ISIT312 Big Data Management

Extraction, Transformation and Loading

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Extraction, Transformation and Loading

Outline

- Extraction, Transformation and Loading
- Conceptual ETL Design using BPMN
- Conceptual Design of the Northwind ETL

Extraction, Transformation and Loading (ETL)

Extract data from internal and external sources, transform data, and load data into a data warehouse (ETL)

No agreed way to specify ETL at a conceptual level

We study conceptual ETL design

Conceptual model based on the Business Process Modeling Notation (BPMN)

- Users already familiar with BPMN do not need to learn another language to design ETL
- BPMN provides a conceptual and implementation-independent specification of processes
- Processes expressed in BPMN can be translated into executable specifications(e.g., Microsoft’s Integration Services)

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Conceptual ETL Design using BPMN

Basic assumption for using BPMN as conceptual model: ETL process is a type of business process

There is no standard model for defining ETL processes

Each tool provides its own model, too detailed to be conceptual

Using BPMN constructs we define the most common ETL tasks and define a BPMN notation for ETL

ETL process: A combination of control and data processes

- Control processes manage the coarse-grained groups of tasks
- Data processes detail how input data are transformed and output data are produced

Two kinds of tasks in ETL conceptual modeling

- Control tasks highlight the control procedures provided by BPMN. Represent a workflow (arrows represent the precedence between activities)
- Data tasks refer to the tasks that directly manipulate data during an ETL process. Represent a data flow (arrows represent data ‘flowing’ along them)

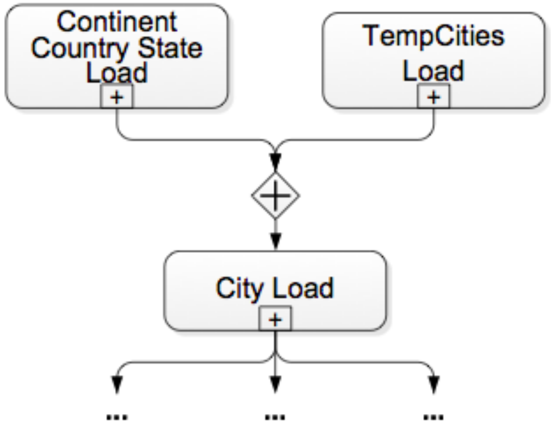
Control Tasks

Represent the workflow sequence or orchestration of the ETL process independently of the data flow

Control tasks are represented by means of BPMN constructs

For example, gateways are used to control the sequence of activities in an ETL process

The most used types of gateways in an ETL context are exclusive and parallel



Data Tasks

Show how data are manipulated within an activity

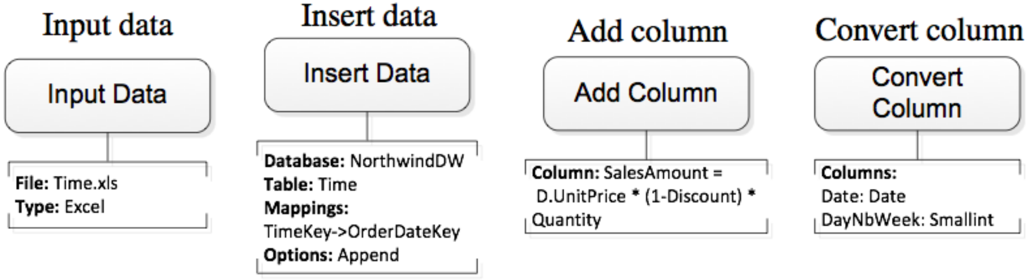
At lower abstraction level than control tasks

Represent activities typically carried out to manipulate data: input and output data, data conversion and transformation, for instance, change the data type of an attribute, add acolumn, remove duplicates, and so on

We denote these tasks unary data tasks since they receive one input flow

n-ary data tasks receive as input more than one flow (e.g., this is the case of union, join, dfference,...)

Row operations are the transformations applied to the source or target data on a row-by-row basis, e.g., updating the value of a column



Input data

Input Data

File: Time.xls
Type: Excel

Insert data

Insert Data

Database: NorthwindDW
Table: Time
Mappings:
TimeKey->OrderDateKey
Options: Append

Add column

Add Column

Column: SalesAmount = D.UnitPrice * (1-Discount) * Quantity

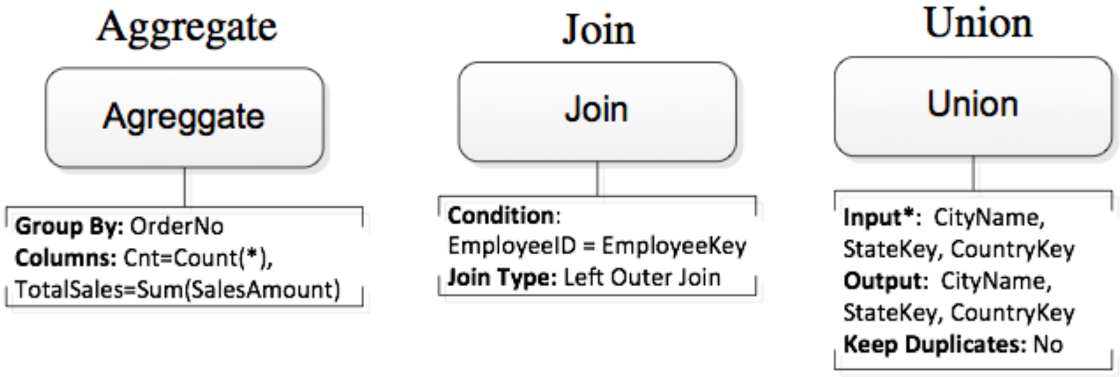
Convert column

Convert Column

Columns:
Date: Date
DayNbWeek: Smallint

Rowset Data Tasks

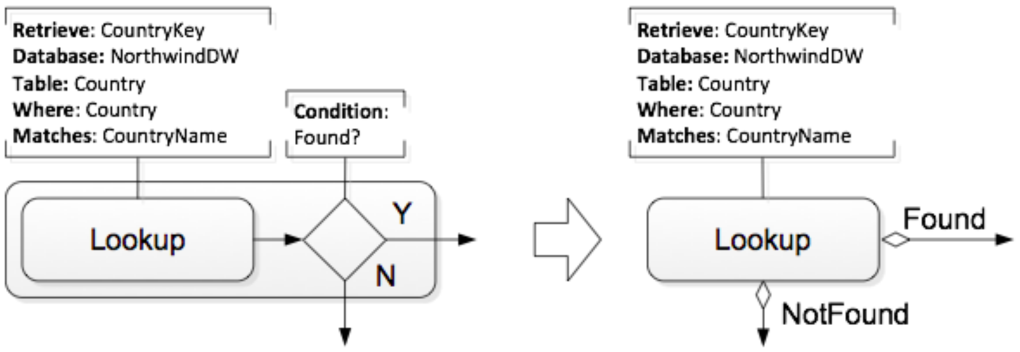
Rowset operations deal with a set of rows, e.g., aggregation is a rowset operation



Lookup Data Tasks

Lookup Data Tasks check if some value is present in a file. Immediately followed by an exclusive gateway with a branching condition. We use a shorthand replacing these two tasks by 2 conditional flows.

Shorthand notation for the lookup task



Extraction, Transformation and Loading

Outline

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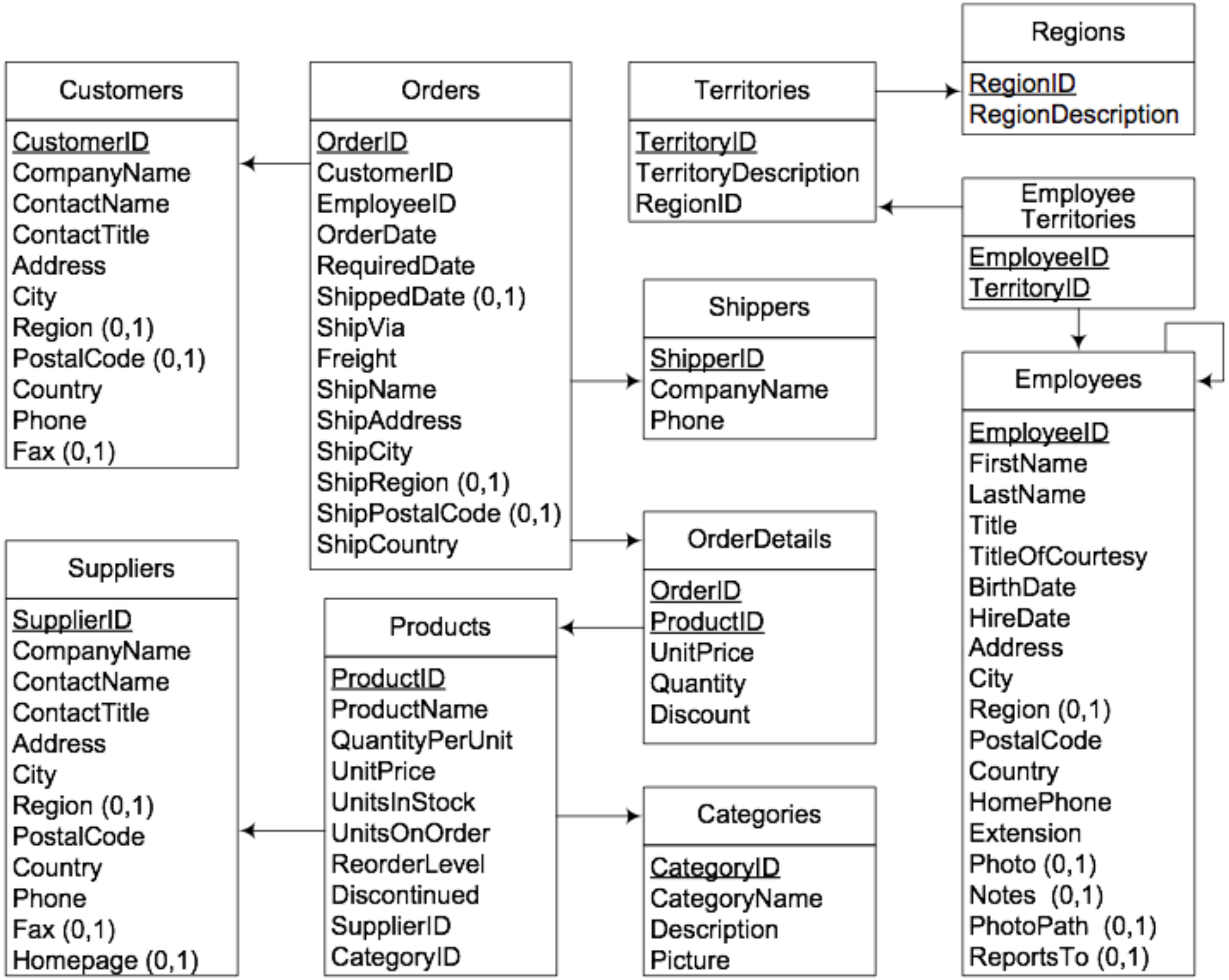
Conceptual ETL Design using BPMN

Conceptual Design of the Northwind ETL

Schema of the Northwind Operational Database



Customers
- CustomerID
- CompanyName
- ContactName
- ContactTitle
- Address
- City
- Region (0,1)
- PostalCode (0,1)
- Country
- Phone
- Fax (0,1)

Orders
- OrderID
- CustomerID
- EmployeeID
- OrderDate
- RequiredDate
- ShippedDate (0,1)
- ShipVia
- Freight
- ShipName
- ShipAddress
- ShipCity
- ShipRegion (0,1)
- ShipPostalCode (0,1)
- ShipCountry

Territories
- TerritoryID
- TerritoryDescription
- RegionID

Regions
- RegionID
- RegionDescription

Employee Territories
- EmployeeID
- TerritoryID

Shippers
- ShipperID
- CompanyName
- Phone

Employees
- EmployeeID
- FirstName
- LastName
- Title
- TitleOfCourtesy
- BirthDate
- HireDate
- Address
- City
- Region (0,1)
- PostalCode
- Country
- HomePhone
- Extension
- Photo (0,1)
- Notes (0,1)
- PhotoPath (0,1)
- ReportsTo (0,1)

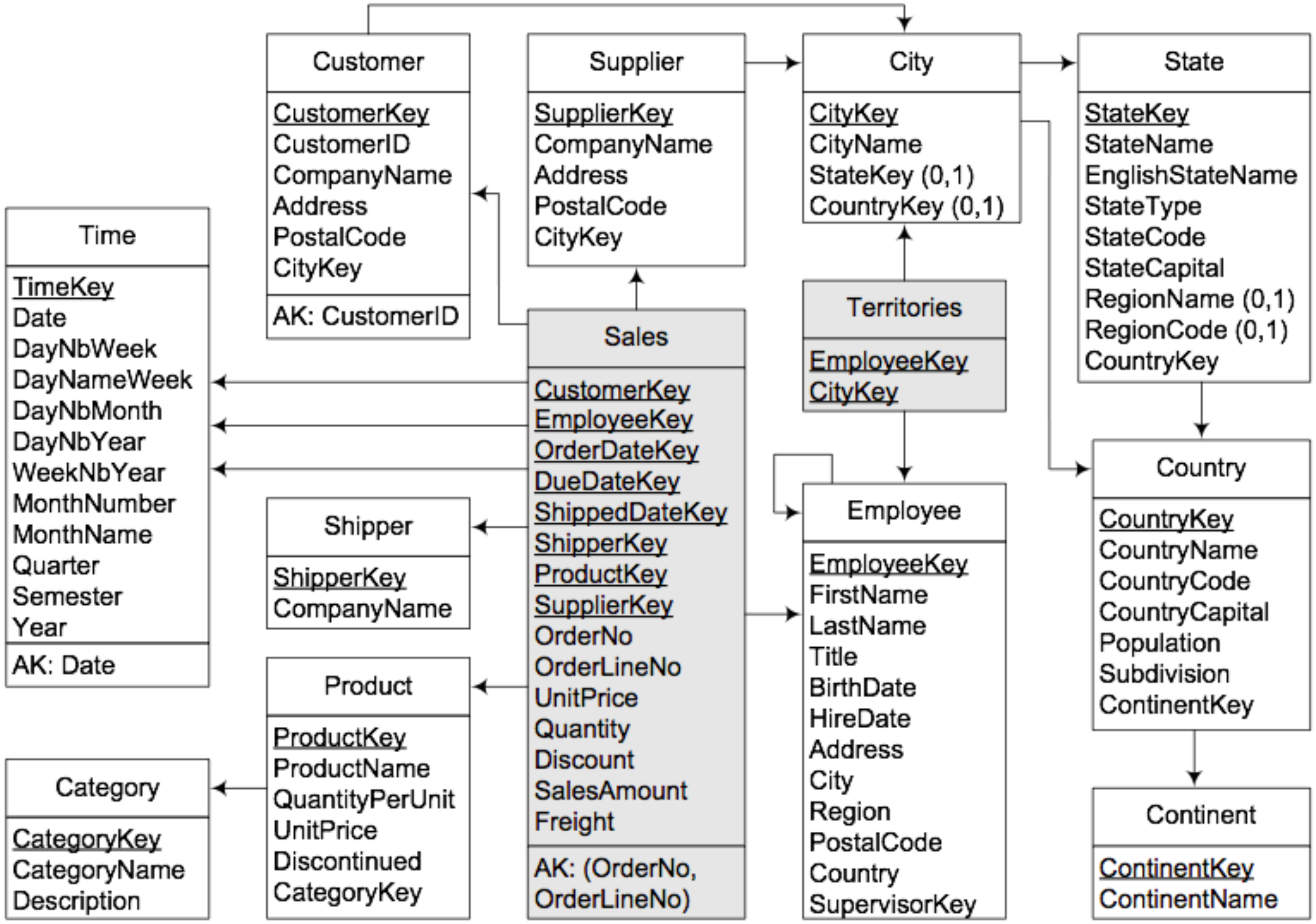
OrderDetails
- OrderID
- ProductID
- UnitPrice
- Quantity
- Discount

Suppliers
- SupplierID
- CompanyName
- ContactName
- ContactTitle
- Address
- City
- Region (0,1)
- PostalCode
- Country
- Phone
- Fax (0,1)
- Homepage (0,1)

Products
- ProductID
- ProductName
- QuantityPerUnit
- UnitPrice
- UnitsInStock
- UnitsOnOrder
- ReorderLevel
- Discontinued
- SupplierID
- CategoryID

Categories
- CategoryID
- CategoryName
- Description
- Picture

Schema of the Northwind Data Warehouse



Customer
CustomerKey
CustomerID
CompanyName
Address
PostalCode
CityKey
AK: CustomerID

Supplier
SupplierKey
CompanyName
Address
PostalCode
CityKey

City
CityKey
CityName
StateKey (0,1)
CountryKey (0,1)

State
StateKey
StateName
EnglishStateName
StateType
StateCode
StateCapital
RegionName (0,1)
RegionCode (0,1)
CountryKey

Time
TimeKey
Date
DayNbWeek
DayNameWeek
DayNbMonth
DayNbYear
WeekNbYear
MonthNumber
MonthName
Quarter
Semester
Year
AK: Date

Sales
CustomerKey
EmployeeKey
OrderDateKey
DueDateKey
ShippedDateKey
ShipperKey
ProductKey
SupplierKey
OrderNo
OrderLineNo
UnitPrice
Quantity
Discount
SalesAmount
Freight
AK: (OrderNo, OrderLineNo)

Territories
EmployeeKey
CityKey

Shipper
ShipperKey
CompanyName

Employee
EmployeeKey
FirstName
LastName
Title
BirthDate
HireDate
Address
City
Region
PostalCode
Country
SupervisorKey

Country
CountryKey
CountryName
CountryCode
CountryCapital
Population
Subdivision
ContinentKey

Product
ProductKey
ProductName
QuantityPerUnit
UnitPrice
Discontinued
CategoryKey

Category
CategoryKey
CategoryName
Description

Continent
ContinentKey
ContinentName

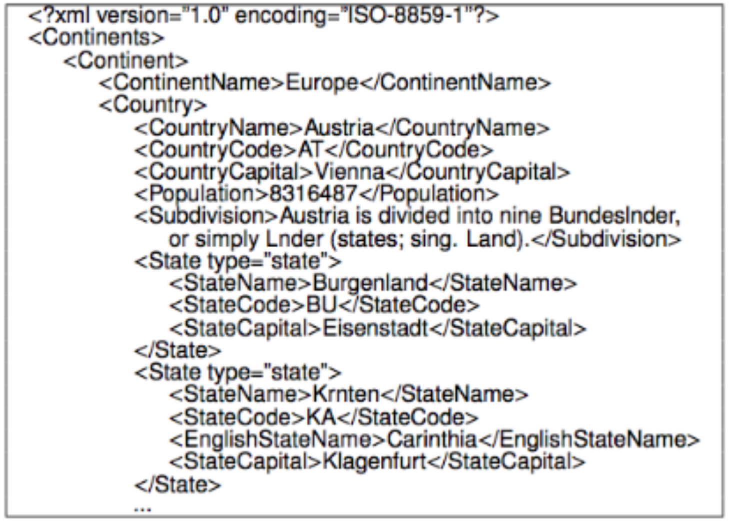
Conceptual Design of the Northwind ETL: Data Sources

File Time.xls contains data for loading the Time dimension, spanning the dates in table Orders of the operational database

Dimensions Customer and Supplier share the geographic hierarchy starting at the City level

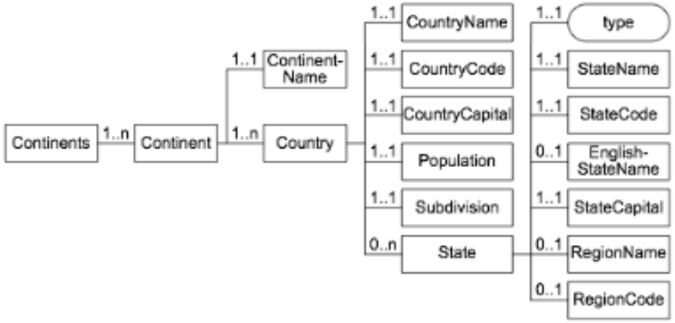
Data for the hierarchy State → Country → Continent loaded from Territories.xml

Start of the file Territories.xml



```
<?xml version="1.0" encoding="ISO-8859-1"?>
<Continents>
    <Continent>
        <ContinentName>Europe</ContinentName>
        <Country>
            <CountryName>Austria</CountryName>
            <CountryCode>AT</CountryCode>
            <CountryCapital>Vienna</CountryCapital>
            <Population>8316487</Population>
            <Subdivision>Austria is divided into nine Bundeslnder,
                or simply Lnder (states; sing. Land).</Subdivision>
            <State type="state">
                <StateName>Burgenland</StateName>
                <StateCode>BU</StateCode>
                <StateCapital>Eisenstadt</StateCapital>
            </State>
            <State type="state">
                <StateName>Krnten</StateName>
                <StateCode>KA</StateCode>
                <EnglishStateName>Carinthia</EnglishStateName>
                <StateCapital>Klagenfurt</StateCapital>
            </State>
            ...
```

XML Schema of Territories.xml



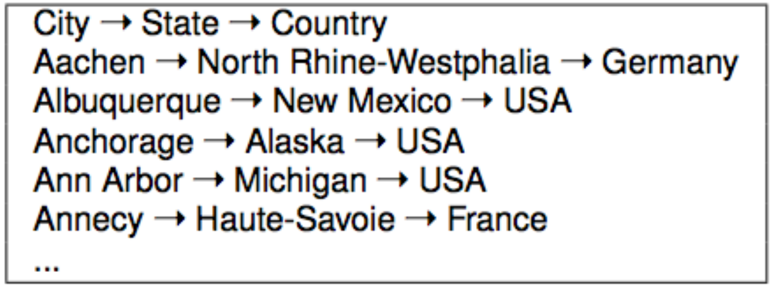
Conceptual Design of the Northwind ETL: Data Sources

File called Cities.txt identifies to which state or province a city belongs

Contains three fields separated by tabs and begins as shown below

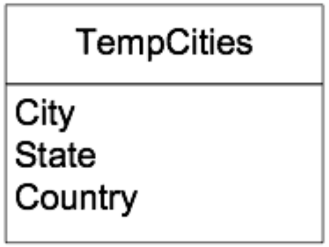
For cities located in countries that do not have states (e.g. Singapore), second field is set to null

The file is also used to identify to which state corresponds the city in the attribute TerritoryDescription of table Territories



```
City → State → Country
Aachen → North Rhine-Westphalia → Germany
Albuquerque → New Mexico → USA
Anchorage → Alaska → USA
Ann Arbor → Michigan → USA
Annecy → Haute-Savoie → France
...
```

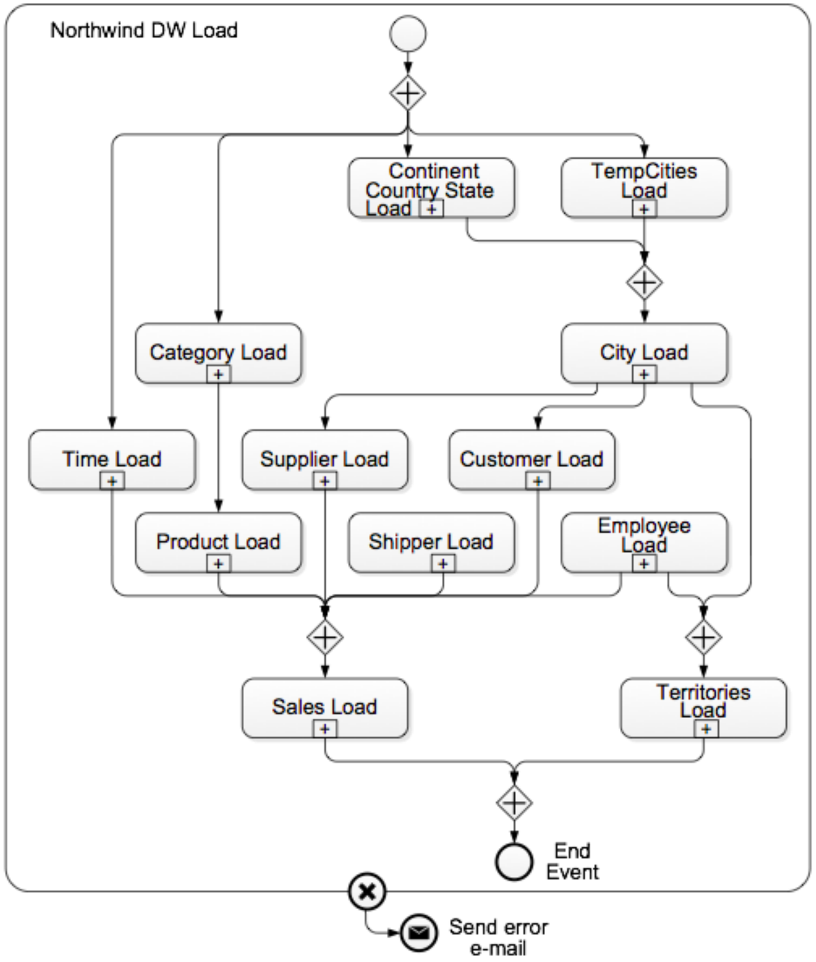
Begining of the file Cities.txt



TempCities
City State Country

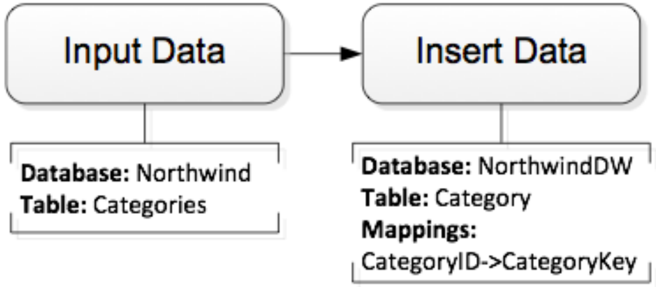
Associated table TempCities

Conceptual Design of the Northwind ETL: Overall View



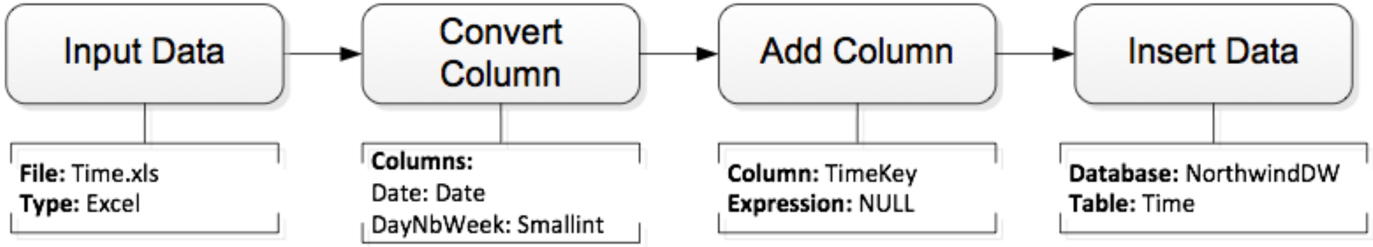
Conceptual Design of the Northwind ETL

Load of the Category dimension table



- Input task loads table Categories from the operational database
- Insert task loads the table Category in the data warehouse, mapping CategoryID to CategoryKey attribute in the Category table

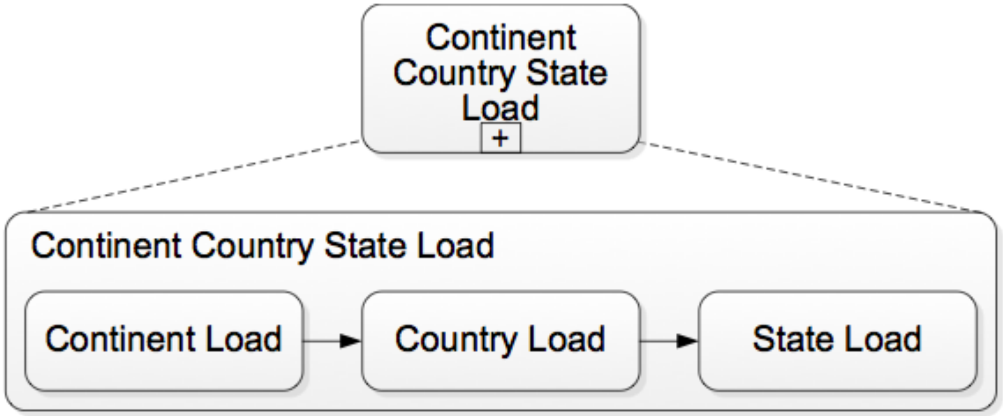
Loading the Time dimension table from an Excel file is similar, but includes a data type conversion, and an addition of the column TimeKey



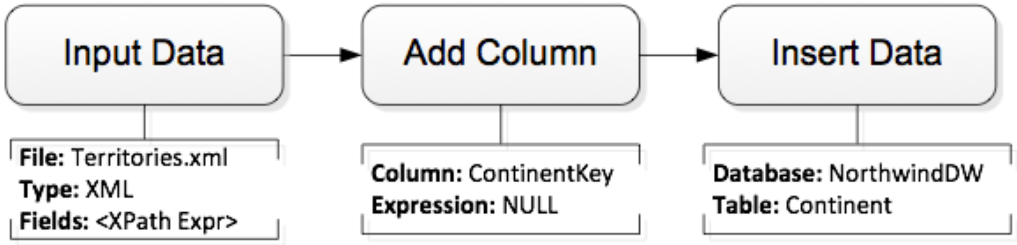
Conceptual Design of the Northwind ETL

Loading the City level first requires loading the Geography hierarchy State → Country → Continent

Associated control task



Load of the Continent table



References

A. VAISMAN, E. ZIMANYI, Data Warehouse Systems: Design and Implementation, Chapter 8 Extraction, Transformation and Loading, Springer Verlag, 2014