OData Extension for Data Aggregation Version 4.0

Committee Specification Draft ~~01~~02 / Public Review Draft ~~01~~02

~~25 July 2013~~

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Additional artifacts:

This prose specification is one component of a Work Product that also includes:

- OData Aggregation ABNF Construction Rules Version 4.0 and OData Aggregation ABNF Test Cases: http://docs.oasis-open.org/odata/odata-data-aggregation-ext/v4.0/csprd0~~1~~2/abnf/
- OData Aggregation Vocabulary: http://docs.oasis-open.org/odata/odata-data-aggregation-ext/v4.0/csprd0~~1~~2/vocabularies/

Related work:

This specification is related to:

- *OData Version 4.0*~~, a~~. Edited by Michael Pizzo, Ralf Handl, and Martin Zurmuehl. A multi-part Work Product that includes:
  - OData Version 4.0 Part 1: Protocol. Latest version. http://docs.oasis-open.org/odata/odata/v4.0/odata-v4.0-part1-protocol.html
  - OData Version 4.0 Part 2: URL Conventions. Latest version. http://docs.oasis-open.org/odata/odata/v4.0/odata-v4.0-part2-url-conventions.html
  - OData Version 4.0 Part 3: Common Schema Definition Language (CSDL). Latest version. http://docs.oasis-open.org/odata/odata/v4.0/odata-v4.0-part3-csdl.html
  - ABNF components: OData ABNF Construction Rules Version 4.0 and OData ABNF Test Cases. ~~24 June~~19 November 2013. http://docs.oasis-open.org/odata/odata/v4.0/~~csprd02~~cos01/abnf/
  - Vocabulary components: OData Core Vocabulary and OData Measures Vocabular. ~~24 June~~19 November 2013. http://docs.oasis-open.org/odata/odata/v4.0/cos01/vocabularies/
- *OData JSON Format Version 4.0*. Edited by Ralf Handl, Mike Pizzo, and Mark Biamonte. Latest version. http://docs.oasis-open.org/odata/odata-json-format/v4.0/odata-json-format-v4.0.html

Abstract:

This specification adds basic grouping and aggregation functionality (e.g. sum, min, and max) to the Open Data Protocol (OData) without changing any of the base principles of OData.

Status:

This document was last revised or approved by the OASIS Open Data Protocol (OData) TC on the above date. The level of approval is also listed above. Check the “Latest version” location noted above for possible later revisions of this document.

Technical Committee members should send comments on this specification to the Technical Committee’s email list. Others should send comments to the Technical Committee by using the “Send A Comment” button on the Technical Committee’s web page at http://www.oasis-open.org/committees/odata/.

For information on whether any patents have been disclosed that may be essential to implementing this specification, and any offers of patent licensing terms, please refer to the Intellectual Property Rights section of the Technical Committee web page (http://www.oasis-open.org/committees/odata/ipr.php).

Citation format:

When referencing this specification the following citation format should be used:

[OData-Data-Agg-v4.0]

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Notices

Table of Contents

1 Introduction

This specification adds the notion of aggregation to the Open Data Protocol (OData) without changing any of the base principles of OData. It defines semantics and a representation for aggregation of data, especially:

- Semantics and operations for querying aggregated data,
- Results format for queries containing aggregated data,
- Vocabulary terms to annotate what can be aggregated, and how.

1.1 Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in **[RFC2119].**

1.2 Normative References

[OData-ABNF] *OData ABNF Construction Rules Version 4.0*.
See the link in "Related work" section on cover page.

[OData-Agg-ABNF] *OData Aggregation ABNF Construction Rules Version 4.0*.
See link in "Additional artifacts" section on cover page.

[OData-CSDL] *OData Version 4.0 Part 3: CSDL*.
See link in "Related work" section on cover page.

[OData-Protocol] *OData Version 4.0 Part 1: Protocol*.
See link in "Related work" section on cover page.

[OData-URL] *OData Version 4.0 Part 2: URL Conventions*.
See link in "Related work" section on cover page.

[OData-VocAggr] *OData Aggregation Vocabulary*.
See link in "Additional artifacts" section on cover page.

[OData-VocMeas] *OData Measures Vocabulary*.
See link in "Related work" section on cover page.

[RFC2119] Bradner, S., “Key words for use in RFCs to Indicate Requirement Levels”, BCP 14, RFC 2119, March 1997. http://www.ietf.org/rfc/rfc2119.txt.

1.3 Non-Normative References

[TSQL ROLLUP] http://msdn.microsoft.com/en-us/library/bb522495.aspx

1.4 Typographical Conventions

Keywords defined by this specification use this `monospaced` font.

```
Normative source code uses this paragraph style.
```

Some sections of this specification are illustrated with non-normative examples.

Example 1: text describing an example uses this paragraph style

```
Non-normative examples use this paragraph style.
```

All examples in this document are non-normative and informative only.

All other text is normative unless otherwise labeled.

2 Overview

Open Data (OData) services expose a data model that describes the schema of the service in terms of the Entity Data Model (EDM, see **[OData-CSDL]**) and then allows for querying data in terms of this model. The responses returned by an OData service are based on that data model and retain the relationships between the entities in the model.

Extending the OData query features with simple aggregation capabilities avoids cluttering OData services with an exponential number of explicitly modeled “aggregation level entities” or else restricting the consumer to a small subset of predefined aggregations.

Adding the notion of aggregation to OData without changing any of the base principles in OData has two aspects:

1. Means for the consumer to query aggregated data on top of any given data model (for sufficiently capable data providers)
2. Means for the provider to annotate what data can be aggregated, and in which way, allowing consumers to avoid asking questions that the provider cannot answer.

Implementing any of these two aspects is valuable in itself independent of the other, and implementing both provides additional value for consumers. The descriptions provided by the provider help a consumer understand more of the data structure looking at the service's exposed data model. The query extensions allow the consumers to express explicitly ~~express~~ the desired aggregation behavior for a particular query. They also allow consumers to formulate queries that refer to the annotations as shorthand.

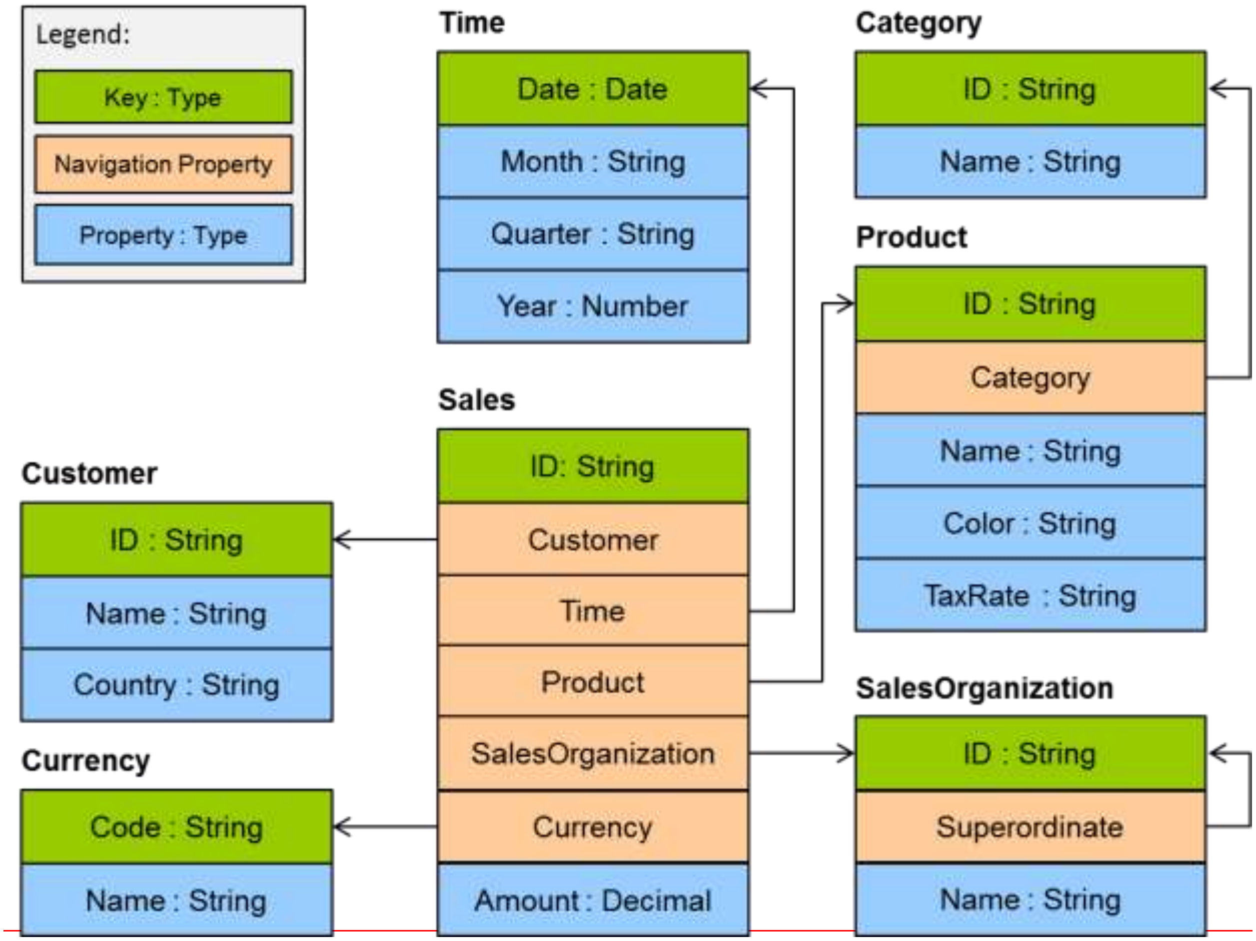
2.1 Definitions

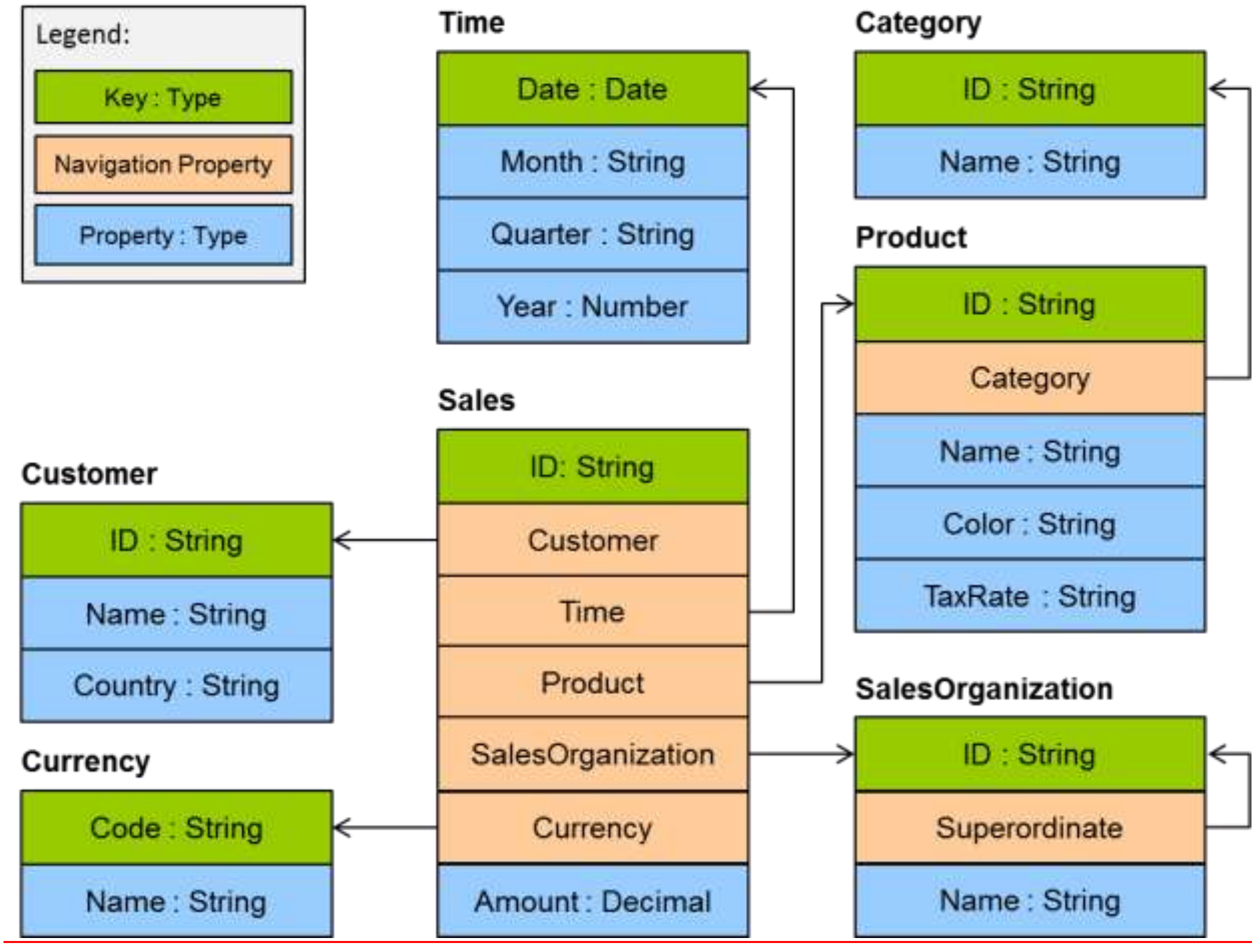
This specification defines the following terms:

- *Aggregatable Property*~~*Aggregatable property*~~ – a property for which the values can be aggregated using an aggregation method.
- *Aggregation Method* – a method that can be used to aggregate an aggregatable property or expression
- *Standard Aggregation Method* – one of the standard aggregation methods: `sum`, `min`, `max`, `average`, and `countdistinct`
- *Custom Aggregation Method* – a custom aggregation method that can be applied to expressions of a specified type
- *Custom Aggregate*~~*Groupable*~~ – a dynamic property that can appear in an aggregate clause
- *Groupable Property* – a property whose values can be used to group entities or complex type instances for aggregation.
- *Hierarchy*~~*Hierarchy*~~ – an arrangement of groupable properties whose values are represented as being “above”, “below”, or “at the same level as” one another.

2.2 Example Data Model

Example 2: The following diagram shows the terms defined in the section above applied to a simple model that is used throughout this document.


Legend:
Key : Type
Navigation Property
Property : Type
Time
Date : Date
Month : String
Quarter : String
Year : Number
Category
ID : String
Name : String
Product
ID : String
Category
Name : String
Color : String
TaxRate : String
Sales
ID: String
Customer
Time
Product
SalesOrganization
Currency
Amount : Decimal
Customer
ID : String
Name : String
Country : String
Currency
Code : String
Name : String
SalesOrganization
ID : String
Superordinate
Name : String



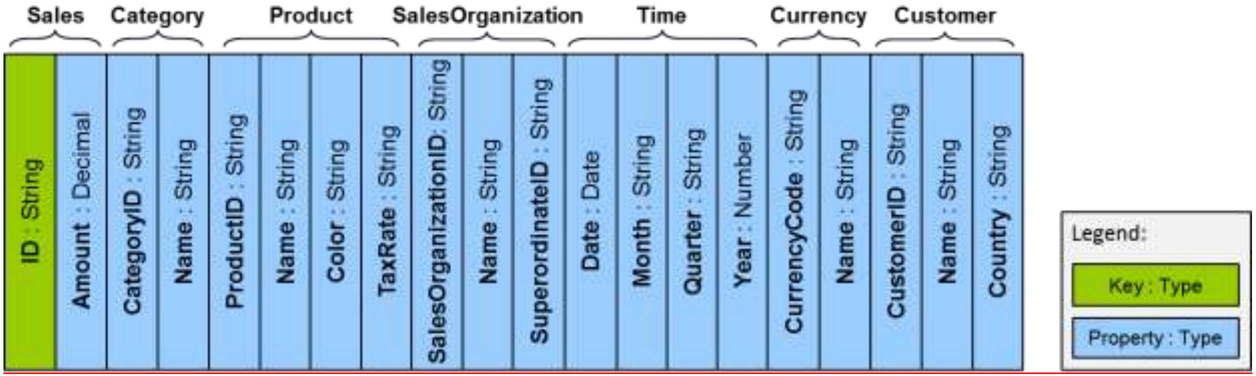
The Amount property in the Sales entity type is an aggregatable property, and the properties of the related entity types are groupable. These can be arranged in four hierarchies:

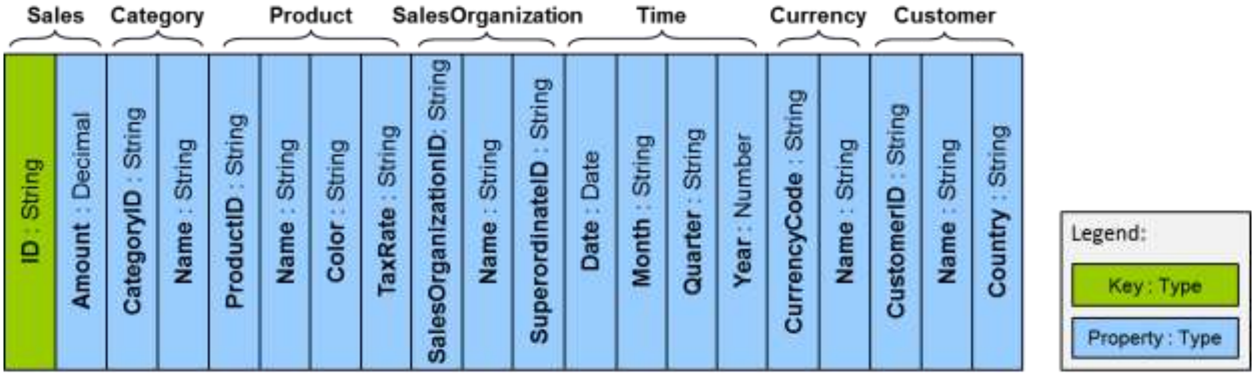
- *Product hierarchy based on groupable properties of the Category and Product entity types*
- *Customer hierarchy based on Country and Customer*
- *Time hierarchy based on Year, Month and Date*
- *SalesOrganization based on the recursive association to itself*

~~*The examples throughout the document, based on this diagram, assume that the default aggregation behavior of Amount has been set to summation. To further assist consumers of this service, the service metadata is accordingly annotated using the vocabulary defined in section .*~~

In the context of Online Analytical Processing (OLAP), this model might be described in terms of a Sales "cube" with an Amount "measure" and three "dimensions". This document will avoid such terms, as they are heavily overloaded.

Query extensions and descriptive annotations can both be applied to normalized as well as partly or fully denormalized schemas.

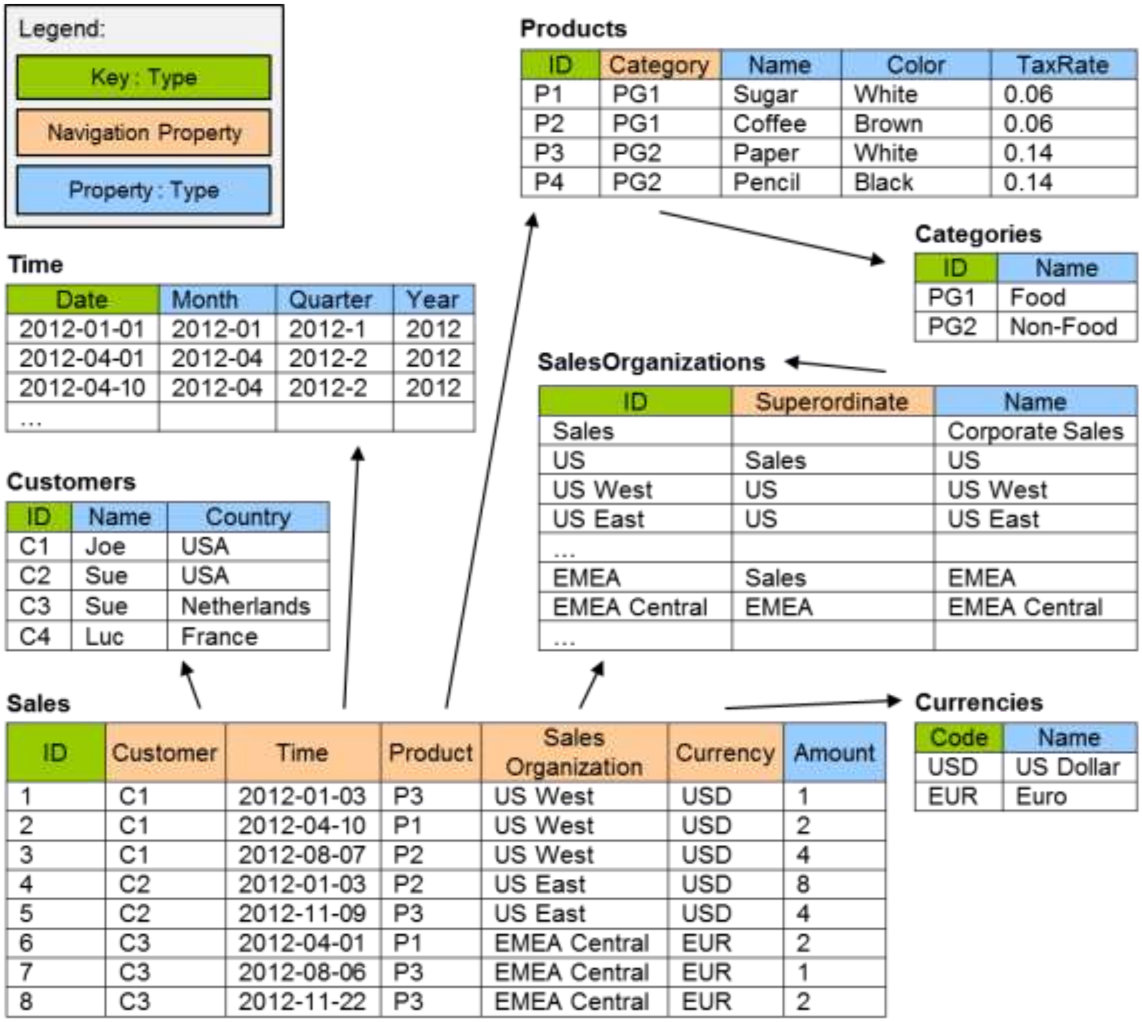




Note that OData's Entity Data Model (EDM) does not mandate a single storage model; it may be realized as a completely conceptual model whose data structure is calculated on-the-fly for each request. The actual "entity-relationship structure" of the model should be chosen to simplify understanding and querying data for the target audience of a service. Different target audiences may well require differently structured services on top of the same storage model.

2.3 Example Data

Example 3: The following sample data will be used to further illustrate the capabilities introduced by this extension.



Legend:

- 🟩 Key : Type
- 🟧 Navigation Property
- 🟦 Property : Type

Products

ID	Category	Name	Color	TaxRate
P1	PG1	Sugar	White	0.06
P2	PG1	Coffee	Brown	0.06
P3	PG2	Paper	White	0.14
P4	PG2	Pencil	Black	0.14

Categories

ID	Name
PG1	Food
PG2	Non-Food

Time

Date	Month	Quarter	Year
2012-01-01	2012-01	2012-1	2012
2012-04-01	2012-04	2012-2	2012
2012-04-10	2012-04	2012-2	2012
…			

SalesOrganizations

ID	Superordinate	Name
Sales		Corporate Sales
US	Sales	US
US West	US	US West
US East	US	US East
…		
EMEA	Sales	EMEA
EMEA Central	EMEA	EMEA Central
…		

Customers

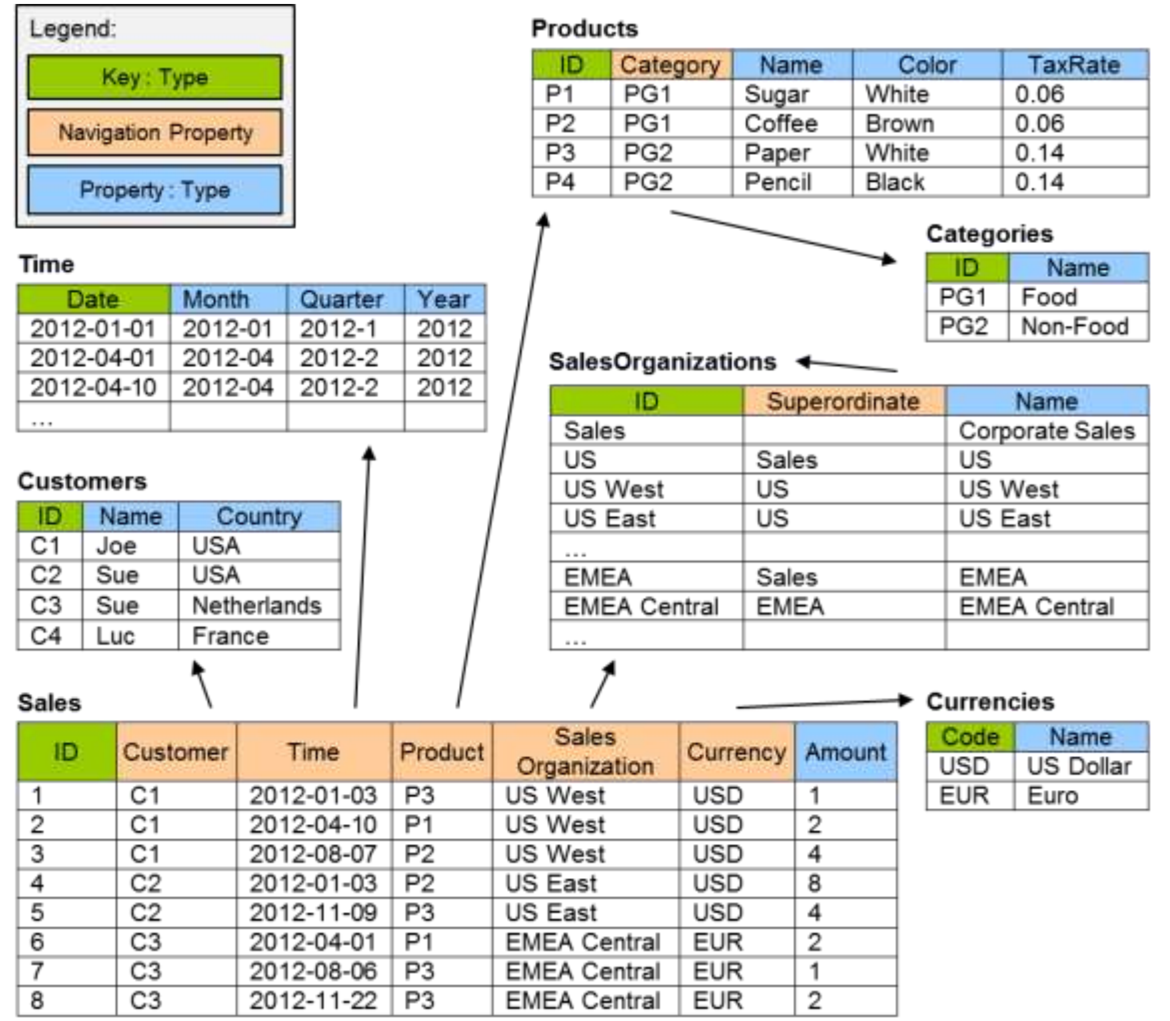
ID	Name	Country
C1	Joe	USA
C2	Sue	USA
C3	Sue	Netherlands
C4	Luc	France

Sales

ID	Customer	Time	Product	Sales Organization	Currency	Amount
1	C1	2012-01-03	P3	US West	USD	1
2	C1	2012-04-10	P1	US West	USD	2
3	C1	2012-08-07	P2	US West	USD	4
4	C2	2012-01-03	P2	US East	USD	8
5	C2	2012-11-09	P3	US East	USD	4
6	C3	2012-04-01	P1	EMEA Central	EUR	2
7	C3	2012-08-06	P3	EMEA Central	EUR	1
8	C3	2012-11-22	P3	EMEA Central	EUR	2

Currencies

Code	Name
USD	US Dollar
EUR	Euro



Legend:

Legend
Key : Type
Navigation Property
Property : Type

Products

ID	Category	Name	Color	TaxRate
P1	PG1	Sugar	White	0.06
P2	PG1	Coffee	Brown	0.06
P3	PG2	Paper	White	0.14
P4	PG2	Pencil	Black	0.14

Categories

ID	Name
PG1	Food
PG2	Non-Food

Time

Date	Month	Quarter	Year
2012-01-01	2012-01	2012-1	2012
2012-04-01	2012-04	2012-2	2012
2012-04-10	2012-04	2012-2	2012
…			

SalesOrganizations

ID	Superordinate	Name
Sales		Corporate Sales
US	Sales	US
US West	US	US West
US East	US	US East
…		
EMEA	Sales	EMEA
EMEA Central	EMEA	EMEA Central
…		

Customers

ID	Name	Country
C1	Joe	USA
C2	Sue	USA
C3	Sue	Netherlands
C4	Luc	France

Sales

ID	Customer	Time	Product	Sales Organization	Currency	Amount
1	C1	2012-01-03	P3	US West	USD	1
2	C1	2012-04-10	P1	US West	USD	2
3	C1	2012-08-07	P2	US West	USD	4
4	C2	2012-01-03	P2	US East	USD	8
5	C2	2012-11-09	P3	US East	USD	4
6	C3	2012-04-01	P1	EMEA Central	EUR	2
7	C3	2012-08-06	P3	EMEA Central	EUR	1
8	C3	2012-11-22	P3	EMEA Central	EUR	2

Currencies

Code	Name
USD	US Dollar
EUR	Euro

2.4 Example Use Cases

Example 4: In the example model, one prominent use case is the relation of customers to products. The first question that is likely to be asked is: "Which customers bought which products?"

This leads to the second more quantitative question: "Who bought how much of what?"

The answer to the second question typically is visualized as a cross-table:

			Food			Non-Food	
				Sugar	Coffee		Paper
USA		USD	**14**	**2**	**12**	**5**	**5**
	Joe	USD	**6**	2	4	**1**	1
	Sue	USD	**8**		8	**4**	4
Netherlands		EUR	**2**	**2**		**3**	**3**
	Sue	EUR	**2**	2		**3**	3

The data in this cross-table can be written down in a shape that more closely resembles the structure of the data model, leaving cells empty that have been aggregated away:

Customer/Country	Customer/Name	Product/Category/Name	Product/Name	Amount	Currency /Code
USA	Joe	Non-Food	Paper	1	USD
USA	Joe	Food	Sugar	2	USD
USA	Joe	Food	Coffee	4	USD
USA	Sue	Food	Coffee	8	USD

USA	Sue	Non-Food	Paper	4	USD
Netherlands	Sue	Food	Sugar	2	EUR
Netherlands	Sue	Non-Food	Paper	3	EUR
USA		**Food**	**Sugar**	**2**	**USD**
USA		**Food**	**Coffee**	**12**	**USD**
USA		**Non-Food**	**Paper**	**5**	**USD**
Netherlands		**Food**	**Sugar**	**2**	**EUR**
Netherlands		**Non-Food**	**Paper**	**1**	**EUR**
USA	**Joe**	**Food**		**6**	**USD**
USA	**Joe**	**Non-Food**		**1**	**USD**
USA	**Sue**	**Food**		**8**	**USD**
USA	**Sue**	**Non-Food**		**4**	**USD**
Netherlands	**Sue**	**Food**		**2**	**EUR**
Netherlands	**Sue**	**Non-Food**		**3**	**EUR**
USA		**Food**		**14**	**USD**
USA		**Non-Food**		**5**	**USD**
Netherlands		**Food**		**2**	**EUR**
Netherlands		**Non-Food**		**3**	**EUR**

Note that this result contains seven fully qualified aggregate values, plus fifteen rollup rows with subtotal values, shown in bold.

3 System Query Option $apply

Aggregation behavior is triggered using the query option $apply. It takes a sequence of set transformations, separated by forward slashes to express that they are consecutively applied, e.g. the result of each transformation is the input to the next transformation. This is consistent with the use of service-defined bindable and composable functions in path segments.

Unless otherwise noted, each set transformation:

- preserves the structure of the input ~~entities~~type, so the structure of the result fits into the data model of the service.
- does not necessarily preserve the number of instances in the result~~ entries~~, as this will typically differ from the number of instances in the input ~~entities~~set.
- does not necessarily guarantee that all properties of the result ~~entities~~instances have a well-defined value.

So the actual (or relevant) structure of each intermediary result will resemble a projection of the original data model that could also have been formed using the standard system query options $expand and $select defined in **[OData-Protocol~~].~~]**, with dynamic properties representing the aggregate values. The parameters of set transformations allow specifying how the result ~~entities~~instances are constructed from the input ~~entities~~instances.

The set transformations defined by this extension are

- aggregate
- topcount
- topsum
- toppercent
- bottomcount
- bottomsum
- bottompercent
- identity
- concat
- groupby
- filter
- expand

Service-defined bound functions that take an entity set as their binding parameter MAY be used as set transformations within $apply if the type of the binding parameter matches the type of the result set of the preceding transformation. If it returns an entity set, further transformations can follow the bound function. The parameter syntax for bound function segments is identical to the parameter syntax for bound functions in resource path segments or $filter expressions. See section 7.6 for an example.

If a data service that supports $apply does not support it on the collection identified by the request resource path, it MUST fail with 501 Not Implemented and a meaningful human-readable error message.

3.1 Transformation aggregate

The aggregate transformation takes ~~zero~~one or more *aggregate expressions* as parameters and returns a result set with a single ~~entity~~instance, representing the aggregated value for all ~~entities~~instances in the input set.

~~In its simplest form, it takes one or more paths to properties as parameters. The resulting entity contains those properties (similar to~~ An aggregate expression may be:

- an expression valid in a $~~select~~filter system query option on the input set that results in a simple value, e.g. the path to an aggregatable property, with a specified aggregation method,

- a custom aggregate,
- any of the above, followed by a `from` expression,
- any of the above, enclosed in parentheses and prefixed with a navigation path to related entities,
- the virtual property `$count`.

Any aggregate expression that specifies an aggregation method MUST define an alias~~), and their values represent the~~ for the resulting aggregated value~~ of those properties~~. The resulting instance contains one dynamic property per parameter representing the aggregated value across all ~~entities of~~instances within the input set~~, using the provider-defined default aggregation behavior~~. If paths are present, the corresponding navigation properties are implicitly expanded to make the properties part of the result representation.

~~Applying `aggregate` without parameters produces a set with one entity that does not have any properties.~~

~~*Example :*~~

```
~~GET ~/Sales?$apply=aggregate(Amount)~~
```

~~*results in*~~

```
~~{~~
~~  "odata.context": "$metadata#Sales(Amount)",~~
~~  "value": [~~
~~    { "odata.id": null, "Amount": 24 }~~
~~  ]~~
~~}~~
```

~~*Note that the result has the same structure, but not the same content as*~~

```
~~GET ~/Sales?$select=Amount~~
```

~~*which would result in eight entities.*~~

The aggregate transformation affects the structure of the result set: ~~each parameter property~~ An expression resulting in a simple value and a custom aggregate corresponds to ~~an item~~ a dynamic property in a `$select` option. If ~~the parameter property is~~they are preceded by a navigation path, the corresponding `$select` option would be nested in one `$expand` option for each navigation property in the navigation path.

3.1.1 Keyword `as`

~~When aggregating a simple property,~~Aggregate expressions can define an alias ~~MAY be specified with~~using the `as` keyword, followed by a SimpleIdentifier (see **[OData-CSDL, section 19.2]**).

The alias will introduce a dynamic property in the ~~entity type of the~~ aggregated result set. The introduced dynamic property ~~MUST always be in~~is added to the ~~same entity~~ type ~~as~~containing the original ~~property.~~expression or custom aggregate. The alias MUST NOT collide with names of declared properties, custom aggregates, or other aliases in that~~ entity~~ type.

When an aggregation method is specified, an alias MUST be applied to the expression..

Example 5:

```
GET ~/Sales?$apply=aggregate(Amount with sum as Total~~Amount~~)
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(Total~~Amount~~)",
  "value": [
    { ~~"~~"@odata.id": null, "Total~~Amount~~": 24 }
  ]
}
```

Example 6:

~~When aggregating the result of an arithmetic expression, an alias MUST be specified with the `as` keyword. The expression MUST result in a simple value and MUST be an expression that could also be used in a `$filter` system query option on the input set.~~

~~*Example :*~~

```
GET ~/Sales?$apply=aggregate(Amount mul Product/TaxRate with sum as Tax)
```

results in

```
{
  "@odata.context": "$metadata#Sales(Tax)",
  "value": [
    { "@odata.id": null, "Tax": 2.08 }
  ]
}
```

If the expression is to be evaluated on related entities, the expression and its alias MUST be enclosed in parentheses and prefixed with the navigation path to the related entities. The expression within the parentheses MUST be an expression that could also be used in a `$filter` system query option on the related entities identified by the navigation path. This syntax is intentionally similar to the syntax of `$expand` with nested query options.

Example 7:

```
GET ~/Products?$apply=aggregate(Sales(Amount mul Product/TaxRate with sum as
Tax))
```

results in

```
{
  "@odata.context": "$metadata#Products(Sales(Tax))",
  "value": [
    { "@odata.id": null, "Sales": [ { "Tax": 2.08 } ] }
  ]
~~}~~
```

~~*Note that the result has the same structure, but not the same content as*~~

```
~~GET ~/Products?$expand=Sales($select=Tax)~~
}
```

An alias affects the structure of the result set: each alias corresponds to ~~an item~~a dynamic property in a `$select` option that is nested in an `$expand` option for each navigation property in the path of the aliased ~~property~~expression.

3.1.2 Keyword `with`

The keyword `with` is used to apply an aggregation method to an aggregatable property~~To override the default aggregation behavior, a property path MAY be~~ or expression. The property or expression being aggregated is followed by the keyword `with`~~ and~~, followed by the name of the aggregation method to apply, followed by the keyword `as`~~.~~ and an alias.

3.1.3 Aggregation Methods

Values can be aggregated using the standard aggregation methods `sum`, `min`, `max`, `average`, and `countdistinct`, or with custom aggregation methods defined by the service. Aggregate expressions containing an aggregation method MUST define an alias~~The predefined aggregation methods are sum, min, max, average~~, and ~~countdistinct.~~

~~Providers MAY define non-standard aggregation methods using annotations, see section . These~~ for the resulting aggregate value.

Custom aggregation methods MUST use a namespace-qualified name (see **[OData-ABNF]**), i.e. contain at least one dot. Dot-less names are reserved for future versions of this specification.

~~3.1.2.1~~3.1.3.1 Standard Aggregation Method `sum`

The standard aggregation method `sum` ~~MAY~~can be applied to ~~a~~ numeric ~~property. It returns~~values to return the sum of the non-null values, ~~and~~or null if ~~all values~~there are no non-null~~.~~

~~If an alias is introduced with the keyword, the~~ values. The provider MUST choose a single type for the property across all instances of that type in the result ~~property~~ that is capable of representing the aggregated values. This may require ~~switching to~~ a larger integer type, ~~to~~ `Edm.Decimal` with sufficient `Precision` and `Scale`, or ~~to~~ `Edm.Double`.

Example 8:

~~If no alias is introduced, the aggregated property will contain the result. If the aggregated property has type `Edm.Decimal` or one of the integer types and the result exceeds the limits of the integer part of the type, the producer MUST respond with `400 Bad Request` and a meaningful human-readable error message~~

~~*Example 6:*~~

```
GET ~/Sales?$apply=aggregate(Amount with sum as Total~~Amount~~)
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(Total~~Amount~~)",
  "value": [
    { ~~"~~"@odata.id": null, "Total~~Amount~~": 24 }
  ]
}
```

~~3.1.2.2~~3.1.3.2 Standard Aggregation Method `min`

The standard aggregation method `min` ~~MAY~~can be applied to ~~an property~~values with a totally ordered domain~~. It returns~~ to return the smallest of the non-null values, ~~and~~or null if ~~all values~~there are no non-null values.

~~If an alias is introduced with the keyword, the~~The result property will have the same type as the input property.

Example 9:

~~*Example :*~~

```
GET ~/Sales?$apply=aggregate(Amount with min as MinAmount)
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(MinAmount)",
  "value": [
    { ~~"~~"@odata.id": null, "MinAmount": 1 }
  ]
}
```

~~3.1.2.3~~3.1.3.3 Standard Aggregation Method `max`

The standard aggregation method `max` ~~MAY~~can be applied to ~~an property~~values with a totally ordered domain~~. It returns~~ to return the largest of the non-null values, ~~and~~or null if ~~all values~~there are no non-null values.

~~If an alias is introduced with the keyword, the~~The result property will have the same type as the input property

Example 10:

~~*Example 8:*~~

```
GET ~/Sales?$apply=aggregate(Amount with max as MaxAmount)
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(MinAmount)",
  "value": [
    { ~~"~~"@odata.id": null, "MaxAmount": 8 }
  ]
}
```

~~3.1.2.4~~3.1.3.4 Standard Aggregation Method `average`

The standard aggregation method `average` ~~MAY~~can be applied to ~~a~~ numeric ~~property. It returns~~values to return the sum of the non-null values divided by the count of the non-null values, ~~and~~or null if ~~all values~~there are no non-null values.

~~If an alias is introduced with~~ The provider MUST choose a single type for the ~~keyword,~~ property across all instances of that type in the result ~~property will be of type `Edm.Double`.~~

~~If no alias is introduced,~~that is capable of representing the aggregated ~~property will contain the result,~~values; either `Edm.Double` or `Edm.Decimal` with sufficient `Precision` and ~~the result will be rounded according to the rounding rules defined in .~~`Scale`..

~~*Example 9:*~~

Example 11:

```
GET ~/Sales?$apply=aggregate(Amount with average as AverageAmount)
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(AverageAmount)",
  "value": [
    { ~~"~~"@odata.id": null, "AverageAmount": 3.0 }
  ]
}
```

~~3.1.2.5~~3.1.3.5 Standard Aggregation Method `countdistinct`

The aggregation method `countdistinct` counts the distinct values~~ of a property~~, omitting any null values. For navigation properties, it counts the distinct entities~~ (comparing the key property values)~~ in the union of all entities related to entities in the input set. For collection-valued primitive properties, it counts the distinct items in the union of all collection values in the input set.

~~An alias MUST be introduced with the keyword, and the~~The result property MUST have type `Edm.Decimal` with `Scale="0"` and sufficient `Precision`.

Example 12:

~~*Example 10:*~~

```
GET ~/Sales?$apply=aggregate(Product with countdistinct as DistinctProducts)
```

results in

```
{
  "@odata.context": "$metadata#Sales(DistinctProducts)",
  "value": [
    { "@odata.id": null, "DistinctProducts": 3 }
  ]
}
```

The number of instances in the input set can be counted with the virtual property `$count`.

~~3.1.3~~3.1.4 Keyword `from`

The `from` keyword gives control over the order of aggregation across properties that are not part of the result structure and over the aggregation methods applied in every step.

Instead of applying a single aggregation method for calculating the aggregated value of ~~some property~~an expression across all properties not included in the result structure, other aggregation methods to be applied when aggregating away certain properties MAY be specified using the `from` keyword, followed by a property path~~, and optionally~~ of a groupable property. Each groupable property MUST be followed by a `with` clause~~. If~~ unless the ~~`with` clause~~aggregate expression is ~~omitted,~~a custom aggregate, in which case the provider-~~controlled default aggregation method~~defined behavior of the custom aggregate is ~~applied~~used:

~~*aggregatableProperty* [with *aggregationMethod*~~*aggregateExpression* as *alias* ~~]~~

from $\mathit{groupableProperty}_1$ [with $\mathit{aggregationMethod}_1$]

…

from $\mathit{groupableProperty}_n$ [with $\mathit{aggregationMethod}_n$]

If the `from` keyword is used, an alias MUST be introduced~~ with the `as` keyword~~.

If the `from` keyword is present, first the ~~default~~ aggregation method ~~(provider-controlled or explicitly specified for~~determined by the ~~aggregatable property)~~aggregate expression is used to aggregate away properties that ~~don't have~~are not mentioned in a ~~special aggregation method specified~~`from` clause and are not grouping properties.

Then consecutively properties not part of the result are aggregated away ~~using the specific method~~ in the order of the `from` clauses and using the method specified by the `from` clause.

More formally, the calculation of `aggregate` with the `from` keyword is equivalent with a list of set transformations:

groupby((~~$\mathit{groupableProperty}_1$~~$\mathit{groupableProperty}_1$, ~~…, $\mathit{groupableProperty}_n$~~…, $\mathit{groupableProperty}_n$),

aggregate(~~*aggregatableProperty*))~~*aggregateExpression* as $\mathit{tmpalias}_1$))

/groupby((~~$\mathit{groupableProperty}_2$~~$\mathit{groupableProperty}_2$, ~~…, $\mathit{groupableProperty}_n$~~…, $\mathit{groupableProperty}_n$),

aggregate(~~*aggregatableProperty*~~$\mathit{tmpalias}_1$ with ~~$\mathit{aggregationMethod}_1$~~ $\mathit{aggregationMethod}_1$ as $\mathit{tmpalias}_2$))

~~as $\mathit{aggregateableProperty}_{tmp,1}$))~~

…

/groupby((~~$\mathit{groupableProperty}_n$~~$\mathit{groupableProperty}_n$),

aggregate(~~$\mathit{aggregatableProperty}_{tmp,n-2}$~~$\mathit{tmpalias}_{n-1}$ with ~~$\mathit{aggregationMethod}_{n-1}$~~ $\mathit{aggregationMethod}_{n-1}$ as $\mathit{tmpalias}_n$))

~~as $\mathit{aggregationProperty}_{tmp,n-1}$))~~

/aggregate(~~$aggregatableProperty_{tmp,n-1}$~~ $tmpalias_n$ with ~~$aggregationMethod_n$~~$aggregationMethod_n$ as $alias$))

The order of from clauses has to be compatible with hierarchies referenced from a leveled hierarchy annotation or specified as an unnamed hierarchy in groupby with rollup: lower nodes in a hierarchy need to be mentioned before higher nodes in the same hierarchy. Properties not belonging to any hierarchy can appear at any point in the from clause.

Example 13:

```
GET ~/Sales?$apply=aggregate(Amount with sum as DailyAverage
                             from Time with average)
```

is equivalent to

```
GET ~/Sales?$apply=groupby((Time),aggregate(Amount with sum as Total))
                    /aggregate(~~Amount~~Total with average as DailyAverage)
```

and results in the average sales volume per day

```
{
  ~~"~~"@odata.context": "$metadata#Sales(DailyAverage)",
  "value": [
    { ~~"~~"@odata.id": null, "DailyAverage": 3.428571428571429 }
  ]
}
```

~~3.1.4~~3.1.5 Virtual Property $count

The value of the virtual property $count is the number of ~~entities~~instances in ~~a group.~~the input set. It MUST always specify an alias~~alias with the keyword~~ and MUST NOT specify an aggregation method~~aggregation method with the keyword.~~.

The result property will have type Edm.Decimal with Scale="0" and sufficient Precision.

Example 14:

```
GET ~/Sales?$apply=aggregate($count as SalesCount)
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(SalesCount)",
  "value": [
    { ~~"~~"@odata.id": null, "SalesCount": 8 }
  ]
}
```

3.2 Transformation topcount

The topcount transformation takes two parameters.

The first parameter specifies the number of ~~entities~~instances to return in the transformed set. It MUST be an expression that can be evaluated on the set level and MUST result in a positive integer.

The second parameter specifies the value by which the ~~entities~~instances are compared for determining the result set. It MUST be an expression that can be evaluated on ~~entities~~instances of the input set and MUST result in a primitive numeric value.

The transformation retains the number of ~~entities~~instances specified by the first parameter that have the highest values specified by the second expression~~. It does not change the order of the entities in the input set~~.

In case the value of the second expression is ambiguous, the service MUST impose a stable ordering ~~of~~before determining the ~~input set is additionally taken into account~~returned instances.

Example 15:

~~Example :~~

```
GET ~/Sales?$apply=topcount(2,Amount)
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales",
  "value": [
    { "ID": 3, "Amount": 4, ... },
    { "ID": 4, "Amount": 8, ... }
  ]
}
```

The result set of `topcount` has the same structure as the input set.

3.3 Transformation `topsum`

The `topsum` transformation takes two parameters.

The first parameter indirectly specifies the number of ~~entities~~instances to return in the transformed set. It MUST be an expression that can be evaluated on the set level and MUST result in a number.

The second parameter specifies the value by which the ~~entities~~instances are compared for determining the result set. It MUST be an expression that can be evaluated on ~~entities~~instances of the input set and MUST result in a primitive numeric value.

The transformation returns the minimum set of ~~entities~~instances that have the highest values specified by the second parameter and whose sum of these values is equal to or greater than the value specified by the first parameter. It does not change the order of the ~~entities~~instances in the input set.

In case the value of the second expression is ambiguous, the service MUST impose a stable ordering ~~of~~before determining the ~~input set is additionally taken into account~~returned instances.

Example 16:

~~Example :~~

```
GET ~/Sales?$apply=topsum(15,Amount)
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales",
  "value": [
    { "ID": 3, "Amount": 4, ... },
    { "ID": 4, "Amount": 8, ... },
    { "ID": 5, "Amount": 4, ... }
  ]
}
```

The result set of `topsum` has the same structure as the input set.

3.4 Transformation `toppercent`

The `toppercent` transformation takes two parameters.

The first parameter specifies the number of ~~entities~~instances to return in the transformed set. It MUST be an expression that can be evaluated on the set level and MUST result in a positive number less than or equal to 100.

The second parameter specifies the value by which the ~~entities~~instances are compared for determining the result set. It MUST be an expression that can be evaluated on ~~entities~~instances of the input set and MUST result in a primitive numeric value.

The transformation returns the minimum set of ~~entities~~instances that have the highest values specified by the second parameter and whose cumulative total is equal to or greater than the percentage of the cumulative total of all ~~entities~~instances in the input set specified by the first parameter. It does not change the order of the ~~entities~~instances in the input set.

In case the value of the second expression is ambiguous, the service MUST impose a stable ordering ~~of~~before determining the ~~input set is additionally taken into account~~returned instances.

Example 17:

~~*Example 15:*~~

```
GET ~/Sales?$apply=toppercent(50,Amount)
```

results in

```
{
  ""@odata.context": "$metadata#Sales",
  "value": [
    { "ID": 3, "Amount": 4, ... },
    { "ID": 4, "Amount": 8, ... }
  ]
}
```

The result set of `toppercent` has the same structure as the input set.

3.5 Transformation `bottomcount`

The `bottomcount` transformation takes two parameters.

The first parameter specifies the number of ~~entities~~instances to return in the transformed set. It MUST be an expression that can be evaluated on the set level and MUST result in a positive integer.

The second parameter specifies the value by which the ~~entities~~instances are compared for determining the result set. It MUST be an expression that can be evaluated on ~~entities~~instances of the input set and MUST result in a primitive numeric value.

The transformation retains the number of ~~entities~~instances specified by the first parameter that have the lowest values specified by the second parameter. It does not change the order of the ~~entities~~instances in the input set.

In case the value of the second expression is ambiguous, the service MUST impose a stable ordering ~~of~~before determining the ~~input set is additionally taken into account~~returned instances.

Example 18:

~~*Example 16:*~~

```
GET ~/Sales?$apply=bottomcount(2,Amount)
```

results in

```
{
  ""@odata.context": "$metadata#Sales"
  "value": [
    { "ID": 1, "Amount": 1, ... },
    { "ID": 7, "Amount": 1, ... }
  ]
}
```

The result set of `bottomcount` has the same structure as the input set.

3.6 Transformation `bottomsum`

The `bottomsum` transformation takes two parameters.

The first parameter indirectly specifies the number of ~~entities~~instances to return in the transformed set. It MUST be an expression that can be evaluated on the set level and MUST result in a number.

The second parameter specifies the value by which the ~~entities~~instances are compared for determining the result set. It MUST be an expression that can be evaluated on ~~entities~~instances of the input set and MUST result in a primitive numeric value.

The transformation returns the minimum set of ~~entities~~instances that have the lowest values specified by the second parameter and whose sum of these values is equal to or greater than the value specified by the first parameter. It does not change the order of the ~~entities~~instances in the input set.

In case the value of the second expression is ambiguous, the service MUST impose a stable ordering ~~of~~before determining the ~~input set is additionally taken into account~~returned instances.

~~*Example 17:*~~

Example 19:

```
GET ~/Sales?$apply=bottomsum(7,Amount)
```

results in

```
{
  ""@odata.context": "$metadata#Sales",
  "value": [
    { "ID": 2, "Amount": 2, ... },
    { "ID": 6, "Amount": 2, ... },
    { "ID": 7, "Amount": 1, ... },
    { "ID": 8, "Amount": 2, ... }
  ]
}
```

The result set of `bottomsum` has the same structure as the input set.

3.7 Transformation `bottompercent`

The `bottompercent` transformation takes two parameters.

The first parameter indirectly specifies the number of ~~entities~~instances to return in the transformed set. It MUST be an expression that can be evaluated on the set level and MUST result in a positive number less than or equal to 100.

The second parameter specifies the value by which the ~~entities~~instances are compared for determining the result set. It MUST be an expression that can be evaluated on ~~entities~~instances of the input set and MUST result in a primitive numeric value.

The transformation returns the minimum set of ~~entities~~instances that have the lowest values specified by the second parameter and whose cumulative total is equal to or greater than the percentage of the cumulative total of all ~~entities~~instances in the input set specified by the first parameter. It does not change the order of the ~~entities~~instances in the input set.

In case the value of the second expression is ambiguous, the service MUST impose a stable ordering ~~of~~before determining the ~~input set is additionally taken into account~~returned instances.

Example 20:

~~*Example 18:*~~

```
GET ~/Sales?$apply=bottompercent(50,Amount)
```

results in

```
{
  ""@odata.context": "$metadata#Sales",
  "value": [
    { "ID": 1, "Amount": 1, ... },
    { "ID": 2, "Amount": 2, ... },
    { "ID": 5, "Amount": 4, ... },
    { "ID": 6, "Amount": 2, ... },
    { "ID": 7, "Amount": 1, ... },
    { "ID": 8, "Amount": 2, ... }
  ]
}
```

The result set of `bottompercent` has the same structure as the input set.

3.8 Transformation `identity`

The `identity` transformation returns its input set.

Example 21:

```
GET ~/Sales?$apply=identity
```

3.9 Transformation `concat`

The `concat` transformation takes two or more parameters, each of which is a sequence of set transformations.

It applies each ~~parameter~~transformation sequence to the input set and concatenates the intermediate result sets in the order of the parameters into the result set, ~~k~~pre~~s~~e~~p~~rving the ordering of the individual result sets as well as the structure of each result instance, potentially leading to an inhomogeneously structured result set.

~~*Example 20:*~~

Example 22:

```
GET ~/Sales?$apply=concat(topcount(2,Amount),
                          ~~bottomcount(2,~~aggregate(Amount))
```

results in

```
{
  ""@odata.context": "$metadata#Sales",
  "value": [
    { "ID": 4, "Amount": 8, ... },
    { "ID": 3, "Amount": 4, ... },
    { ~~"ID": 4, "Amount": 8, ... },~~
~~    { "ID": 1, "~~"@odata.context": "$metadata#Sales(Amount~~": 1, ... },~~
~~    { "ID": 7,~~)/$entity", "Amount": ~~1, ...~~24 }
  ]
}
```

Note that two Sales entities with the second highest amount 4 exist in the input set; the entity with ID 3 is included in the result, because the service chose to use the `ID` property for imposing a stable ordering.

The result set of `concat` has a ~~hybrid~~mixed form consisting of the structures imposed by the two transformation sequences.

3.10 Transformation `groupby`

The `groupby` transformation ~~groups~~takes one or two parameters and

1. Splits the ~~entities of the input~~initial set into subsets~~, transforms each~~ where all instances in a subset~~, and then concatenates~~ have the same values for the ~~transformed subsets. It takes two parameters,~~grouping properties specified in the first ~~specifying how the input~~parameter,
2. Applies set ~~is split into subsets, the second how~~ transformations to each subset ~~is transformed. This transformation may remove properties from the input set or add~~according to the second parameter, resulting in a new ~~properties to it (see) as well as the number of entities it contains.~~set of potentially different structure and cardinality,
3. Ensures that the instances in the result set contain all grouping properties with the correct values for the group,
4. Concatenates the intermediate result sets into one result set.

3.10.1 Simple Grouping

In its simplest form the first parameter of `groupby` specifies the *grouping properties*, a comma-separated list of one or more single-valued property paths (paths ending in a single-valued primitive, complex, or navigation property) that is enclosed in parentheses. The same property path SHOULD NOT appear more than once; redundant property paths MAY be considered valid, but MUST NOT alter the meaning of the request. If the property path leads to a single-valued navigation property, this means grouping by the entity-id of the related entities.

The optional second par~~gu~~ame~~n~~ter is a list of set transformations, separated by forward slashes to express that they are consecutively applied. Transformations may take into account the grouping properties for producing their result, e.g. `aggregate` removes properties that are used neither for grouping nor for aggregation.

~~The `groupby` transformation:~~

- ~~Splits the initial set into subsets where all entities in a subset have the same values for the grouping properties specified in the first parameter,~~
- ~~Applies the set transformations to each subset, resulting in a new set of potentially different cardinality,~~

~~•~~3. ~~Ensures that the entities in the result set contain all grouping properties with the correct values for the group,~~
~~•~~4. ~~Concatenates the intermediate result sets into one result set.~~

If the service is unable to group by same values for any of the specified properties, it MUST reject the request with an error response. It MUST NOT apply any implicit rules to group ~~entities~~instances indirectly by another property related to it in some way.

Example 23:

```
GET ~/Sales?$apply=groupby((Customer/Country,Product/Name),
                           aggregate(Amount with sum as Total))
```

results in

```
{
  ~~"~~"@odata.context":
"$metadata#Sales(Customer(Country),Product(Name),~~Amount~~Total)",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Country" : "Netherlands" },
      "Product": { "Name": "Paper" }, "~~Amount~~Total": 3 },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "Product": { "Name": "Sugar" }, "~~Amount~~Total": 2},
    { ~~"~~"@odata.id": null, "Customer": { "Country: "USA" },
      "Product": { "Name": "Coffee" }, "~~Amount~~Total": 12},
    { ~~"~~"@odata.id": null, "Customer": { "Country: "USA" },
      "Product": { "Name": "Paper" },"~~Amount~~Total": 5},
    { ~~"~~"@odata.id": null, "Customer": { "Country: "USA" },
      "Product": { "Name": "Sugar" }, "Total": 2}
  ]
}
```

The second parameter can be omitted to request distinct value combinations of the grouping properties.

Example 24:

```
GET ~/Sales?$apply=groupby((Product/Name,Amount))
```

and result in

```
{
  "@odata.context": "$metadata#Sales(Product(Name),Amount)",
  "value": [
    { "@odata.id": null, "Product": { "Name": "Coffee" }, "Amount": 4 },
    { "@odata.id": null, "Product": { "Name": "Coffee" }, "Amount": 8 },
    { "@odata.id": null, "Product": { "Name": "Paper"  }, "Amount": 1 },
    { "@odata.id": null, "Product": { "Name": "Paper"  }, "Amount": 2~~}~~ },
    { "@odata.id": null, "Product": { "Name": "Paper"  }, "Amount": 4 },
    { "@odata.id": null, "Product": { "Name": "Sugar"  }, "Amount": 2 }
  ]
  ~~}~~
}
```

Note that the result has the same structure, but not the same content as

```
GET ~/Sales?$expand=~~Customer($select=Country),~~Product($select=Name~~)~~
             ~~&$~~)&$select=Amount
```

~~Combined with without parameters `groupby` produces the distinct value combinations of the grouping properties. As this is an important special case, the second parameter of `groupby` can be omitted to request distinct value combinations.~~

~~*Example : Both requests are equivalent*~~

```
~~GET ~/Sales?$apply=groupby((Product/Name,Amount),aggregate())~~
~~GET ~/Sales?$apply=groupby((Product/Name,Amount))~~
```

~~*and result in*~~

```
~~{~~
~~  "odata.context": "$metadata#Sales(Product(Name),Amount)",~~
~~  "value": [~~
~~    { "odata.id": null, "Product": { "Name": "Coffee" }, "Amount": 4 },~~
~~    { "odata.id": null, "Product": { "Name": "Coffee" }, "Amount": 8 },~~
~~    { "odata.id": null, "Product": { "Name": "Paper"  }, "Amount": 1 },~~
~~    { "odata.id": null, "Product": { "Name": "Paper"  }, "Amount": 2 },~~
~~    { "odata.id": null, "Product": { "Name": "Paper"  }, "Amount": 4 },~~
~~    { "odata.id": null, "Product": { "Name": "Sugar"  }, "Amount": 2 }~~
~~  ]~~
~~}~~
```

~~*Note that the result has the same structure, but not the same content as*~~

```
~~GET ~/Sales?$expand=Product($select=Name)&$select=Amount~~
```

A `groupby` transformation affects the structure of the result set~~:~~ similar to `$select` where each grouping property corresponds to an item in a `$select` ~~option~~ clause. Grouping properties that specify navigation properties are automatically expanded, and the specified properties of that ~~is nested in an `$expand` option for each~~ navigation property ~~in the path of the grouping~~correspond to properties specified in a `$select` expand option on the expanded navigation property. The set transformations ~~used~~specified in the second parameter of `groupby` further~~more~~ affect the structure as described for ~~every~~each transformation; for example, the `aggregate` transformation adds properties for each aggregate expression.

3.10.2 Grouping with `rollup` and `$all`

The `rollup` grouping operator allows ~~query option is used to~~ requesting additional levels of aggregation in addition to the most granular level defined by the grouping properties. It can be used instead of a property path in the first parameter of `groupby`.

The `rollup` grouping operator has two overloads, depending on the number of parameters.

If used with one parameter, the parameter MUST be the value of the `Qualifier` attribute of an annotation with term `LeveledHierarchy` prefixed with the navigation path leading to the annotated entity type. This named hierarchy is used for grouping ~~entities~~instances.

If used with two or more parameters, it defines an unnamed leveled hierarchy. The first parameter is the root of the hierarchy defining the coarsest granularity and MUST either be a single-valued property path or the virtual property `$all`. The other parameters MUST be singe-valued property paths and define consecutively finer-grained levels of the hierarchy. This unnamed hierarchy is used for grouping ~~entities~~instances.

After resolving named hierarchies, the same property path MUST NOT appear more than once.

Grouping with `rollup` is processed for leveled hierarchies using the following equivalence relationships, in which p_i is a property path, T is a transformation, the ellipsis stands in for zero or more property paths, and R stands in for zero or more `rollup` operators or property paths:

- `groupby((rollup(`$p_1,\ldots,p_{n-1},p_n$`),`R`),`T`)` is equivalent to
  `concat(groupby((`$p_1,\ldots,p_{n-1},p_n,R$`),`T`),groupby((rollup(`$p_1,\ldots,p_{n-1}$`),`R`),`T`))`
- `groupby((rollup(`p_1,p_2`),`R`),`T`)` is equivalent to
  `concat(groupby((`p_1,p_2,R`),`T`), groupby((`p_1,R`),`T`))`
- `groupby((rollup($all,`p_1`),`R`),`T`)` is equivalent to
  `concat(groupby((`p_1,R`),`T`),groupby((`R`),`T`))`
- `groupby((rollup($all,`p_1`)),`T`)` is equivalent to
  `concat(groupby((`p_1`),`T`),`T`)`

Loosely speaking `groupby` with `rollup` splits the input set into groups using all grouping properties, then removes the last property from one of the hierarchies and splits it again using the remaining grouping properties. This is repeated until all of the hierarchies have been used up.

Example 25: rolling up two hierarchies, the first with two levels, the second with three levels:

```
(rollup($p_{1,1}$,$p_{1,2}$),rollup($p_{2,1}$,$p_{2,2}$,$p_{2,3}$))
```

will result in the six groupings

```
               ($p_{1,1}$,$p_{1,2}$,          $p_{2,1}$,$p_{2,2}$,$p_{2,3}$)
               ($p_{1,1}$,$p_{1,2}$,          $p_{2,1}$,$p_{2,2}$)
               ($p_{1,1}$,$p_{1,2}$,          $p_{2,1}$)
               ($p_{1,1}$,                    $p_{2,1}$,$p_{2,2}$,$p_{2,3}$)
               ($p_{1,1}$,                    $p_{2,1}$,$p_{2,2}$)
               ($p_{1,1}$,                    $p_{2,1}$)
```

Note that `rollup` stops one level earlier than `GROUP BY ROLLUP` in TSQL, see [TSQL ROLLUP], unless the virtual property `$all` is used as the hierarchy root level. Loosely speaking the root level is never rolled up.

Ordering of rollup ~~entities~~instances within detail ~~entities~~instances is up to the service if no `$orderby` is given, otherwise at the position determined by `$orderby`.

Example 26: answering the second question in section 2.4

```
GET ~/Sales?$apply=groupby((rollup(Customer/Country,Customer/Name),
                            rollup(Product/Category/Name,Product/Name),
                            Currency/Code),
                           aggregate(Amount with sum as Total))
```

results in seven entities for the finest grouping level

```
{
  ~~"~~"@odata.context":"$metadata#Sales(Customer(Country,Name),Product(Category(N
ame),Name),~~Amount~~Total,Currency(Code))",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA", "Name": "Joe" },
      "Product": { "Category": { "Name": "Non-Food" }, "Name": "Paper" },
      "~~Amount~~Total": 1, "Currency": { "Code": "USD" }
    },
    ...
```

plus additional fifteen rollup entities for subtotals: five without customer name

```
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "Product": { "Category": { "Name": "Food" }, "Name": "Sugar" },
      "~~Amount~~Total": 2, "Currency": { "Code": "USD" }
    },
    ...
```

six without product name

```
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA", "Name": "Joe" },
      "Product": { "Category": { "Name": "Food" } },
      "~~Amount~~Total": 6, "Currency": { "Code": "USD" }
    },
    ...
```

and four with neither customer nor product name

```
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "Product": { "Category": { "Name": "Food" } },
      "~~Amount~~Total": 14, "Currency": { "Code": "USD" }
    },
    ...
  ]
}
```

Note that the absence of one or more properties of the result structure imposed by the surrounding OData context allows distinguishing rollup entities from other entities.

3.11 Transformation `filter`

The `filter` transformation takes a Boolean expression that could also be passed as a `$filter` system query option to its input set and returns all ~~entities~~instances for which this expression evaluates to `true`.

Example 27:

```
GET ~/Sales?$apply=filter(Amount gt 3)
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales",
  "value": [
    { "ID": 3, "Amount": 4, ... },
    { "ID": 4, "Amount": 8, ... },
    { "ID": 5, "Amount": 4, ... }
  ]
}
```

The result set of `filter` has the same structure as the input set.

3.12 Transformation `expand`

The `expand` transformation takes a navigation property path ~~as its first parameter and a Boolean expression as its second parameter~~ that could also be passed as a `$`~~`filter`~~`expand` system query option as its first parameter. The optional second parameter can be either a `filter` transformation that will be applied to the ~~set of~~ related entities or an `expand` transformation. An arbitrary number of `expand` transformations can be passed as additional parameters to achieve multi-level expansion.

The result set is the input set with the specified navigation property expanded ~~by those related entities for which~~ according to the ~~Boolean expression evaluates to `true`.~~specified expand options.

Example 28:

```
GET ~/Customers?$apply=expand(Sales,filter(Amount gt 3~~)~~))
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Customers",
  "value": [
    { "ID": "C1", "Name": "Joe", "Country": "USA",
      "Sales": [{ "ID": 3, "Amount": 4, ... }]},
    { "ID": "C2", "Name": "Sue", "Country": "USA",
      "Sales": [{ "ID": 4, "Amount": 8, ... },
                { "ID": 5, "Amount": 4, ... }]},
    { "ID": "C3", "Name": "Sue", "Country": "Netherlands", "Sales": []},
    { "ID": "C4", "Name": "Luc", "Country": "France",      "Sales": []}
  ]
```

~~*Note that the result has the same structure, but not the same content as*~~

```
}
```

Note that the result has the same structure, but not the same content as

```
GET ~/Customers?$expand=Sales
```

An `expand` transformation affects the structure of the result set in the same way as an `$expand` option for the first parameter, with nested `$expand` options ~~if the path contains more than one navigation property~~for the optional nested `expand` transformations.

Example 29: nested `expand` transformations

```
GET ~/Categories?$apply=expand(Products,expand(Sales,filter(Amount gt 3)))
```

results in

```
{
  "@odata.context": "$metadata#Customers",
  "value": [
    { "ID": "PG1", "Name": "Food",
      "Products": [
        { "ID": "P1", "Name": "Sugar",  "Color": "White", "Sales": [] },
        { "ID": "P2", "Name": "Coffee", "Color": "Brown",
          "Sales": [ { "ID": 3, "Amount": 4, ... },
                     { "ID": 4, "Amount": 8, ... } ] }
      ]
    },
    { "ID": "PG2", "Name": "Non-Food",
      "Products": [
        { "ID": "P3", "Name": "Paper",  "Color": "White",
          "Sales": [ { "ID": 5, "Amount": 4, ... },
                     { "ID": 8, "Amount": 2, ... } ] },
        { "ID": "P4", "Name": "Pencil", "Color": "Black", "Sales": [] }
        ]
      }
    ]
}
```

3.13 Transformation `search`

The `search` transformation takes a search expression that could also be passed as a `$search` system query option to its input set and returns all entities that match this search expression.

Example 30: assuming that free-text search on `Sales` takes the related product name into account,

```
GET ~/Sales?$apply=search(coffee)
```

results in

```
{
  ""@odata.context": "$metadata#Sales",
  "value": [
    { "ID": 3, "Amount": 4, ... },
    { "ID": 4, "Amount": 8, ... }
  ]
}
```

The result set of ~~`filter`~~`search` has the same structure as the input set.

3.14 Filter Function `isdefined`

Properties that are not explicitly mentioned in `aggregate` or `groupby` are considered to have been *aggregated away* and are treated as having the null value in `$filter` expressions.

The filter function `isdefined` can be used to determine whether a property has been aggregated away. It takes a single-valued property path as its only par~~gu~~ame~~n~~ter and returns `true` if the property has a defined value for the aggregated entity. A property with a defined value can still have the null value; it can represent a grouping of null values, or an aggregation that results in a null value.

Example 31: assuming that free-text search on `Sales` takes the related product name into account,

```
GET ~/Sales?$apply=aggregate(Amount~~)&$filter=isdefined(Product~~ with sum as
Total)
           &$filter=isdefined(Product)
```

results in

```
{
  ""@odata.context": "$metadata#Sales(~~Amount~~Total)",
  "value": []
}
```

3.15 Evaluating `$apply`

The new system query option `$apply` is evaluated first, then the other system query options are evaluated, if applicable, on the result of `$apply` in their normal order (see **[OData-Protocol, section 11.2.1]**). If the result is a collection, `$filter`, `$orderby`, `$expand` and `$select` work as usual on properties that are ~~still~~ defined on the output set after evaluating `$apply`.

Properties that have been aggregated away in a result entity are not represented, even if the properties are listed in `$select` or `$expand`. In `$filter` they are treated as having the null value, and in `$orderby` as having a value that is even lower than null, i.e. instances for which a property has been rolled up appear before instances that have a null value for that property when ordering ascending.

Providers MAY support `$count`, `$top` and `$skip` together with `rollup`, in which case rollup ~~entities and detail entities are treated identically~~instances are counted identically to detail instances, i.e. `$skip=5` skips the first five instances, independently of whether some of them are rollup entities.

If a provider cannot satisfy a request using `$apply`, it MUST respond with `501 Not Implemented` and a human-readable error message.

3.16 ABNF for Extended URL Conventions

The normative ABNF construction rules for this specification are defined in **[OData-Agg-ABNF]**. They incrementally extend the rules defined in **[OData-ABNF]**.

4 Representation of Aggregated ~~Entities~~Instances

Aggregated ~~entities~~instances are based on the structure of the individual ~~entities~~instances from which they have been calculated, so the structure of the results fits into the data model of the service.

Properties that have been aggregated away are not represented at all in the aggregated ~~entities~~instances.

Dynamic properties introduced through an alias or with ~~the keyword~~ custom aggregates are represented as defined by the response format.

~~Aggregated entities MAY~~Aggregated instances are logically instances of the declared type of the collection identified by the resource path of the request. If the resource path identifies a collection of entities, the aggregated instances are also entities. These aggregated entities can be transient or persistent. Transient entities don't possess an edit link or read link, and in the JSON representation are marked with `~~"~~"@odata.id": null`. Edit links or read links of persistent entities MUST encode the necessary information to re-retrieve that particular aggregate value. How the necessary information is exactly encoded is not part of this specification. Only the boundary conditions defined in **[OData-Protocol]**, sections 4.1 and 4.2 MUST be met.

Example 32: looking again to the sample request for getting sales amounts per product and country presented in section 3.10.1 (Example 23):

```
GET ~/Sales?$apply=groupby((Customer/Country,Product/Name),
                            aggregate(Amount with sum as Total))
```

will return corresponding metadata as shown here for a single transient aggregated entity:

```
{
~~"~~"@odata.context":"$metadata#Sales(Customer(Country),Product(Name),~~Amount~~Total
)",
  "value": [
    { ~~"~~"@odata.id": null,
      "Customer": { "Country": "Netherlands" },
      "Product": { "Name": "Paper" },
      "~~Amount~~Total": 3
    },
    ...
  ]
}
```

5 Cross-Joins and Aggregation

OData supports querying related entities through defining ~~relationship and~~ navigation properties in the data model. These navigation paths help guide simple consumers in understanding and navigating relationships.

In some cases, however, requests ~~may~~need to span entity sets with no predefined associations. Such requests can be sent to the ~~entity container~~special resource `$crossjoin` instead of an individual entity set. The cross join of a list of entity sets is the Cartesian product of the listed entity ~~container acts~~sets, represented as ~~an entity set~~a collection of complex type instances that ~~has implicit~~have a navigation propert~~ies~~y with cardinality to-one ~~to~~for each participating entity set~~ it contains~~, and queries across entity sets can be formulated using these ~~implicit~~ navigation properties. See **[OData-URL]** for details.

Where useful navigations exist it is beneficial to expose those as explicit navigation properties in the model, but the ability to pose queries that span entity sets not related by an association provides a mechanism for advanced consumers to ~~pose queries across entity sets based on other~~use more flexible join conditions.

Example 33: if Sales had a string property ProductID instead of the navigation property Product, a "join" between Sales and Products could be accessed via the `$crossjoin` resource

```
GET ~/$crossjoin(Products,Sales)
                         ?$expand=Products($select=Name),Sales($select=Amount)
                         &$filter=Products/ID eq Sales/ProductID
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Collection(Edm.ComplexType)",
  "value": [
    { "Products": { "Name": "Paper" }, "Sales": { "Amount": 1 } },
    { "Products": { "Name": "Sugar" }, "Sales": { "Amount": 2 } },
    ...
  ]
}
```

Example 34: using the `$crossjoin` resource for aggregate queries

```
GET ~/$crossjoin(Products,Sales)
                         ?$apply=filter(Products/ID eq Sales/ProductID)
                         /groupby((Products/Name),~~aggregate(Sales/Amount))~~
                                   aggregate(Sales(Amount with sum as Total)))
```

~~*results in*~~

```
~~{~~
```

~~–"~~*results in*

```
{
  "@odata.context": "$metadata#Collection(Edm.ComplexType)",
  "value": [
    { "Products": { "Name": "Coffee" }, "Sales": { "~~Amount~~Total": 12 } },
    { "Products": { "Name": "Paper"  }, "Sales": { "~~Amount~~Total":  8 } },
    { "Products": { "Name": "Sugar"  }, "Sales": { "~~Amount~~Total":  4 } }
  ]
}
```

The entity container may be annotated in the same way as entity sets to express which aggregate queries are supported, see section 6.

6 Vocabulary for Data Aggregation

The following terms are defined in the vocabulary for data aggregation **[OData-VocAggr]**.~~ They are included in an entity model schema with the alias `Aggregation`.~~

6.1 Aggregation Capabilities

The term ~~`SupportsApply `~~`ApplySupported` can be applied to an entity container or to structured types and describes the aggregation capabilities ~~and lists~~of the ~~properties that can be used for aggregate queries on~~entity container or of collections of instances of the annotated ~~entity set or container in the system query option. It has a~~ structured types. If present, it implies that instances of the annotated structured type, or of structured types used in the annotated entity container, can contain dynamic properties as an effect of `$apply` even if they do not specify the `OpenType` attribute, see **[OData-CSDL]**. The term has a complex type with the following properties:

- ~~`SupportsCount` indicates whether the virtual property can be used in .~~
- ~~The `SupportedTransformations`~~The `Transformations` collection lists all supported set transformations. Allowed values are the names of the standard transformations~~ defined in chapter :~~ `aggregate`, `topcount`, `topsum`, `toppercent`, `bottomcount`, `bottomsum`, `bottompercent`, `identity`, `concat`, `groupby`, `filter`, and `expand`, or a namespace-qualified name identifying a service-defined bindable function. If ~~`Supported`~~`Transformations` is omitted the server supports all transformations defined by this specification.
- The `CustomAggregationMethods` collection lists ~~all properties that can be used in the transformation. If it is omitted the server supports all properties not listed as `GroupableProperties` (including the) in the~~supported custom aggregation ~~transformation .~~
- ~~The collection lists all dynamic properties that can be used in the transformation.~~
- ~~The collection lists all properties that can be used in the transformation. If it is omitted then all properties not listed as `AggregatableProperties` can be used in the `groupby` transformation.~~
- ~~Properties can appear in both collections. At least one of these collections SHOULD be provided; if both~~methods. Allowed values are ~~omitted the `AggregatableProperties` and `GroupableProperties`~~namespace-qualified names identifying service-specific aggregation methods. If omitted, no custom aggregation methods are ~~unspecified~~supported.
- ~~`Supports`~~`Rollup` specifies ~~to which extent~~whether the service~~r~~ supports no rollup, only a single rollup hierarchy, or multiple rollup hierarchies in a `groupby` transformation. If omitted, multiple rollup hierarchies are supported.
- `PropertyRestrictions` specifies whether all properties can be used in `groupby` and `aggregate`. If not specified, or specified with a value of `false`, all properties can be grouped and aggregated. If specified with a value of `true` clients have to check which properties are tagged as `Groupable` or `Aggregatable`.

All properties of `ApplySupported` are optional, so it can be used as a tagging annotation to signal unlimited support of aggregation.

Example 35: an entity container supporting everything defined in this specification.

```
<EntityContainer Name="SalesData">
  <Annotation Term="Aggregation.ApplySupported" />
  ...
</EntityContainer>
```

6.2 Property Annotations

6.2.1 Groupable Properties

If a structured type is annotated with ApplySupported or used within an entity container that is annotated with ApplySupported, and the ApplySupported annotation has a value of true for PropertyRestrictions, only those properties that are annotated with the tagging term Groupable can be used in groupby.

~~6.1~~6.2.2 Aggregatable Properties

~~A property that can be used in the transformation is described with the complex~~If a structured type ~~AggregatableProperty which has the following properties:~~

- ~~The Name contains the path to the aggregatable property.~~
- ~~The DefaultAggregationMethod is either one of the standard aggregation methods , and , or a namespace-qualified name identifying a provider-specific function, see section . It MUST appear in the list of supported aggregation methods.~~
- ~~The SupportedAggregationMethods collection lists all supported aggregation methods. If the collection of supported aggregation methods is null or not specified the aggregatable property MAY only be used without specifying an aggregation method.~~

~~This collection is of a complex type with the properties:~~

- ~~The Name follows the same rule as the DefaultAggregationMethod.~~
- ~~The RequiredGroupingProperties collection lists properties that MUST be specified in the first parameter of when using the aggregatable property in . Typical candidates for required grouping properties are properties that contain the currency code for a monetary amount or the unit of measure for a measured quantity (these SHOULD also be~~ is annotated ~~using the Measures vocabulary, see~~with ApplySupported~~).~~

~~6.2 Dynamic Aggregatable Properties~~

~~Some aggregated values are only defined for certain levels of aggregation. If represented as declared properties, they would not possess values for queries without aggregate, which would be somewhat confusing. Therefore, they can be represented as dynamic properties and are declared in~~ or used within an ~~additional collection property of the SupportsApply annotation on entity set or~~ entity container that is annotated with ApplySupported, and the ApplySupported~~level. A dynamic aggregatable property is described by a complex type~~ annotation has a value of true for PropertyRestrictions, only those properties that are annotated with the tagging term Aggregatable can be used in aggregate~~following properties:~~.

6.2.3 Custom Aggregates

The term CustomAggregate allows defining dynamic properties that can be used in aggregate~~Name must not~~. No assumptions can be made on how the values of these custom aggregates are calculated, and which input values are used.

When applied to a structured type, the annotation specifies custom aggregates that are available for collections of instances of that structured type. When applied to an entity container, the annotation specifies custom aggregates whose input set may span multiple entity sets within the container.

~~•~~ A custom aggregate is identified by the value of the Qualifier attribute when applying the term. The value of the Qualifier attribute is the name of the dynamic property. The name MUST NOT collide with the names of ~~declared properties or~~ other ~~dynamic aggregatable properties.~~custom aggregates of the same model element.

~~•~~ ~~The Type must be~~The value of the annotation is a string with the qualified name of a primitive type or type definition in scope~~.~~ that specifies the type returned by the custom aggregate.

- If the custom aggregate is associated with a structured type, the value of the `Qualifier` attribute MAY be identical to the name of a declared property of the structured type. In this case, the value of the `Type` property MUST have the same value as the `Type` attribute of the declared property. This is typically done when the custom aggregate is used as a default aggregate for that property. In this case, the name refers to the custom aggregate within an aggregate expression without a `with`~~The `SupportedGroupingProperties` collection lists the properties that define the maximum level of granularity for the dynamic aggregatable property. It only has a defined value of the set of grouping properties is a subset of or identical to the set of supported grouping properties.~~

clause, and to the property in all other cases.

If the custom aggregate is associated with an entity container, the value of the `Qualifier` attribute MUST NOT collide with the names of any entity sets defined in the entity container.

Example 36: Sales forecasts are ~~only available per month and country, and budget is only available per org unit and year. Sales forecasts are~~ modeled as a ~~dynamic aggregation property~~custom aggregate of the Sales entity ~~set~~type because it belongs there. For the budget, ~~there's~~there is no appropriate ~~entity set because there's no matching association between org units and time~~structured type, so it is ~~placed it at~~modeled as a custom aggregate of the `SalesData` entity container ~~level~~.

```
<Annotations Target="SalesModel.~~Container~~Sales">
  <Annotation
Term="~~DataAggregation.SupportsApply">~~Aggregation.CustomAggregate"
Qualifier="Forecast"
~~    <Record>~~
             ~~      <PropertyValue Property="DynamicAggregatableProperties">~~
~~        <Collection>~~
~~          <Record>~~
~~            <PropertyValue Property="Name" String="Budget" />~~
~~            <PropertyValue Property="Type"~~ String="Edm.Decimal" />
~~            <PropertyValue Property="SupportedGroupingProperties">~~
~~              <Collection>~~
~~                <PropertyPath>Time/Year</PropertyPath>~~
~~                <PropertyPath>SalesOranizations/Unit</PropertyPath>~~
~~              </Collection>~~
~~            </PropertyValue>~~
~~          </Record>~~
~~        </Collection>~~
~~      </PropertyValue>~~
~~      ...~~
~~    </Record>~~
~~  </Annotation>~~
</Annotations>

<Annotations Target="SalesModel.~~Container/Sales~~SalesData">
  <Annotation
Term="~~DataAggregation.SupportsApply">~~Aggregation.CustomAggregate"
Qualifier="Budget"
             ~~<Record>~~
~~      <PropertyValue Property="DynamicAggregatableProperties">~~
~~        <Collection>~~
~~          <Record>~~
~~            <PropertyValue Property="Name" String="ForeCast" />~~
~~            <PropertyValue Property="Type"~~ String="Edm.Decimal" />
~~            <PropertyValue Property="SupportedGroupingProperties">~~
~~              <Collection>~~
~~                <PropertyPath>Customer/Country</PropertyPath>~~
~~                <PropertyPath>Time/Month</PropertyPath>~~
~~                <PropertyPath>Time/Quarter</PropertyPath>~~
~~                <PropertyPath>Time/Year</PropertyPath>~~
~~              </Collection>~~
~~            </PropertyValue>~~
~~          </Record>~~
~~        </Collection>~~
~~      </PropertyValue>~~
~~    </Record>~~
~~  </Annotation>~~
</Annotations>
```

These ~~dynamic aggregatable properties~~custom aggregates can ~~now~~ be used in the `aggregate` transformation:

```
GET ~/Sales?$apply=groupby((Time/Month~~)),~~),aggregate(Forecast))
```

and:

```
GET ~/$crossjoin(Time)?$apply=groupby((Time/Year),aggregate(Budget))
```

~~6.31.1.1 Groupable Properties~~

~~A property that can be used in is described by a complex type with the following properties:~~

- ~~The `Name` contains the path to the groupable property.~~

6.2.4 ~~The `DependentProperties` collection lists properties that are functionally dependent on the groupable property and should not be used in without this groupable property. In the , the customer `Name` could be listed~~ Context-Defining Properties

Sometimes the value of a property or custom aggregate is only well-defined within the context given by values of other properties, e.g. a postal code together with its country, or a monetary amount together with its currency unit. These context-defining properties can be listed with the term `ContextDefiningProperties` whose type is a collection of property paths.

If present, the context-defining properties SHOULD be used as ~~dependent on the customer `ID`. Providers MUST~~grouping properties when aggregating the annotated property or custom aggregate, or alternatively be restricted to a single value by a pre-filter operation. Services MAY respond with `400 Bad Request` if the context-defining properties are not sufficiently specified for calculating a meaningful aggregate value.

6.2.5 Example

Example 37~~a dependent~~: This simplified `Sales` entity type has a single aggregatable property `Amount` whose context is defined by the `Code` property *~~is used in~~of* the *~~first parameter of without its groupable~~related `Currency`, and a custom aggregate `Forecast` with the same context. The `Code`* property *of `Currency` is groupable. All other properties are neither groupable nor aggregatable*.

```
<EntityType Name="Currency">
  <Key>
    <PropertyRef Name="Code" />
  </Key>
  <Property Name="Code" Type="Edm.String">
    <Annotation Term="Aggregation.Groupable" />
  </Property>
  <Property Name="Name" Type="Edm.String">
    <Annotation Term="Core.IsLanguageDependent" />
  </Property>
</EntityType>

<EntityType Name="Sales">
  <Key>
    <PropertyRef Name="ID" />
  </Key>
  <Property Name="ID" Type="Edm.String" Nullable="false" />

  <Property Name="Amount" Type="Edm.Decimal" Scale="variable">
```

```
    <Annotation Term="Aggregation.Aggregateable" />
    <Annotation Term="Aggregation.ContextDefiningProperties">
      <Collection>
        <PropertyPath>Currency/Code</PropertyPath>
      </Collection>
    </Annotation>
  </Property>

  <NavigationProperty Name="Currency" Type="SalesModel.Currency"
                      Nullable="false">
    <Annotation Term="Aggregation.Groupable" />
  </NavigationProperty>

  <Annotation Term="Aggregation.CustomAggregate" Qualifier="Forecast"
              String="Edm.Decimal">
    <Annotation Term="Aggregation.ContextDefiningProperties">
      <Collection>
        <PropertyPath>Currency/Code</PropertyPath>
      </Collection>
    </Annotation>
  </Annotation>
</EntityType>

<EntityContainer Name="SalesData">
  <Annotation Term="Aggregation.ApplySupported">
    <Record>
      <PropertyValue Property="PropertyRestrictions" Bool="true" />
    </Record>
  </Annotation>

  <EntitySet Name="Sales" EntityType="SalesModel.Sales" />
  <EntitySet Name="Currencies" EntityType="SalesModel.Currency" />
</EntityContainer>
```

~~6.4~~6.3 Hierarchies

A hierarchy is an arrangement of groupable properties whose values are represented as being “above”, “below”, or “at the same level as” one another. A hierarchy can be *leveled* or *recursive.*

~~6.4.1~~6.3.1 Leveled Hierarchy

A *leveled hierarchy* has a fixed number of levels each of which is represented by a groupable property. The values of a lower-level property depend on the property value of the level above.

A leveled hierarchy of an entity type is described with the term `LeveledHierarchy` that lists the properties used to form the hierarchy.

The order of the collection is significant: it lists the properties representing the levels, starting with the root level (coarsest granularity) down to the lowest level of the hierarchy.

The term `LeveledHierarchy` can only be applied to entity types, and the applying `Annotation` element MUST specify the `Qualifier` attribute. The value of the `Qualifier` attribute can be used to reference the hierarchy in grouping with rollup.

~~6.4.2~~6.3.2 Recursive Hierarchy

A *recursive hierarchy* organizes the values of a single groupable property as nodes of a hierarchical structure. This structure does not need to be as uniform as a leveled hierarchy. It is described by a complex term `RecursiveHierarchy` with the properties:

- The `NodeProperty` contains the path to the identifier of the node.
- The `ParentNodeProperty` contains the path to the identifier of the parent node.

- The optional `HierarchyLevelProperty` contains the path to a property that contains the level of the node in the hierarchy.
- The optional `IsLeafProperty` contains the path to a Boolean property that indicates whether the node is a leaf of the hierarchy.

The term `RecursiveHierarchy` can only be applied to entity types, and the applying `Annotation` element MUST specify the `Qualifier` attribute. The value of the `Qualifier` attribute can be used to reference the hierarchy in Hierarchy Filter Functions.

~~6.4.2.1~~6.3.2.1 Hierarchy Filter Functions

For testing the position of a given entity instance in a recursive hierarchy annotated to the entity's type, the Aggregation vocabulary ~~includes model~~defines functions that can be applied to any entity in `$filter` expressions:

- `isroot` returns true if and only if the value of the node property of the specified hierarchy is the root of the hierarchy,
- `isdescendant` returns true if and only if the value of the node property of the specified hierarchy is a descendant of the given parent node with a distance of less than or equal to the optionally specified maximum distance,
- `isancestor` returns true if and only if the value of the node property of the specified hierarchy is an ancestor of the given child node with a distance of less than or equal to the optionally specified maximum distance,
- `issibling` returns true if and only if the value of the node property of the specified hierarchy has the same parent node as the specified node,
- `isleaf` returns true if and only if the value of the node property of the specified hierarchy has no descendants.

~~6.4.3~~6.3.3 Examples

Example 38: leveled hierarchies for products and time, and a recursive hierarchy for the sales organizations

```
<edmx:Edmx xmlns:edmx="http://docs.oasis-open.org/odata/ns/edmx"
           Version="4.0">
 <edmx:Reference Uri="http://docs.oasis-open.org/odata/odata-data-aggregation-
ext/v4.0/cs01/vocabularies/Org.OData.Aggregation.V1.xml">
  <edmx:Include Alias="~~Data~~Aggregation"
                Namespace="Org.OData.Aggregation.V1" />
 </edmx:Reference>
 <edmx:DataServices>
  <Schema xmlns="http://docs.oasis-open.org/odata/ns/edm"
          Alias="SalesModel" Namespace="org.example.odata.salesservice">
   <Annotations Target="SalesModel.Product">
    <Annotation Term="~~Data~~Aggregation.LeveledHierarchy"
                Qualifier="ProductHierarchy">
     <Record>
      <PropertyValue Property="Levels">
        <Collection>
          <String>Category/Name</String>
          <String>Name</String>
        </Collection>
      </PropertyValue>
     </Record>
    </Annotation>
   </Annotations>
   <Annotations Target="SalesModel.Time">
    <Annotation Term="~~Data~~Aggregation.LeveledHierarchy"
                Qualifier="TimeHierarchy">
     <Record>
      <PropertyValue Property="Levels">
       <Collection>
         <String>Year</String>
         <String>Quarter</String>
         <String>Month</String>
       </Collection>
      </PropertyValue>
     </Record>
    </Annotation>
   </Annotations>

   <Annotations Target="SalesModel.SalesOrganization">
    <Annotation Term="~~Data~~Aggregation.RecursiveHierarchy"
                Qualifier="SalesOrgHierarchy">
     <Record>
      <PropertyValue Property="NodeProperty" String="ID" />
      <PropertyValue Property="ParentNodeProperty"
                     String="Superordinate/ID" />
     </Record>
    </Annotation>
   </Annotations>
  </Schema>
 </edmx:DataServices>
</edmx:Edmx>
```

The recursive hierarchy `SalesOrgHierarchy` can be used in functions with the `$filter` system query option.

Example 39: requesting all organizations below EMEA

```
GET ~/SalesOrganizations?
           $filter~~=$~~=
       $it/Aggregation.isdescendant(Hierarchy='SalesOrgHierarchy',Node='EMEA')
```

results in

```
{
```

~~*results in*~~

```
~~{~~
  ~~"~~"@odata.context": "$metadata#SalesOrganizations",
  "value": [
    { "ID": "EMEA Central",     "Name": "EMEA Central" },
    { "ID": "Sales Netherland", "Name": "Sales Netherland" },
    { "ID": "Sales Germany",    "Name": "Sales Germany" },
    { "ID": "EMEA South",       "Name": "EMEA South" },
    ...
    { "ID": "EMEA North",       "Name": "EMEA North" },
    ...
  ]
}
```

Example 40: requesting just those organizations directly below EMEA

```
GET SalesOrganizations?$filter~~=$~~=
                   $it/Aggregation.isdescendant(Hierarchy='SalesOrgHierarchy',
                                                Node='EMEA',MaxDistance=1)
```

results in

```
{
```

"@~~results in~~

```
~~{~~
  "odata.context": "$metadata#SalesOrganizations",
  "value": [
    { "ID": "EMEA Central", "Name": "EMEA Central" },
    { "ID": "EMEA South",   "Name": "EMEA South" },
    { "ID": "EMEA North",   "Name": "EMEA North" },
    ...
  ]
}
```

Example 41: just the lowest-level organizations

```
GET SalesOrganizations?$filter~~=$~~=
                         $it/Aggregation.isleaf(Hierarchy='SalesOrgHierarchy')
```

results in

```
{
```

~~results in~~

```
~~{~~
  ""@odata.context": "$metadata#SalesOrganizations",
  "value": [
    { "ID": "Sales Office London",   "Name": "Sales Office London" },
    { "ID": "Sales Office New York", "Name": "Sales Office New York" },
    ...
  ]
}
```

Example 42: the lowest-level organizations including their superordinate's ID

```
GET SalesOrganizations?$filter~~=$~~=
                         $it/Aggregation.isleaf(Hierarchy='SalesOrgHierarchy')
                      &$expand=Superordinate($select=ID)
```

results in

```
{
```

"@~~results in~~

```
~~{~~
  "odata.context": "$metadata#SalesOrganizations(*,Superordinate(ID))",
  "value": [
    { "ID": "Sales Office London",   "Name": "Sales Office London",
      "Superordinate: { "ID": "EMEA United Kingdom" } },
    { "ID": "Sales Office New York", "Name": "Sales Office New York",
      "Superordinate: { "ID": "US East" } },
    ...
  ]
}
```

Example 43: retrieving the sales IDs involving sales organizations from EMEA can be requested by

```
GET Sales?$select=ID&$filter=
     SalesOrganization/Aggregation.isdescendant(Hierarchy='SalesOrgHierarchy',
                                                Node='EMEA')
```

results in

```
{
  ""@odata.context": "$metadata#Sales(ID)",
  "value": [
    { "ID": 6 },
    { "ID": 7 },
    { "ID": 8 }
  ]
}
```

~~6.5~~6.4 Actions and Functions on Aggregated Entities

Bound actions and functions may or may not be applicable to aggregated entities. By default such bindings are not applicable to aggregated entities. Actions or functions annotated with the term `AvailableOnAggregates` are applicable to (a subset of the) aggregated entities under specific conditions:

- The `RequiredProperties` collection lists all properties that must be available in the aggregated entities; otherwise, the annotated function or action will be inapplicable.

Example 44: assume the product is an implicit input for a function bindable to Sales, then aggregating away the product makes this function inapplicable.

Calculating a set of aggregated entities and invoking an action on them cannot be accomplished with a single request, because the action URL cannot be constructed by the client. It is also impossible to construct a URL that calculates a single aggregated entity and applies a function or action on it. Consequently, applicable bound actions or functions on a single aggregated entity, or bound actions on a collection of aggregated entities MUST be advertised in the response to make them available to clients. A client is then able to request the aggregated entities in a first request and invoke the action or function in a follow-up request using the advertised target URL.

Example 45: full representation of an action applicable to a collection of aggregated entities, and an action that is applicable to one of the entities in the collection. The string `<properties in $apply>` is a stand-in for the list of properties describing the shape of the result set

```
{
  ""@odata.context":
                ~~"http://host/service/$~~ "$metadata#Sales(<properties in
$apply>)",
  ""@odata.readLink": "http://.../aggregated-stuff2143248437259843",
  "#Model.ColAction": {
    "title": "Do something on this collection",
    "target": "http://.../aggregated-stuff2143248437259843/Model.ColAction"
  },
  "value": [
    {
      ""@odata.id": "aggregated-stuff2143248437259843-1",
      "#Model.SingleAction": {
        "title": "Do something on this entity",
        "target":
            "http://.../aggregated-stuff2143248437259843-1/Model.SingleAction"
      },
      ...
    },
    ...
  ]
}
```

Services advertising the availability of functions or actions via the term `AvailableOnAggregates` MUST provide read links or edit links for aggregated entities, see section 4.

7 Examples

The following examples show some common aggregation-related questions that can be answered by combining the transformations defined in chapter 3.

7.1 Distinct Values

Grouping without specifying a set transformation returns the distinct combination of the grouping properties.

Example 46:

```
GET ~/Customers?$apply=groupby((Name))
```

results in

```
{
  ""@odata.context": "$metadata#Customers(Name)",
  "value": [
    { ""@odata.id": null, "Name": "Luc" },
    { ""@odata.id": null, "Name": "Joe" },
    { ""@odata.id": null, "Name": "Sue" }
  ]
}
```

Note that "Sue" appears only once although the customer base contains two different Sues.

Aggregation is also possible across related entities.

Example 47: customers that bought something

```
GET ~/Sales?$apply=groupby((Customer/Name))
```

results in

```
{
  ""@odata.context": "$metadata#Sales(Customer(Name))",
  "value": [
    { ""@odata.id": null, "Customer": { "Name": "Joe" } },
    { ""@odata.id": null, "Customer": { "Name": "Sue" } }
  ]
}
```

The result has the same structure as a standard OData request that expands the navigation properties and selects the data properties specified in `groupby` *and* `aggregate`*.*

```
GET ~/Sales?$expand=Customer($select=Name)
```

Note that "Luc" does not appear in the aggregated result as he hasn't bought anything and therefore there are no sales entities that refer/navigate to Luc.

However, even though both Sues bought products, only one "Sue" appears in the aggregate result. Including properties that guarantee the right level of uniqueness in the grouping can repair that.

Example 48:

```
GET ~/Sales?$apply=groupby((Customer/Name,Customer/ID))
```

results in

```
{
  ""@odata.context": "$metadata#Sales(Customer(Name,ID))",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Name": "Joe", "ID": "C1" } },
    { ~~"~~"@odata.id": null, "Customer": { "Name": "Sue", "ID": "C2" } },
    { ~~"~~"@odata.id": null, "Customer": { "Name": "Sue", "ID": "C3" } }
  ]
}
```

This could also have been formulated as

```
GET ~/Sales?$apply=groupby((Customer))
           &$expand=Customer($select=Name,ID)
```

Grouping by a navigation property adds the deferred representation of the navigation property to the result structure, which then can be expanded and projected partially away using the standard query options `$expand` and `$select`.

Note: the typical representation of a deferred navigation property is a URL "relative" to the source entity, e.g. `~/Sales(1)/Customer`. This has the benefit that this URL doesn't change if the sales entity would be associated to a different customer. For aggregated entities this would actually be a drawback, so the representation MUST be the canonical URL of the target entity, i.e. `~/Customers('C1')` for the first entity in the above result.

Example 49: the first question in the motivating example in section 2.4, which customers bought which products, can now be expressed as

```
GET ~Sales?$apply=groupby((Customer/Name,Customer/ID,Product/Name~~),~~))
~~                          aggregate())~~
```

and results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(Customer(Name,ID),Product(Name))",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Name": "Joe", "ID": "C1" },
      "Product": { "Name": "Coffee"} },
    { ~~"~~"@odata.id": null, "Customer": { "Name": "Joe", "ID": "C1" },
      "Product": { "Name": "Paper" } },
    { ~~"~~"@odata.id": null, "Customer": { "Name": "Joe", "ID": "C1" },
      "Product: { "Name: "Sugar" } },
    { ~~"~~"@odata.id": null, "Customer": { "Name": "Sue", "ID": "C2" },
      "Product: { "Name": "Coffee"} },
    { ~~"~~"@odata.id": null, "Customer": { "Name": "Sue", "ID": "C2" },
~~      "Product": { "Name": "Paper" } },~~
~~    { "~~         "Product": { "Name": "Paper" } },
    { "@odata.id": null, "Customer": { "Name": "Sue", "ID": "C3" },
      "Product": { "Name": "Paper" } },
    { "@~~         "Product": { "Name": "Paper" } },~~
~~    { "~~odata.id": null, "Customer": { "Name": "Sue", "ID": "C3" },
      "Product": { "Name": "Sugar" } }
  ]
}
```

7.2 ~~Provider-Controlled~~ Aggregation Methods

The client may specify one of the predefined aggregation methods `min`, `max`, `sum`, `average`, and `countdistinct`, or a custom aggregation method, to aggregate an aggregatable property. Expressions defining an aggregate method MUST specify an alias. The aggregated values ~~will be~~are returned in ~~the entity~~a dynamic property whose ~~values are aggregated, of course without changing its type~~name is determined by the alias.

Example 50:

```
GET ~/Products?$apply=groupby((Name),
                              aggregate(Sales/Amount with sum as Total))
```

results in

```
{
```

"@~~results in~~

```
~~{~~
~~  "~~odata.context": "$metadata#Products(Name,Sales(~~Amount~~Total))",
  "value": [
    { ~~"~~"@odata.id": null, "Name": "Coffee", "Sales": [ { "~~Amount~~Total": 12 } ]
},
    { ~~"~~"@odata.id": null, "Name": "Paper",  "Sales": [ { "~~Amount~~Total":  8 } ]
},
    { ~~"~~"@odata.id": null, "Name": "Pencil", "Sales": [] },
    { ~~"~~"@odata.id": null, "Name": "Sugar",  "Sales": [ { "~~Amount~~Total":  4 } ]
}
  ]
}
```

Note that aggregation does not alter the cardinality of the Sales navigation property, and that it always returns an array with at most one ~~object~~item. If there are no "base" entities to be aggregated, the array is empty.

Example 51: careful observers will notice that the above amounts have been aggregated across currencies, which is semantically wrong. Yet it is the correct response to the question asked, so be careful what you ask for. The semantically meaningful question

```
GET ~/Products?$apply=groupby((Name,Sales/Currency/Code),
                              aggregate(Sales/Amount with sum as Total))
```

~~*results in*~~

```
~~{~~
```

results in

```
{
  ~~  "~~"@odata.context":
"$metadata#Products(Name,Sales(~~Amount~~Total,Currency(Code)))",
  "value": [
    { ~~"~~"@odata.id": null, "Name": "Coffee",
      "Sales": [ { "~~Amount~~Total": 12, "Currency": { "Code": "USD" } } ] },
    { ~~"~~"@odata.id": null, "Name: "Paper",
      "Sales": [ { "~~Amount~~Total":  3, "Currency": { "Code": "EUR" } },
                 { "~~Amount~~Total":  5, "Currency": { "Code": "USD" } } ] },
    { ~~"~~"@odata.id": null, "Name: "Pencil",
      "Sales": [] },
    { ~~"~~"@odata.id": null, "Name: "Sugar",
      "Sales": [ { "~~Amount~~Total":  2, "Currency": { "Code": "EUR" } },
                 { "~~Amount~~Total":  2, "Currency": { "Code": "USD" } } ] }
  ]
}
```

Note that associations are "expanded" in a left-outer-join fashion, starting from the target of the aggregation request, before grouping the entities for aggregation. Afterwards the results are "folded back" to match the cardinality.

Example 52:

```
GET ~/Customers?$apply=groupby((Country,Sales/Product/Name))
```

returns the different products sold per country:

```
{
  ~~"~~"@odata.context": "$metadata#Customers(Country,Sales(Product(Name)))",
  "value": [
    { ~~"~~"@odata.id": null, "Country": "Netherlands",
      "Sales": [ { "Product": { "Name": "Paper"  },
                 { "Product": { "Name": "Sugar"  } ] },
    { ~~"~~"@odata.id": null, "Country": "USA",
      "Sales": [ { "Product": { "Name": "Coffee" },
                 { "Product": { "Name": "Paper"  },
                 { "Product": { "Name": "Sugar"  } ] }
  ]
}
```

Example 53:

~~7.3 Consumer-Controlled Aggregation~~

~~Instead of using the provider-defined default aggregation behavior, the consumer may specify one of the predefined aggregation methods , , , , and .~~

~~*Example :*~~

```
GET ~/Sales?$apply=groupby((Customer/Country),
                           ~~aggregate(Amount with sum as TotalAmount))~~
```

~~*results in*~~

```
~~{~~
~~  "odata.context": "$metadata#Sales(Customer(Country),TotalAmount)",~~
~~  "value": [~~
~~    { "odata.id": null, "Customer": { "Country": "Netherlands" },~~
~~      "TotalAmount":  5 },~~
~~    { "odata.id": null, "Customer": { "Country": "USA" },~~
~~      "TotalAmount": 19 }~~
~~  ]~~
~~}~~
```

~~If no alias is specified, the aggregated values will be returned in the entity property whose values are aggregated, of course without changing its type.~~

~~*Example :*~~

```
~~GET ~/Sales?$apply=groupby((Customer/Country),~~
                           aggregate(Amount with average as AverageAmount))
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(Customer(Country),AverageAmount)",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "AverageAmount": 1.6666667 },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "AverageAmount": 3.8 }
  ]
}
```

~~*In the example above Amount is an `Edm.Decimal` with `Scale="variable"`. If it were an integer or had a fixed `Scale`, the aggregated values would have been rounded accordingly, see section .*~~

If the example model would contain a list of hobbies per customer, with Hobbies a collection of strings, the number of different hobbies across the customer base could be requested. A navigation property followed by a `/$count` segment is a valid expression in the context that declares the navigation property, so the result property is placed in the same context as the navigation property.

Example 54:

```
GET ~/Products?$apply=groupby((Name),aggregate(Sales/$count as SalesCount))
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Products(Name,SalesCount)",
  "value": [
    { ~~"~~"@odata.id": null, "Name": "Coffee", "SalesCount": 2 },
    { ~~"~~"@odata.id": null, "Name": "Paper",  "SalesCount": 4 },
    { ~~"~~"@odata.id": null, "Name": "Pencil", "SalesCount": 0 },
    { ~~"~~"@odata.id": null, "Name": "Sugar",  "SalesCount": 2 }
  ]
}
```

Note that this differs from the placement of an ~~aliased~~ aggregated property in a related entity: the ~~aliased~~ aggregated property has the same navigation path as the original value.

Example 55: the result properties for Sales/$count and Sales~~/~~(Amount...) are placed differently

```
GET ~/Products?$apply=groupby((Name),aggregate(Sales/$count as SalesCount,
                                         Sales~~/~~(Amount with sum as
TotalAmount~~))~~)))
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Products(Name,SalesCount,Sales(TotalAmount))",
  "value": [
    { ~~"~~"@odata.id": null, "Name": "Coffee", "SalesCount": 2,
      "Sales": [ { "TotalAmount": 12 } ] },
    { ~~"~~"@odata.id": null, "Name": "Paper",  "SalesCount": 4,
      "Sales": [ { "TotalAmount":  8 } ] },
    { ~~"~~"@odata.id": null, "Name": "Pencil", "SalesCount": 0,
      "Sales": [ { "TotalAmount": null ~~0~~ } ] },
    { "@odata.id": null, "Name": "Sugar",  "SalesCount": 2,
      "Sales": [ { "TotalAmount":  4 } ] }
  ]
}
```

To place the number of instances in a group next to other aggregated values, the virtual property `$count` can be used:

Example 56: the result properties for Sales/$count and Sales/Amount are placed differently

```
GET ~/Products?$apply=groupby((Name),aggregate(Sales($count as SalesCount),
                                         Sales(Amount with sum as TotalAmount)))
```

results in

```
{
  "@odata.context": "$metadata#Products(Name,Sales(SalesCount,TotalAmount))",
  "value": [
    { "@odata.id": null, "Name": "Coffee",
      "Sales": [ { "SalesCount": 2, "TotalAmount": 12 } ] },
    { "@odata.id": null, "Name": "Paper",
      "Sales": [ { "SalesCount": 4, "TotalAmount":  8 } ] },
    { "@odata.id": null, "Name": "Pencil",
      "Sales": [ { "SalesCount": 0, "TotalAmount":  null } ] },
    { "@odata.id": null, "Name": "Sugar",
      "Sales": [ { "SalesCount": 2, "TotalAmount":  4 } ] }
  ]
}
```

7.3 Custom Aggregates

Custom aggregates are defined through the `CustomAggregate` annotation. They can be associated with either an entity type or an entity container.

A custom aggregate can be used by specifying the name of the custom aggregate in the `aggregate` clause.

Example 57:

```
GET ~/Sales?$apply=groupby((Customer/Country),
                           aggregate(Amount with sum as Actual,Forecast))
```

results in

```
{
  "@odata.context": "$metadata#Sales(Customer(Country),Actual,Forecast))",
  "value": [
    { "@odata.id": null, "Customer": { "Country": "Netherlands" },
      "Actual":  5, "Forecast": 4 },
    { "@odata.id": null, "Customer": { "Country": "USA" },
      "Actual": 19, "Forecast": 21 }
  ]
}
```

The introduced dynamic properties MUST always be in the same set as the original property.

Example 58:

```
GET ~/Products?$apply=groupby((Name),
                              aggregate(Sales(Amount with sum as Actual),
                                        Sales/Forecast))
```

results in

```
{
  "@odata.context": "$metadata#Products(Name,Sales(Actual,Forecast))",
  "value": [
    { "@odata.id":null,"Name":"Coffee","Sales":[{"Actual":12,"Forecast":6}] },
    { "@odata.id":null,"Name":"Paper", "Sales":[{"Actual": 8,"Forecast":2}] },
    { "@odata.id":null,"Name":"Pencil","Sales":[] },
    { "@odata.id":null,"Name":"Sugar", "Sales":[{"Actual": 4,"Forecast":7}] }
  ]
}
```

When associated with an entity type a custom aggregate MAY have the same name as a property of the entity with the same type as the type returned by the custom aggregate. This is typically done when the aggregate is used as a default aggregate for that property.

Example 59 A custom aggregate can be defined with the same name as a property of the same type in order to define a default aggregate for that property.

```
GET ~/Sales?$~~}~~
apply=groupby((Customer/Country),aggregate(Amount))
```

results in

```
{
  "@odata.context": "$metadata#Sales(Customer(Country),Amount)",
  "value": [
    { "@odata.id":null, "Customer":{ "Country":"Netherlands" }, "Amount": 5 },
    { "@odata.id":null, "Customer":{ "Country":"USA" },         "Amount":19 }
  ]
}
```

7.4 Aliasing

A property can be aggregated in multiple ways, each with a different alias.

Example 60:

```
GET ~/Sales?$apply=groupby((Customer/Country),
                           aggregate(Amount with sum as Total,
                                     Amount with average as AvgAmt))
```

results in

```
{
```

~~results in~~

```
~~{~~
  ~~"~~"@odata.context": "$metadata#Sales(Customer(Country),~~Amount~~Total,AvgAmt))",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "~~Amount~~Total":  5, "AvgAmt": 1.6666667 },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "~~Amount~~Total": 19, "AvgAmt": 3.8 }
  ]
}
```

The introduced dynamic propert~~y~~ies MUST always be in the same set as the original property.

~~Example 53:~~

Example 61:

```
GET ~/Products?$apply=groupby((Name),
                              aggregate(Sales~~/~~(Amount~~,~~ with sum as Total),
                                        Sales(Amount with average as AvgAmt)))
```

results in

```
{
```

~~results in~~

```
~~{~~
  ~~"~~"@odata.context": "$metadata#Products(Name,Sales(~~Amount~~Total,AvgAmt))",
  "value": [
    ~~{ "~~{"@odata.id":null~~, "~~,"Name":"Coffee~~", "~~","Sales":[{"~~Amount":~~Total":
12,"AvgAmt":   6~~}] },~~
~~    { "~~}]},
    {"@odata.id":null~~, "~~,"Name":"Paper", "Sales":[{"~~Amount":~~Total":
8,"AvgAmt":   2~~}] },~~
~~    { "~~}]},
    {"@odata.id":null~~, "~~,"Name":"Pencil~~", "~~","Sales~~":[] },~~
~~    { "~~":[{"Total":null,"AvgAmt":null}]},
    {"@odata.id":null~~, "~~,"Name":"Sugar", "Sales":[{"~~Amount":~~Total":
4,"AvgAmt":   2~~}] }~~}]}
  ]
}
```

There is no hard distinction between groupable and aggregatable properties: the same property can be aggregated and used to group the aggregated results.

Example 62:

```
GET ~/Sales?$apply=groupby((Amount),aggregate(Amount with sum as Total~~Sales~~))
```

will return all distinct amounts appearing in sales orders and how much money was made with deals of this amount

```
{
  ~~"~~"@odata.context": "$metadata#Sales(Amount,Total~~Sales~~)",
  "value": [
    { ~~"~~"@odata.id": null, "Amount": 1, "Total~~Sales~~": 2 },
    { ~~"~~"@odata.id": null, "Amount": 2, "Total~~Sales~~": 6 },
    { ~~"~~"@odata.id": null, "Amount": 4, "Total~~Sales~~": 8 },
    { ~~"~~"@odata.id": null, "Amount": 8, "Total~~Sales~~": 8 }
  ]
}
```

7.5 Combining Transformations per Group

Example 63: to get the best-selling product per country with sub-totals for every country, the partial results of a transformation sequence and a `groupby` *transformation are concatenated:*

```
GET ~/Sales?$apply=concat(
                     groupby((Customer/Country,Product/Name,Currency/Code),
                             aggregate(Amount with sum as Total))
                       /groupby((Customer/Country,Currency/Code),
                                topcount(1,~~Amount~~Total)),
                     groupby((Customer/Country,Currency/Code),
                             aggregate(Amount with sum as Total)))
```

~~*results in*~~

```
~~{~~
```

~~—~~*"results in*

```
{
  "@odata.context":

"$metadata#Sales(Customer(Country),Product(Name),~~Amount~~Total,Currency(Code))",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "Product":  { "Name": "Coffee" },
      "~~Amount~~Total": 12, "Currency": { "Code": "USD" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "Product":  { "Name": "Paper" },
      "~~Amount~~Total":  3, "Currency": { "Code": "EUR" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "~~Amount~~Total": 19, "Currency": { "Code": "USD" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "~~Amount~~Total":  5, "Currency": { "Code": "EUR" }
    }
  ]
}
```

Example 64: transformation sequences are also useful inside `groupby`*: To get the aggregated amount by only considering the top two sales amounts per product and county:*

```
GET ~/Sales?$apply=groupby((Customer/Country,Product/Name,Currency/Code),
                      topcount(2,Amount)/aggregate(Amount with sum as Total))
```

results in

```
{
```

~~*results in*~~

```
~~{~~
```

```
  ~~"~~"@odata.context":

"$metadata#Sales(Customer(Country),Product(Name),~~Amount~~Total,Currency(Code))",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "Product": { "Name": "Paper" },
      "~~Amount~~Total":  3, "Currency": { "Code": "EUR" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "Product": { "Name": "Sugar" },
      "~~Amount~~Total":  2, "Currency": { "Code": "EUR" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "Product": { "Name": "Coffee" },
      "~~Amount~~Total": 12, "Currency": { "Code": "USD" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "Product": { "Name": "Paper" },
      "~~Amount~~Total":  5, "Currency": { "Code": "USD" }
    }
  ]
}
```

7.6 ~~Applying~~ Model Functions as Set Transformations

Example 65: as a variation of the example shown in the previous section, a query for returning the best-selling product per country and the total amount of the remaining products can be formulated with the help of a model function.

For this purpose, the model includes a definition of a `TopCountAndBalance` *function that accepts the count for the top entities in the given input set not to be considered for the balance:*

```
<edm:Function Name="TopCountAndBalance"
              ReturnType="Collection(Edm.EntityType)"
              IsBound="true">
    <edm:Parameter Name="EntityCollection"
                   Type="Collection(Edm.EntityType)"/>
    <edm:Parameter Name="Count" Type="Edm.Int16"/>
    <edm:Parameter Name="Property" Type="Edm.String"/>
</edm:Function>
```

The function takes the name of a numeric property as ~~argument and~~a parameter, retains those entities that `topcount` *also would retain, and replaces the remaining entities by a single aggregated entity, where only the numeric property has a defined value being the aggregated value over those remaining entities~~.~~:*

~~The request~~

```
GET ~/Sales?$apply=groupby((Customer/Country,Product/Name),
                           aggregate(Amount with sum as Total))
                  /groupby((Customer/Country),

Self.TopCountAndBalance(Count=1,Property=~~'Amount'~~'Total'))
```

~~returns the entities shown in the request result in the previous section plus the following entities~~

```
~~{~~
```

~~"~~"results in

```
{
  "@odata.context":
"$metadata#Sales(Customer(Country),Product(Name),~~Amount~~Total)",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "Product": { "Name": "Paper" }, "~~Amount~~Total":  3 },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "Product": { "Name": "**Other**" }, "~~Amount~~Total":  2 },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "Product": { "Name": "Coffee" }, "~~Amount~~Total": 12 },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "Product": { "Name": "**Other**" }, "~~Amount~~Total":  5 }
  ]
}
```

Note that these two entities get their values for the `Country` property from the `groupby` transformation, which ensures that they contain all grouping properties with the correct values.

7.7 Controlling Aggregation per Rollup Level

Consumers may specify a different aggregation method per level for every property passed to `rollup` as a hierarchy level below the root level.

Example 66: get the average of the overall amount by month per product.

Using a transformation sequence:

```
GET ~/Sales?$apply=groupby((Product/ID,Product/Name,Time/Month),
                           aggregate(Amount with sum) as ~~SumAmount~~Total))
                  /groupby((Product/ID,Product/Name),
                           aggregate(~~SumAmount~~Total with average as
AverageAmount))
```

Using `from`:

```
GET ~/Sales?$apply=groupby((Product/ID,Product/Name),
                      aggregate(Amount with sum as MonthlyAverage
                                       from Time/Month with average))
```

Example 67: for an aggregate entity set listing the total sales amounts per customer and country, the rollup shall produce additional ~~entities~~instances for the average total sales amount of customers per country and the average of that average (which is a bit boring because the example data doesn't have two countries with the same currency☺)

```
GET ~/Sales?$apply=groupby((rollup($all,Customer/Country,Customer/ID),
                            Currency/Code),
                           aggregate(Amount with sum as CustomerCountryAverage
                                     from Customer/ID      with average
                                     from Customer/Country with average))
```

results in

```
{
  ~~"~~"@odata.context":
"$metadata#Sales(Customer(Country,ID),CustomerCountryAverage,Currency(Code))",
  "value": [
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA", "ID": "C1" },
      "CustomerCountryAverage":   7, "Currency": { "Code": "USD" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA", "ID": "C2" },
      "CustomerCountryAverage":  12, "Currency": { "Code": "USD" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "USA" },
      "CustomerCountryAverage": 9.5, "Currency": { "Code": "USD" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands", "ID": "C3"
},
      "CustomerCountryAverage":   5, "Currency": { "Code": "EUR" }
    },
    { ~~"~~"@odata.id": null, "Customer": { "Country": "Netherlands" },
      "CustomerCountryAverage":   5, "Currency": { "Code": "EUR" }
    },
    { ~~"~~"@odata.id": null,
      "CustomerCountryAverage": 9.5, "Currency": { "Code": "USD" }
    },
    { ~~"~~"@odata.id": null,
      "CustomerCountryAverage":   5, "Currency": { "Code": "EUR" }
    }
  ]
}
```

7.8 Transformation Sequences

Applying aggregation first covers the most prominent use cases~~, yet it is insufficient to answer~~. The slightly more sophisticated ~~questions like~~question "how much money is earned with small sales~~", which~~" requires filtering the base set before applying the aggregation. To enable this type of question several transformations can be specified in `$apply` in the order they are to be applied, separated by a forward slash.

Example 68:

```
GET ~/Sales?$apply=filter(Amount le 1)/aggregate(Amount with sum as Total)
```

means "filter first, then aggregate", and results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(~~Amount~~Total)",
  "value": [
    { ~~"~~"@odata.id": null, "~~Amount~~Total": 2 }
  ]
}
```

Using `filter` within `$apply` does not preclude using it as a normal system query option.

Example 69:

```
GET ~/Sales?$apply=filter(Amount le 2)/groupby((Product/Name),
                                          aggregate(Amount with sum as Total))
           &$filter=~~Amount~~Total ge 4
```

results in

```
{
  ~~"~~"@odata.context": "$metadata#Sales(Product(Name),~~Amount~~Total)",
  "value": [
    { ~~"~~"@odata.id": null, "~~Amount~~Total": 4, "Product": { "Name": "Paper" } },
    { ~~"~~"@odata.id": null, "~~Amount~~Total": 4, "Product": { "Name": "Sugar" } }
  ]
}
```

Example 70: Revisiting the Example 13 in section 3.1.4 for using the `from` keyword with the `aggregate` function, the request

```
GET ~/Sales?$apply=aggregate(Amount as DailyAverage from Time with average)
```

could be rewritten in a more procedural way using a transformation sequence returning the same result

```
GET ~/Sales?$apply=groupby((Time),aggregate(Amount~~)~~ with sum as Total))
                  /aggregate(~~Amount~~Total with average as DailyAverage)
```

For further examples, consider another data model containing entity sets for cities, countries and continents and the obvious associations between them.

Example 71: getting the population per country with

```
GET ~/Cities?$apply=groupby((Continent/Name,Country/Name),
                            aggregate(Population with sum as TotalPopulation))
```

~~results in~~

```
~~{~~
```

~~—~~"results in

```
{
  "@odata.context":
     "$metadata#Cities(Continent(Name),Country(Name),TotalPopulation)",
  "value": [
    { ""@odata.id": null, "Continent": { "Name": "Asia" },
      "Country": { "Name": "China" }, "TotalPopulation": 692.580.000 },
    { ""@odata.id": null, "Continent": { "Name": "Asia" },
      "Country": { "Name": "India" }, "TotalPopulation": 390.600.000 },
    ...
  ]
}
```

Example 72: all countries with megacities and their continents

```
GET ~/Cities?$apply=filter(Population ge 10000000)
                   /groupby((Continent/Name,Country/Name),
                            aggregate(Population with sum as TotalPopulation))
```

Example 73: all countries with tens of millions of city dwellers and the continents only for these countries

```
GET ~/Cities?$apply=groupby((Continent/Name,Country/Name),
                          aggregate(Population with sum as CountryPopulation))
                   /filter(CountryPopulation ge 10000000)
                   /concat(identity,
                         groupby((Continent/Name),
                           aggregate(~~Population)))~~CountryPopulation with sum
--                                    as TotalPopulation)))
```

– OR –

```
GET ~/Cities?$apply=groupby((Continent/Name,Country/Name),
                          aggregate(Population with sum as CountryPopulation))
                   /filter(CountryPopulation ge 10000000)
                   /groupby((rollup(Continent/Name,Country/Name)),
                             aggregate(~~Population))~~CountryPopulation with sum
                                      as TotalPopulation))
```

Example 74: all countries with tens of millions of city dwellers and all continents with cities independent of their size

```
GET ~/Cities?$apply=groupby((Continent/Name,Country/Name),
                          aggregate(Population with sum as CountryPopulation))
                   /concat(filter(CountryPopulation ge 10000000),
                         groupby((Continent/Name),
                                 aggregate(~~Population)))~~CountryPopulation with
sum
                                       as TotalPopulation)))
```

Example 75: filter the base set and filter related items before aggregation

```
GET ~/SalesOrders?$apply=filter(Status eq 'incomplete')
                        /expand(Items,filter(not Shipped~~)~~))
                        /groupby((Customer/Country),
                         aggregate(Items/Amount with sum as ItemAmount))
```

8 Conformance

Conforming services MUST follow all rules of this specification for the set transformations and aggregation methods they support. They MUST implement all set transformations and aggregation methods they advertise via the Custom Aggregates annotation.

Conforming clients MUST be prepared to consume a model that uses any or all of the constructs defined in this specification, including custom aggregation methods defined by the service, and MUST ignore any constructs not defined in this version of the specification.

Appendix A. Acknowledgments

The contributions of the OASIS OData Technical Committee members, enumerated in **[OData-Protocol]**, are gratefully acknowledged.

Appendix B. Revision History

Revision	Date	Editor	Changes Made
Working Draft 01	2012-11-12	Ralf Handl	Translated contribution into OASIS format
Committee Specification Draft 01	2013-07-25	Ralf Handl Hubert Heijkers Gerald Krause Michael Pizzo Martin Zurmuehl	Switched to pipe-and-filter-style query language based on composable set transformations Fleshed out examples and addressed numerous editorial and technical issues processed through the TC Added Conformance section
Committee Specification Draft 02	2014-01-09	Ralf Handl Hubert Heijkers Gerald Krause Michael Pizzo Martin Zurmuehl	Dynamic properties used all aggregated values.either via aliases or via custom aggregates Refactored annotations