials with SQL Server Shortest Path

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QUANTUMDATIS

Speaker

- **MVP Data Platform**
- **Product Manager** in **Pandora**
  - Sharepoint, Power BI governance, security and access management
- Working and living in Denmark
- Speaker for many community driven events: SQL Saturdays, Data Saturdays, PASS Summit, etc; worldwide
- Author for sqlservercentral.com, sqlshack.com, UGISS (User Group Italiano SQL Server)

Agenda

- Graphs
- Graphs and SQL Server 2017-19
- Query sintax and T-SQL graph extentions in SQL Server 2019
- Shortest Path
  - Navigate through a Bill of Materials
- D365 BOM

DISCLAIMER: This is not an introduction to graph databases. I'm just talking about the features you need to follow the session.

Graphs

Graph objects

A graph is a collection of *Nodes* and *Edges*

- ***Nodes*** = Entities (customers, products, territories, …)
- ***Edges*** = Relationships between entities
- ***Properties*** = Node or Edge attributes

Graph objects

Node

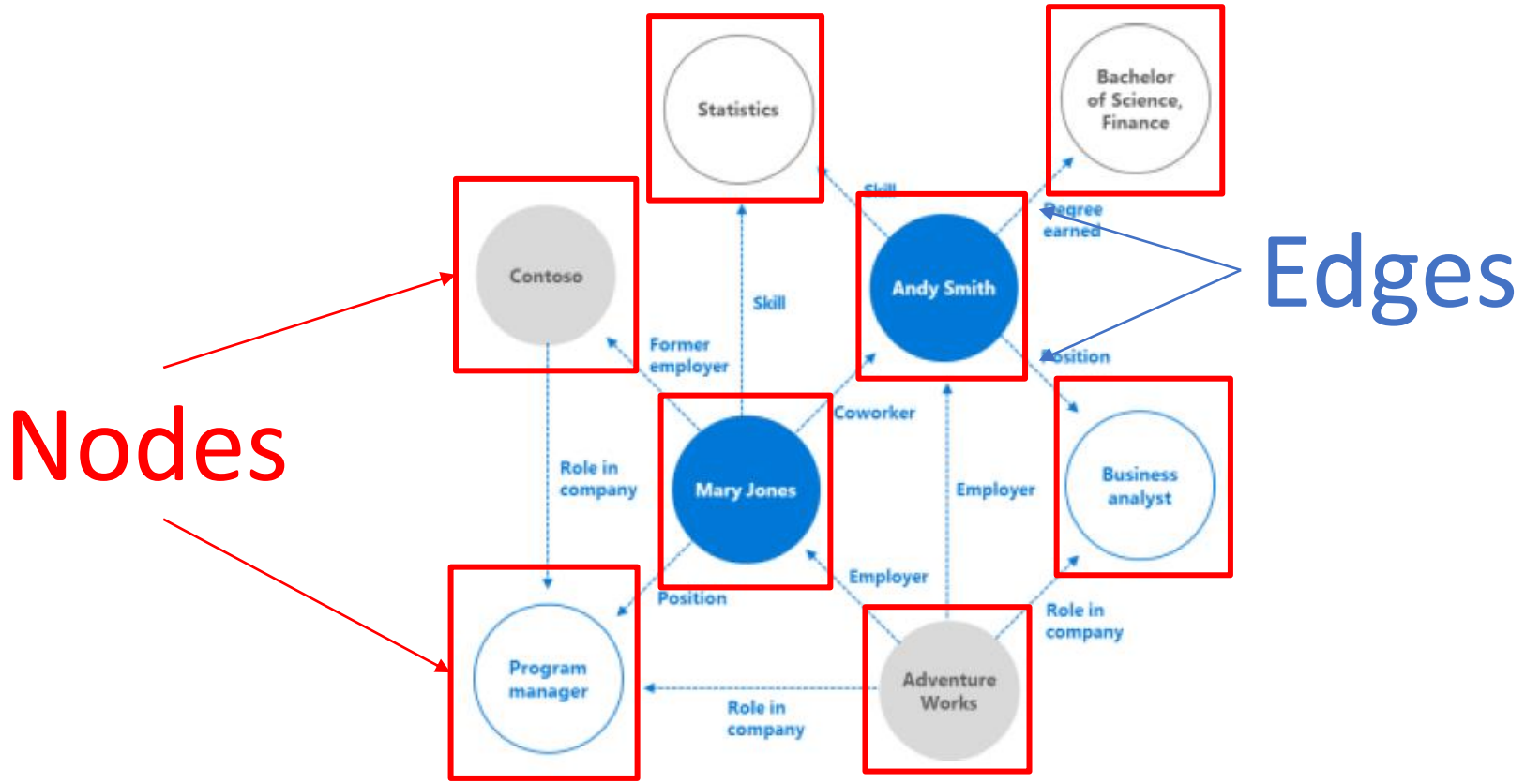
- Represents an entity: Product, Customer, Supplier, …
- Nodes can contain some properties
- Nodes can be labeled with one or more labels
- Stored as physical table in the database

Graph objects

Edges

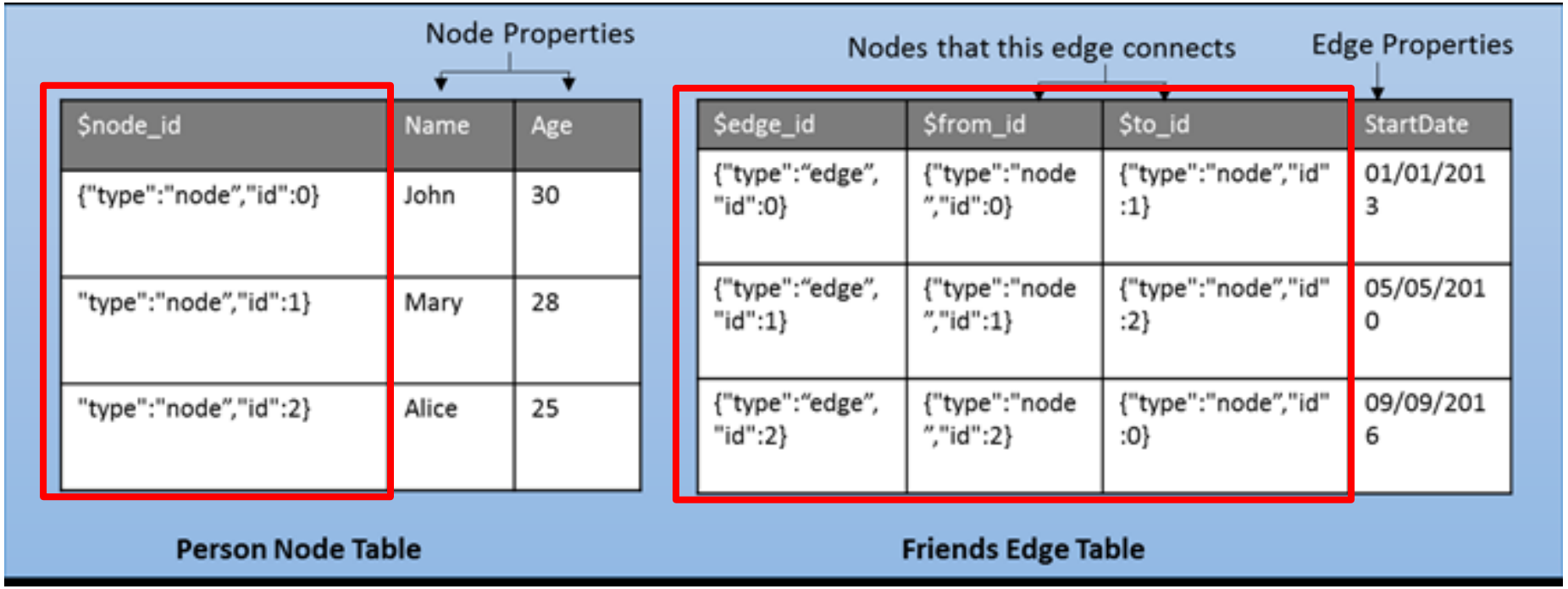
- Relationships between entities
- Relationships are named and directed and always have a start and end node
- Relationship can also contain properties
- Stored as physical table in the database

Graph objects



Graphs and SQL Server 2017-2019

Node and edge tables in SQL Server



Query syntax and T-SQL graph extensions in SQL Server

T-SQL extensions

- **CREATE TABLE … AS NODE / AS EDGE**
- **CREATE EDGE CONSTRAINTS**: enforce specific semantics and maintain data integrity
- **MATCH**: built-in function to support pattern matching and traversal through the graph

T-SQL extensions

MATCH

Specifies a search condition for a graph. MATCH can be used only with graph node and edge tables, in the SELECT statement as part of WHERE clause.

```
-- use MATCH in SELECT to find friends of Alice
SELECT Person2.name AS FriendName
FROM Person Person1, friend, Person Person2
WHERE MATCH(Person1-(friend)->Person2)
AND Person1.name = 'Alice';
```

T-SQL extensions

Syntax: *node-(edge)->node* or *node<-(edge)–node*

From one node to another via an edge

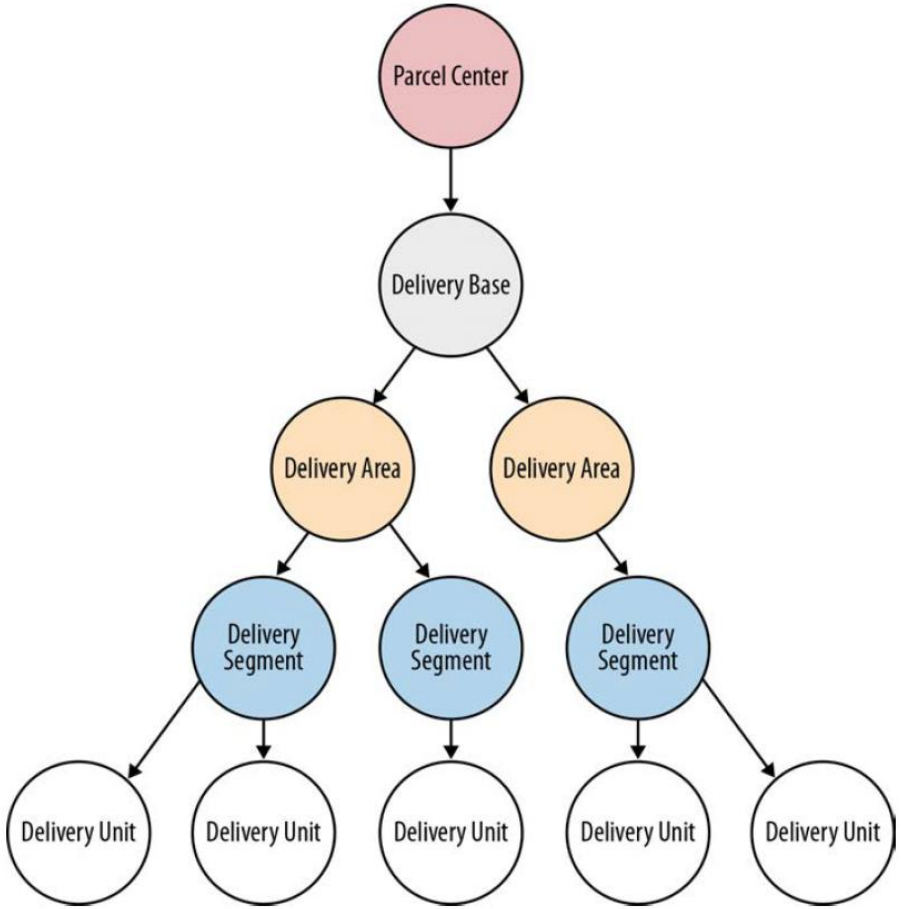
Edge names inside brackets

Easier than a relational JOIN

SHORTEST_PATH

Route calculation and shortest path

Global Post parcel network



Robinson, Webber, Eifrem
”Graph Databases” – O’Reilly

SQL Server 2019 – SHORTEST_PATH

The **SHORTEST_PATH** function:

- Finds a shortest path between two given nodes/entities
- Finds a single source shortest path(s)
- Finds a shortest path from multiple source nodes to multiple target nodes

The function can only be used inside the MATCH clause

https://learn.microsoft.com/en-us/sql/relational-databases/graphs/sql-graph-shortest-path?view=sql-server-ver16

Clauses and patterns to be used in SHORTEST PATH

FOR PATH

Tells the engine that the node or edge table will return an ordered collection representing the list of nodes or edges found along the path traversed.

https://learn.microsoft.com/en-us/sql/relational-databases/graphs/sql-graph-shortest-path?view=sql-server-ver16

Clauses and patterns to be used in SHORTEST PATH

Arbitrary Length Pattern

+ Repeat the pattern 1 or more times. Terminate as soon as the shortest path is found

(1,n) Repeat the pattern 1 to n times. Terminate as soon as the shortest is found

https://learn.microsoft.com/en-us/sql/relational-databases/graphs/sql-graph-shortest-path?view=sql-server-ver16

Clauses and patterns to be used in SHORTEST PATH

LAST_NODE

the node which appears last in the path traversed

https://learn.microsoft.com/en-us/sql/relational-databases/graphs/sql-graph-shortest-path?view=sql-server-ver16

Clauses and patterns to be used in SHORTEST PATH

Graph Path Order

The order of data in the output path

WHITIN GROUP (GRAPH PATH)

https://learn.microsoft.com/en-us/sql/relational-databases/graphs/sql-graph-shortest-path?view=sql-server-ver16

Clauses and patterns to be used in SHORTEST PATH

Graph Path Aggregate Functions

- **STRING_AGG**
- **LAST_VALUE**
- **SUM**
- **COUNT**
- **AVG**
- **MIN**
- **MAX**

https://learn.microsoft.com/en-us/sql/relational-databases/graphs/sql-graph-shortest-path?view=sql-server-ver16

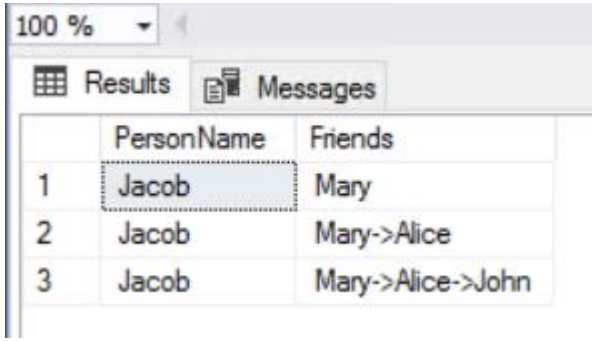
Find shortest path between two people

```
SELECT PersonName, Friends
FROM (
        SELECT
                Person1.name AS PersonName,
                STRING_AGG(Person2.name, '->') WITHIN GROUP (GRAPH PATH) AS Friends,
                LAST_VALUE(Person2.name) WITHIN GROUP (GRAPH PATH) AS LastNode
        FROM
            Node Person AS Person1,
            Edge friendOf FOR PATH AS fo,
            Node Person FOR PATH AS Person2
        WHERE MATCH(SHORTEST_PATH(Person1(-(fo)->Person2)+))
        AND Person1.name = 'Jacob'
) AS Q
WHERE Q.LastNode = 'Alice'
```

SHORTEST_PATH clauses

Find shortest path from a given value to all other nodes in graph

```
SELECT
        Person1.name AS PersonName,
        STRING_AGG(Person2.name, '->') WITHIN GROUP (GRAPH PATH) AS Friends
FROM
        Person AS Person1,
        friendOf FOR PATH AS fo,
        Person FOR PATH AS Person2
WHERE MATCH(SHORTEST_PATH(Person1(-(fo)->Person2)+))
AND Person1.name = 'Jacob'
```

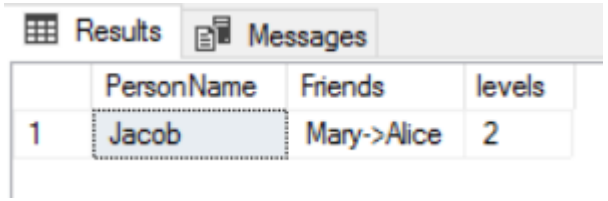


	PersonName	Friends
1	Jacob	Mary
2	Jacob	Mary->Alice
3	Jacob	Mary->Alice->John

Arbitrary length pattern:
repeat the pattern 1 time

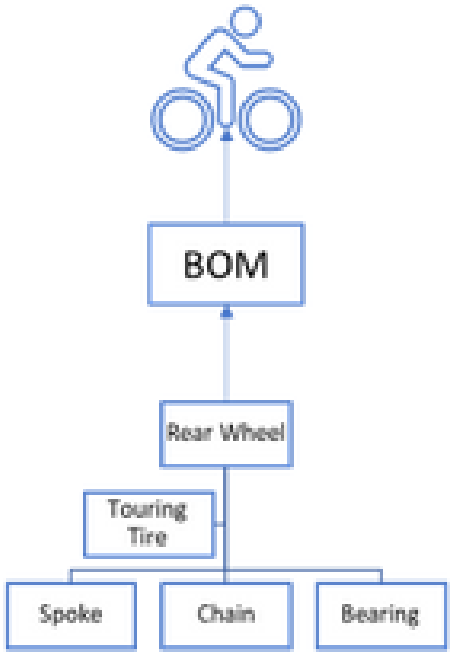
Count the number of levels traversed to go from one person to another in the graph

```
SELECT PersonName, Friends, levels
FROM (
        SELECT
                Person1.name AS PersonName,
                STRING_AGG(Person2.name, '->') WITHIN GROUP (GRAPH PATH) AS Friends,
                LAST_VALUE(Person2.name) WITHIN GROUP (GRAPH PATH) AS LastNode,
                COUNT(Person2.name) WITHIN GROUP (GRAPH PATH) AS levels
        FROM
                Person AS Person1,
                friendOf FOR PATH AS fo,
                Person FOR PATH AS Person2
        WHERE MATCH(SHORTEST_PATH(Person1(-(fo)->Person2)+))
        AND Person1.name = 'Jacob'
) AS Q
WHERE Q.LastNode = 'Alice'
```



Shortest path and BOM (Bill of Material) calculation

BOM in Adventure Works Cycles



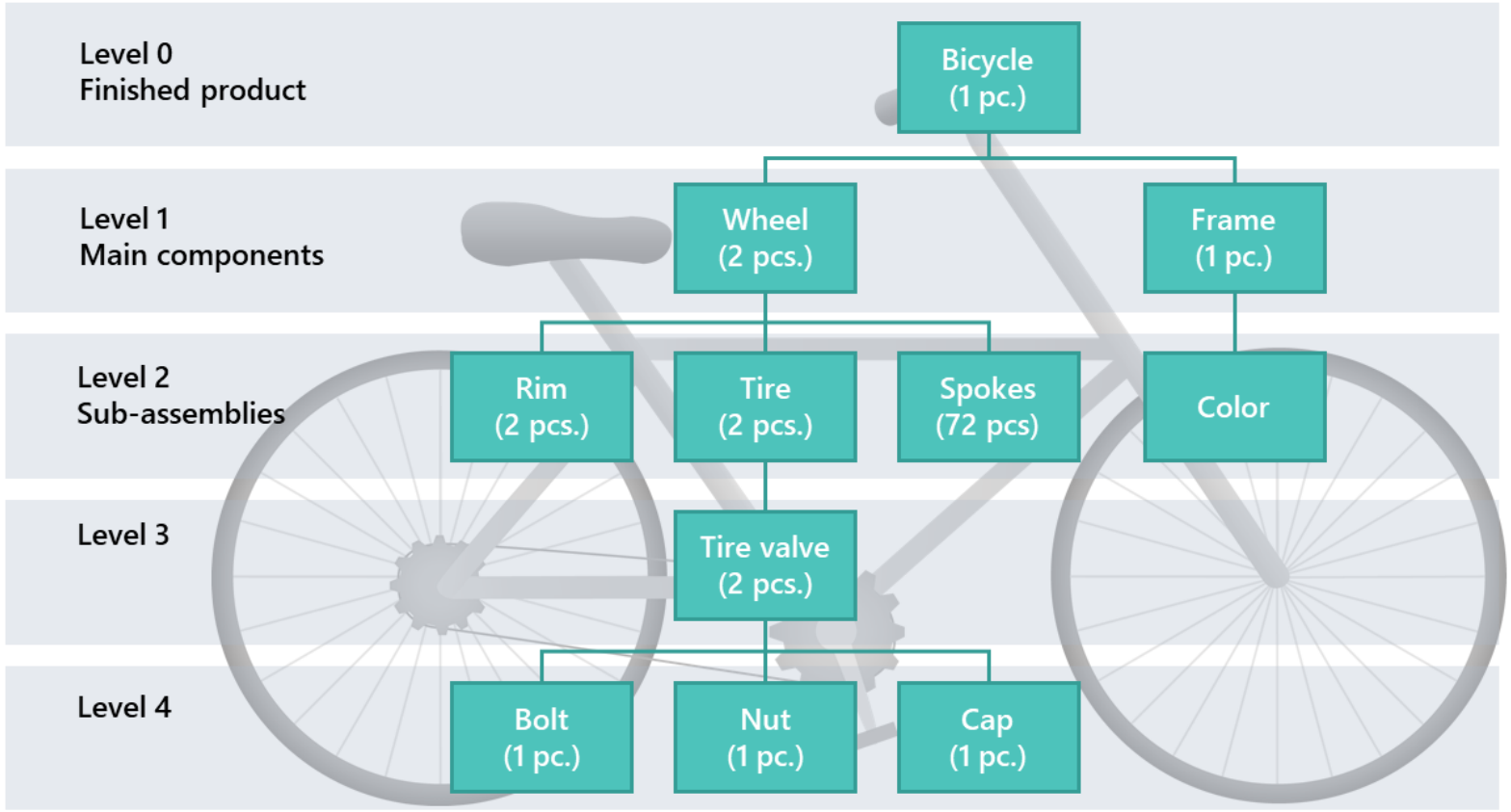
Find all assemblies where a given product is used

```
SELECT
        P1.ProductID,
        P1.Name,
        STRING_AGG(P2.Name,'->') WITHIN GROUP (GRAPH PATH) AS [Assembly],
        LAST_VALUE(P2.ProductID) WITHIN GROUP (GRAPH PATH) AS [Final ProductID]
FROM
        PRODUCT P1,
        PRODUCT FOR PATH P2,
        ISPARTOF FOR PATH IPO
WHERE
        MATCH(SHORTEST_PATH(P1(-(IPO)->P2)+))
        AND P1.ProductID = 2
ORDER BY P1.ProductID
```

Results | Messages

	ProductID	Name	Assembly	Final ProductID
1	2	Bearing Ball	BB Ball Bearing->LL Bottom Bracket->Touring-3000 Blue, 62	960
2	2	Bearing Ball	BB Ball Bearing	3
3	2	Bearing Ball	BB Ball Bearing->LL Bottom Bracket	994
4	2	Bearing Ball	BB Ball Bearing->ML Bottom Bracket->Touring-2000 Blue, 46	970
5	2	Bearing Ball	BB Ball Bearing->LL Bottom Bracket->Touring-3000 Yellow, 44	961

Multilevel BOM



Demo BOM AdventureWorks

Database: AdventureWorks2014

Setup-BOMGraph.sql

ShortestPath.sql

Public Preview of Shortest Path on SQL Server 2019
https://techcommunity.microsoft.com/t5/SQL-Server/Public-Preview-of-Shortest-Path-on-SQL-Server-2019/ba-p/721240
Exploding Bill of Materials using Graph Shortest Path
https://channel9.msdn.com/Shows/Data-Exposed/Exploding-Bill-of-Materials-using-Graph-Shortest-Path

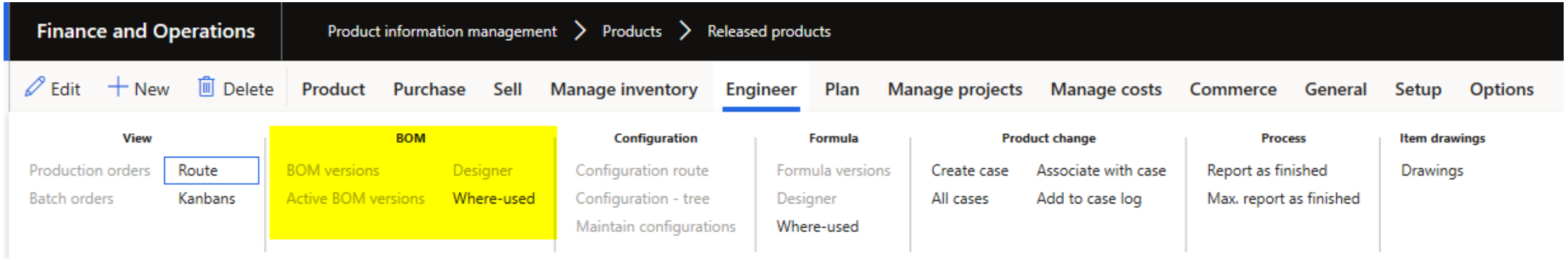
BOM in Dynamics 365

BOM in Dynamics 365

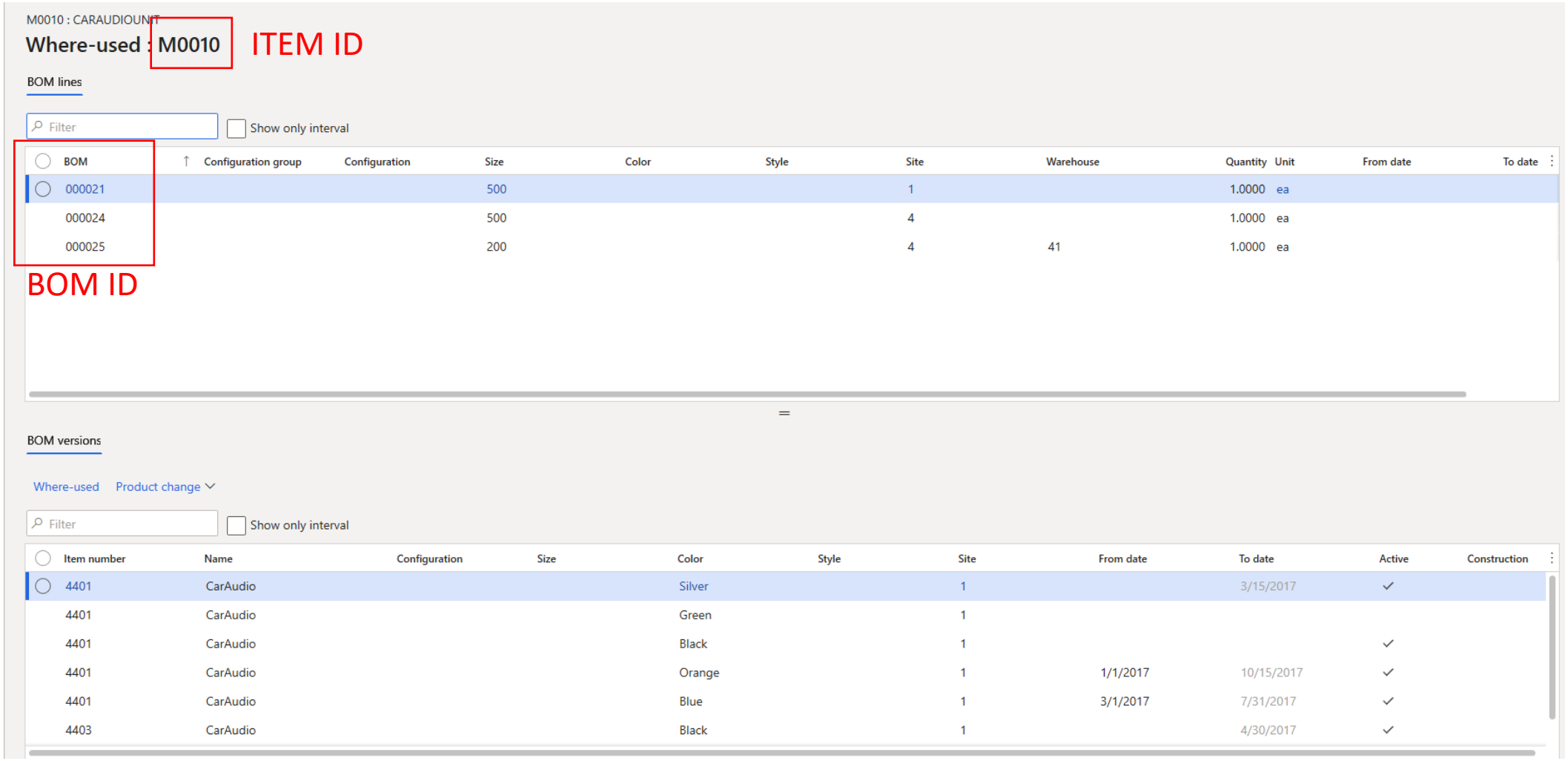
A BOM is described by the following information:

- BOM ID
- BOM name
- The BOM lines that describe the components and ingredients
- The BOM versions, which define the product and period that the BOM can be used for

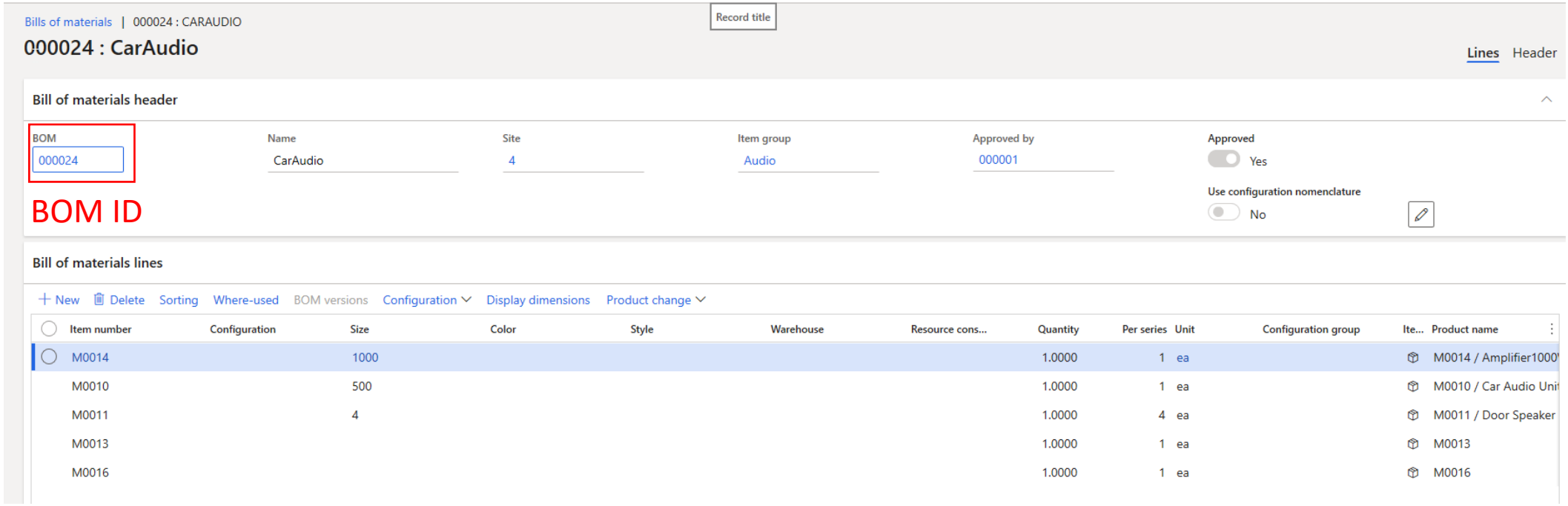
BOM in Dynamics 365



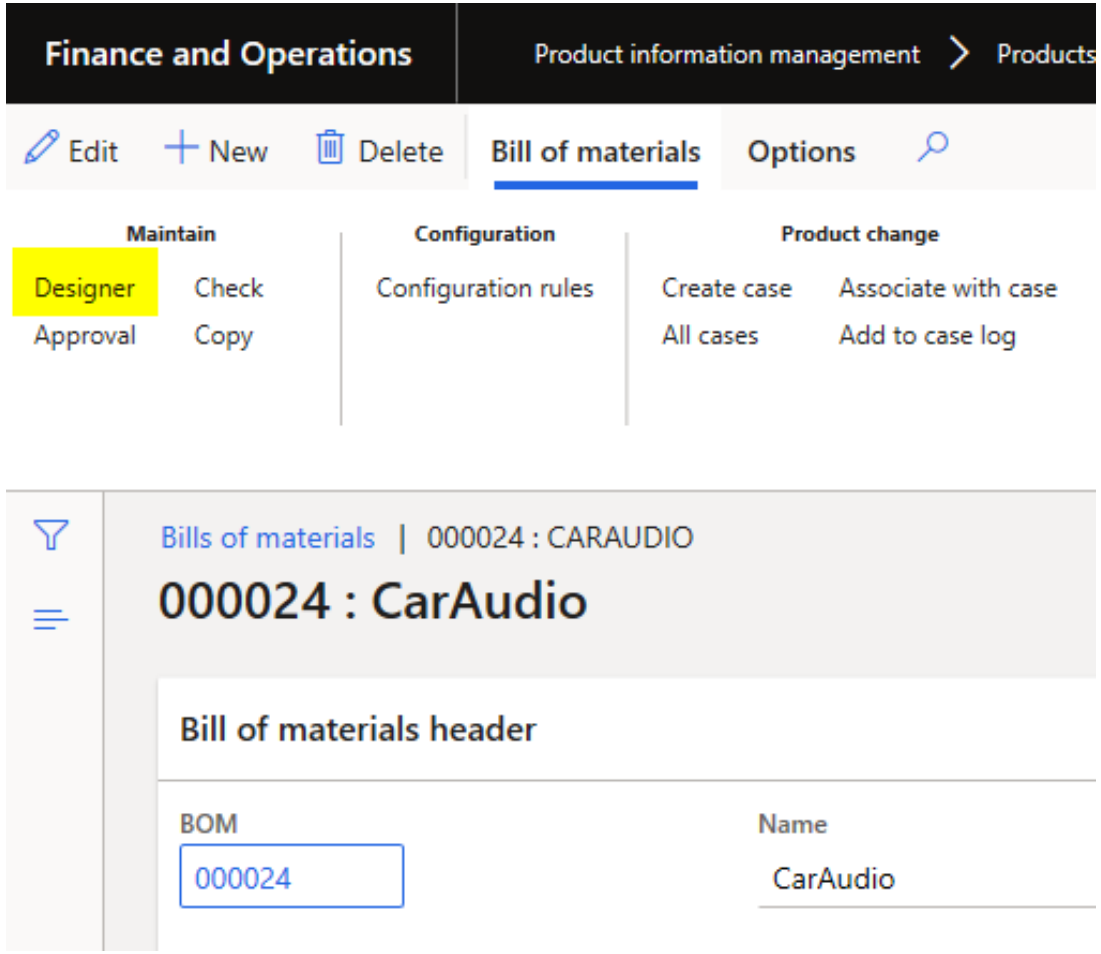
BOM in Dynamics 365



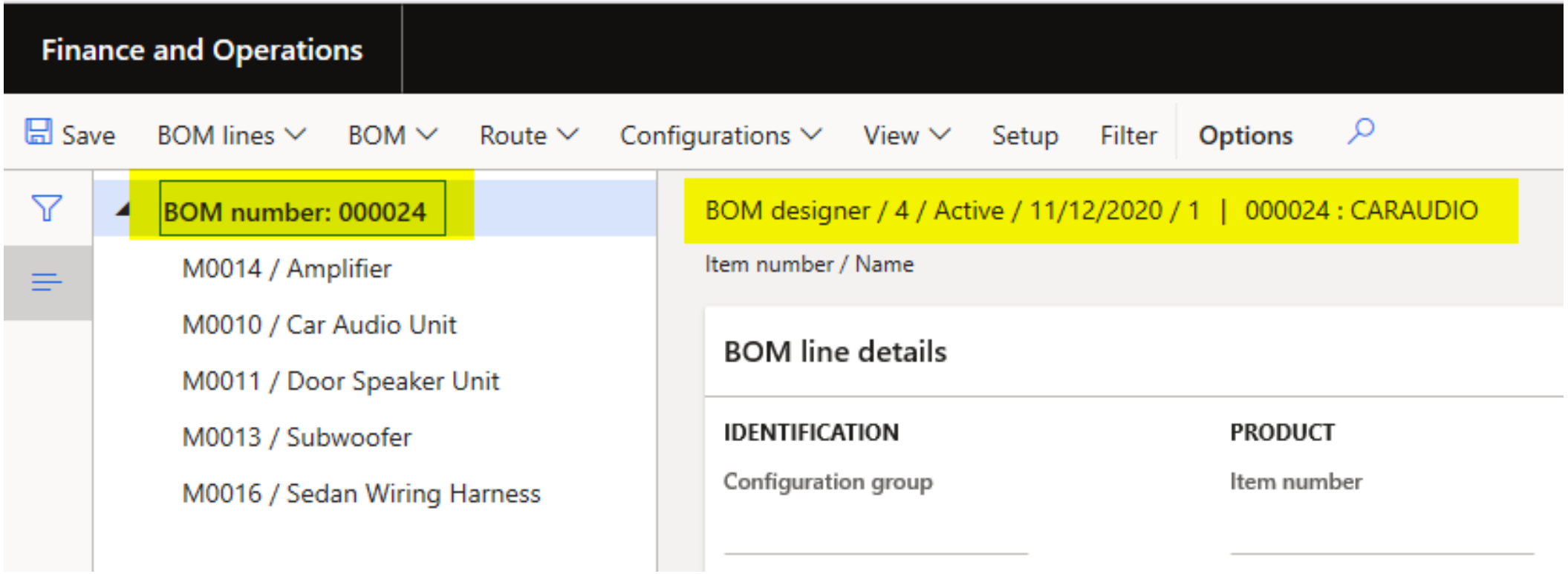
BOM in Dynamics 365



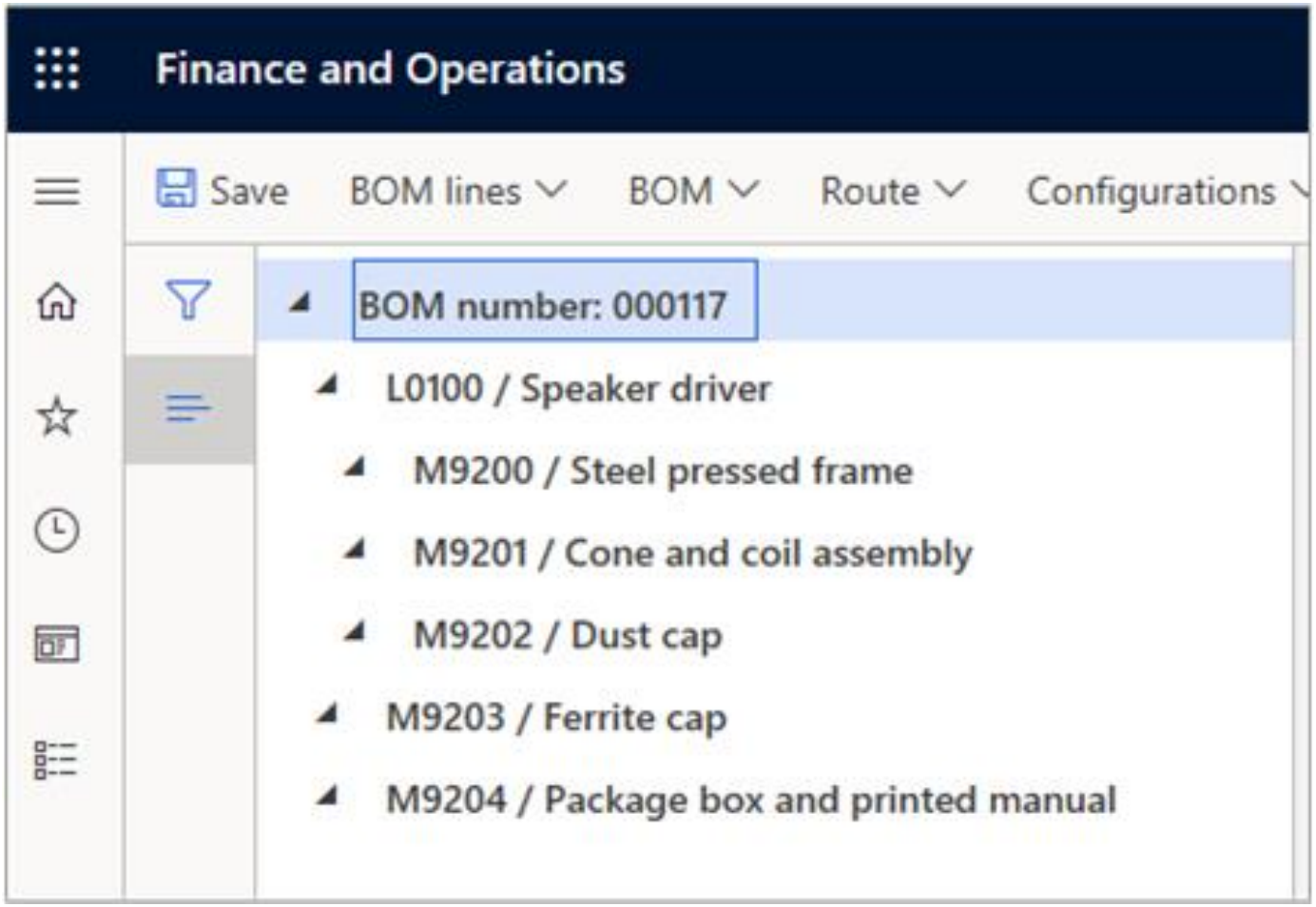
BOM in Dynamics 365



BOM in Dynamics 365



Multilevel BOM



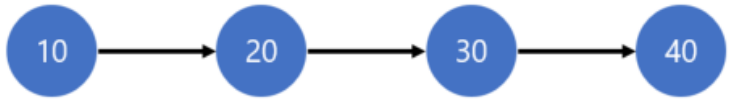
Routes

A route describes the order of operations that is used to produce a product or product variant.

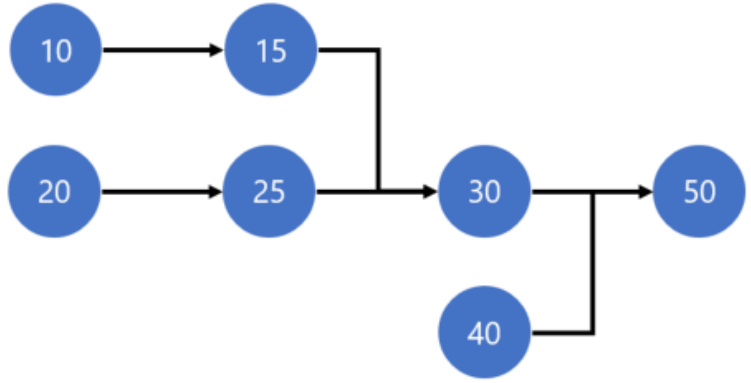
Each operation is assigned an operation number and a successor operation.

The order of operations forms a route network.

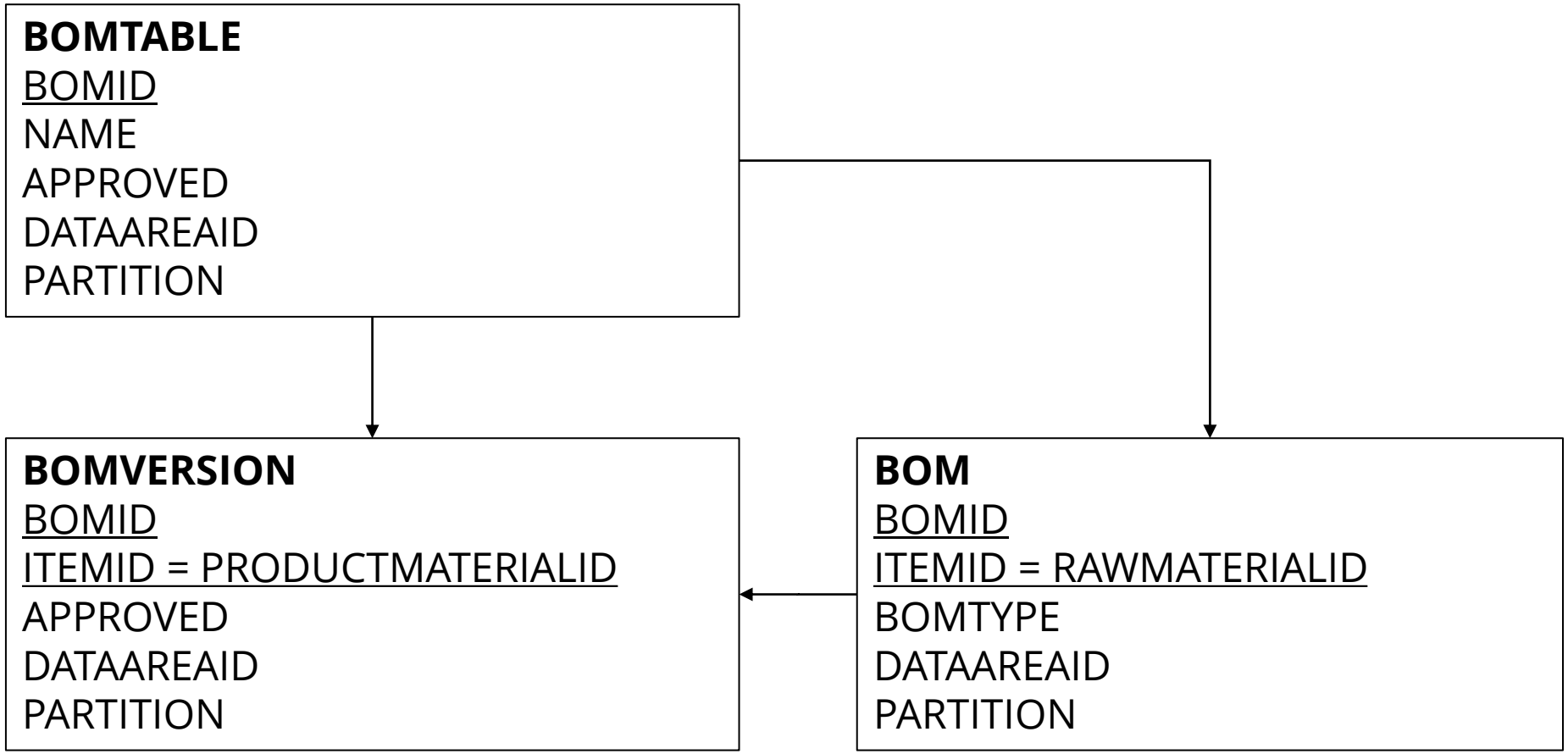
Simple route



Route network



Data model in AX/D365



Demo BOM AX/D365

Database: AXDB
No shortest path. Traditional SQL for reading the BOM:
AX_Database_BOM_loop.sql
Shortest path setup on the AX Database:
AXDB_BOM_graph_setup.sql

SQL Server 2022 and Graph features

Grazie!!!