Hitachi Ops Center Analyzer Detail View

Query Language User Guide

This document provides detailed information on the Ops Center Analyzer detail view query language.

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1 Preface

This document describes how to use Hitachi Ops Center Analyzer detail view Query language.

1.1 Product version

This document revision applies to Hitachi Ops Center Analyzer detail view version 11.0.0-00 or later.

1.2 Accessing product documentation

Product user documentation is available on the Hitachi Vantara Support Website: https://knowledge.hitachivantara.com/Documents. Check this site for the most current

documentation, including important updates that may have been made after the release of

the product.

1.3 Comments

Please send comments to doc.comments@hitachivantara.com. Include the document title and number, including the revision level (for example, -07), and refer to specific sections and paragraphs whenever possible. All comments become the property of Hitachi Vantara LLC.

Thank you!

Thank you!

2 Analyzer detail view query language

The Analyzer detail view query language (referred to as MQL in this document) is a regex-based terse yet expressive query language used to retrieve and filter data stored in Analyzer detail view database.

MQL allows complex analysis on this data in real-time with constant run-time.

MQL syntax makes it possible to traverse relations, identify patterns in data, and provides a mechanism to establish a correlation.

MQL query consists of the following parameters:

- A single line query
- Start time
- End time

You can perform advanced operations like interval rollup, resource rollup etc. using MQL by referring to this guide. For example, you can use the interval rollup operation to aggregate data from a lower interval to a higher interval. To perform advanced operations using MQL, log on to Analyzer detail view, click **Reports** > **Report Builder** and then click **Create Using MQL** option.

Note: You can also build queries through Query Builder option in the Analyzer detail view UI. However, advanced MQL features are not supported in the Query Builder. For more information, refer to the **Creating custom reports using Query Builder** section in the *Hitachi Ops Center Analyzer Detail View Help*.

3 Query language specification

3.1 Terminology

- **Resource**: An entity for which scalar and timeseries data exists in the Analyzer detail view database. Resources may represent real world entities such as a Host, CPU, Storage Volume, Storage System, NIC Card, and Virtual Machine.
- **Attribute:** A property that is attached to a resource which provides more information about it. Two types of attributes are as follows:
    - **Scalar attributes** that might not change frequently. For example, host name or IP address of a host, size of a storage volume.
    - **Timeseries attributes** store timeseries numerical data for a resource. For example, CPU usage of a host, number of IOPS occurring on a storage volume.
- **Relation:** A resource in real world typically does not operate independently. It is either dependent on another resource or contains resources within or under itself. For example, a VM is dependent on the Host it runs. Vice-versa the Host contains a number of VMs which are running on it. Two resources are considered related if one resource depends on another resource or one resource contains the other resource.
- **Resource Definition:** Defines how the resource is modeled. The definition consists of the following:
    - **Type:** An unique identifier for resource definition within a given dataset. For example, LHost can represent a Linux Host, LHostCPU can represent the CPUs in a host.
    - **Scalar Attributes:** IDs of scalar attribute definition for which data can be stored in resources of this type, for example, name, ipAddress, capacity.
    - **Timeseries Attributes:** IDs of timeseries attribute definition for which data can be stored in resources of this type, for example, cpuUsage, memUsage, readIOPS.
    - **Relations:** List of resource types which can be related to resource belonging to this definition, for example, LHost is related with LHostCPU.
- **Attribute Definition:** Defines how the attribute is modeled. The definition consists of the following:
    - **ID**: An unique identifier for attribute definition within a given dataset, for example, name, ipAddress, cpuUsage
    - **Name**: Display name for the attribute definition
    - **Type:** Attribute definition type. Valid values are scalar and timeseries.
    - **Unit:** Specifies the unit in which the value is stored, for example, Percent, MBps, KBps.

3.1.1 Overview

MQL query consists of a series of resource filters separated by the path separator '/'. Each resource filter progressively narrows down from the entire set of resources stored inside the Analyzer detail view database to a smaller set based on the filter criteria.

The very first filter operates on the entire set of resources stored inside the Analyzer detail view database. The successive filters operate on the related resources of the resources matched in the upper level resource filter. Therefore, the very first filter can start by filtering any resource type.

3.1.2 Query structure

```
resource_type[filter]…/related_resource_type[filter]/…
```

- Must contain at least one level
- No limit on number of levels
- Filters are optional

Let's look at few query examples:

- **Example 1: Single resource type without any filter**

  ```
  LHost
  ```

  - Consists of a single resource type with no filters.
  - Returns all the resources of LHost type.

- **Example 2: Resource type followed by a scalar filter**

  ```
  LHost[=name rx node]
  ```

  - Consists of resource type followed by a scalar filter.
  - Returns all the resources of *LHost* type, having scalar attribute *name* whose value matches the regular expression *node*.

- **Example 3: Resource type followed by a timeseries filter**

  ```
  LHost[@L_user rx b .*]
  ```

  - Consists of resource type followed by a timeseries filter.
  - Returns all the resources *LHost* type, having the timeseries attribute *L_user* whose value matches the regular expression '**.***'.

- **Example 4: Two resource types followed by scalar attribute for each resource type**

  ```
  LHost[=name rx node]/LHostDisk[=name rx sda]
  ```

  - Consists of two resource filters (*LHost* and *LHostDisk*) . In the second filter, resource *LHostDisk* is mentioned because *LHost* is related to *LHostDisk*.

- Returns all resources of *LHost* type with name matching the regular expression *node,* and their related resources of *LHostDisk* type name matching the regular expression *sda*.

- **Example 5: One resource type followed by one scalar and one timeseries filter**

  `LHost[=name rx node]&[@L_user rx b [U50-U100]{5,}]`

  - Combines a scalar and a timeseries filter.
  - Returns all resources of *LHost* type with attribute *name* matching regular expression *node,* and timeseries filter on attribute *L_user* matching the regular expression *[U50-U100]{5,}*.
  - The timeseries data returned are those points where *L_user* was between 50 and 100 for 5 consecutive data points.

3.1.3 Resource filters

A resource filter consists of a resource type and any number of attribute filters. Each attribute filter is enclosed between the big angle brackets, for example, r[f1][f2]. By default, logical *OR* is applied between two filters. A logical *AND* can be applied between two filters using the *&* operator, for example, r [f1] & [f2].

Logical *OR* and *AND* operations can be applied between resource filters separated by path separator. By default, the operation is logical *OR*. For example:

- r1[f1]/r2[f2]. Results of r1[f1] are included irrespective of whether a match occurred at r2[f2]
- r1[f1]/&r2[f2]. Only those results of r1[f1] are included that have a match at r2[f2]

A special character ** (asterisk)* can be prefixed to any resource filter. This implies that the results of this resource filter will be suppressed in the output results. This is useful in situations where results from a subsequent resource filter are required but this resource filter is required as a passthrough, for example, *r1[f1]/r2[f2].

3.1.4 Attribute filters

3.1.4.1 Scalar filters

A scalar filter is used to filter resources based on their scalar attribute values using string regular expression. Any regular expression constructed as per JDK 1.7 specifications (http://docs.oracle.com/javase/7/docs/api/java/util/regex/Pattern.html) is supported. The filter tries to find a subsequence using the specified regular expression as opposed to a complete match.

- **Scalar filter structure:**

  ```
  <resource_type>[=<attribute_id> rx regex]
  ```

  Example: Get all hosts that have attribute *name* containing *Host*

```
h[=name rx Host]
```

Multiple scalar filters on different attributes can be specified using logical operators 'OR' and 'AND'.

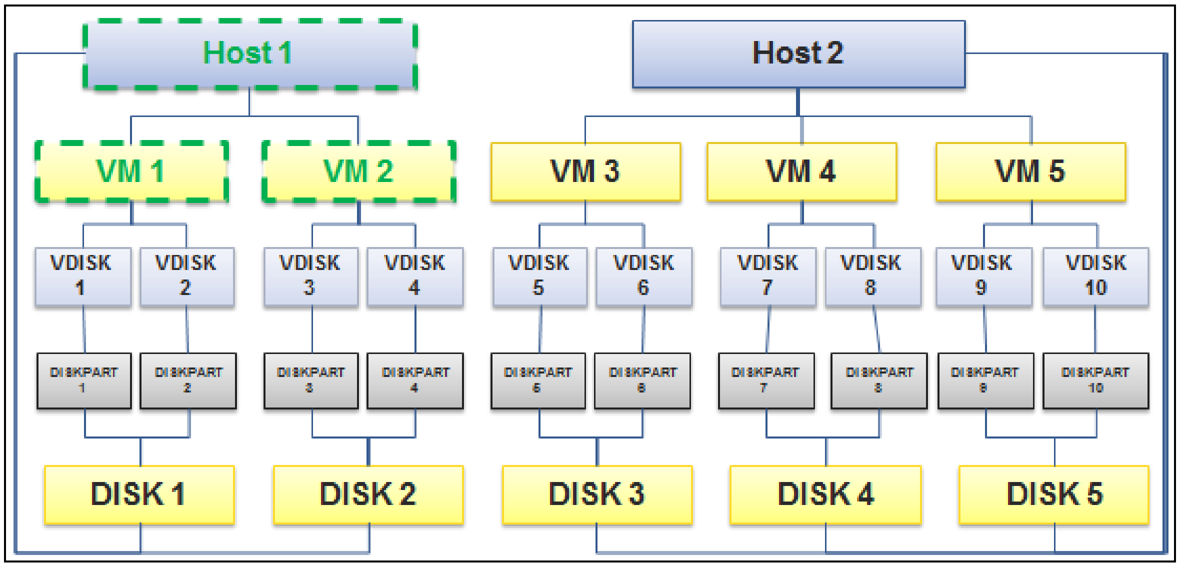
Example: `h[=name rx node AND osVersion rx 2003]`

Scalar filter samples:

NOTE: In scalar filter samples, the dotted boxes show results of the query.

Sample 1: List Host1 and all the VMs that belong to Host1

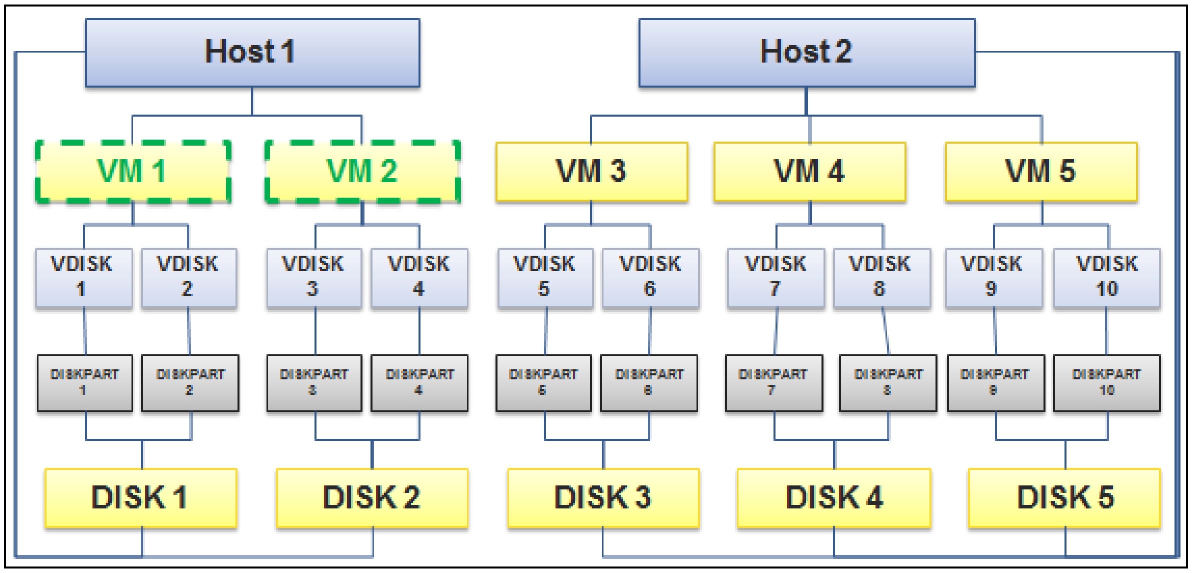
```
h[=name rx Host1]/vm
```



Sample 2: List all the VMs that belong to Host1

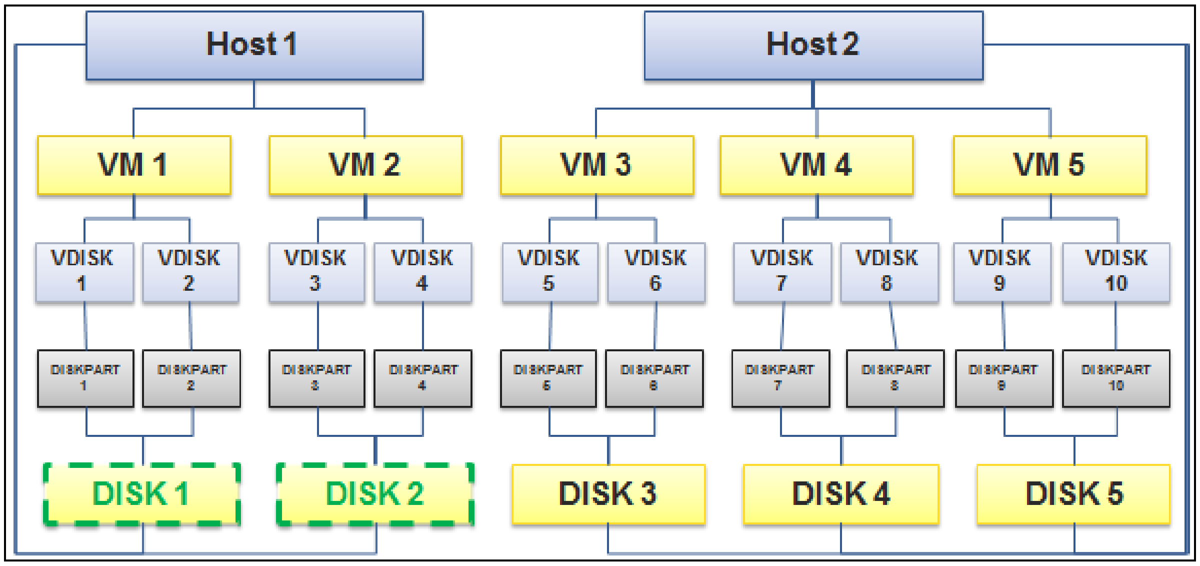
```
*h[=name rx Host1]/vm
```

Note: * prefixed to resource type will cause the resource to be not displayed in the output



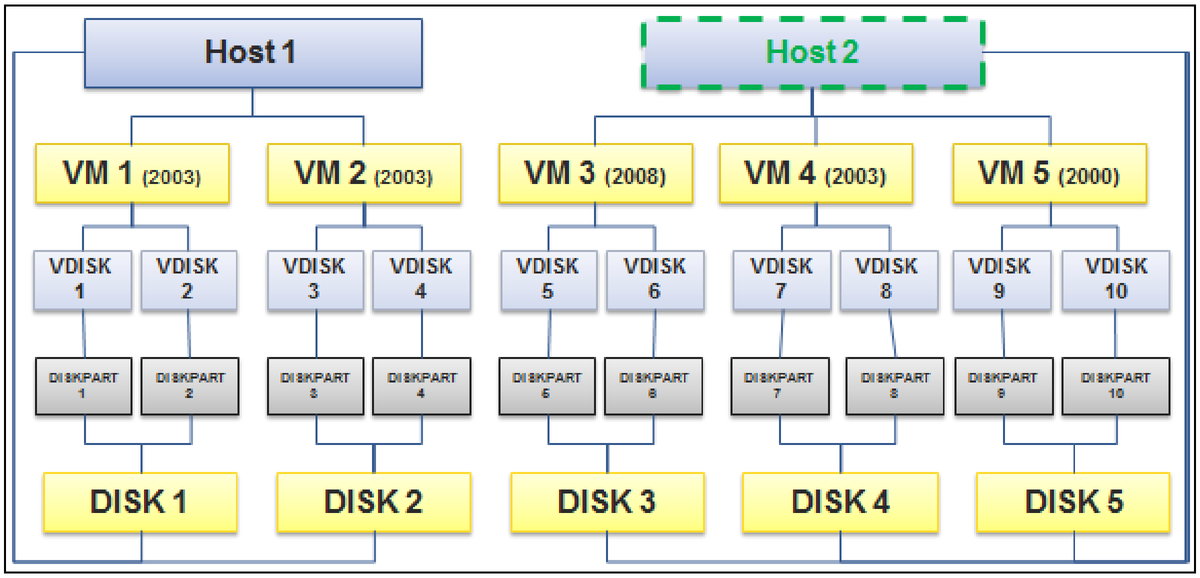
Sample 3: List all Disks that belong to Host 1 and are connected to one or more VMs

```
*h[=name rx Host1]/*vm/*vdisk/*diskpart/disk
```



Sample 4: List all Hosts that have one or more VMs with OS Version 2000

```
h/&*vm[=osVersion rx 2000]
```



3.1.4.2 Timeseries filters

A timeseries filter is used to filter resources based on their timeseries attribute values using modified regular expression syntax used for numerical matching. A basic timeseries filter consists of the timeseries attribute ID, look up type, and a regular expression, for example, [@L_user rx b [U50-U100]{5,}].

The timeseries attribute ID can be a valid timeseries attribute applicable to that resource. The character ‘b’ specifies a basic lookup and character ‘d’ specifies delta lookup. Delta lookup calculates and returns the numerical difference of the current value in the database and its predecessor.

Any regular expression constructed as per JDK 1.7 specifications (http://docs.oracle.com/javase/7/docs/api/java/util/regex/Pattern.html) is supported with some modifications:

- All character and character class lookups are not supported. This is because timeseries does not consist of any characters. It only consists of numerical values.
- A character is substituted by a numerical value prefixed with character ‘U’. This indicates to the query parser that a numerical value is specified, for example, U100 or U90.
- Similar to character range classes, numerical ranges can be specified, for example, [U90-U100].
- All quantifiers in a normal regular expression are supported, for example, [U90-U100]{5}.

Timeseries filter structure:

```
<resource_type>[@<attribute_id> rx b regex]
```

Note: Only numeric values are supported. Numeric values should be prefixed with ‘U’.

Examples:

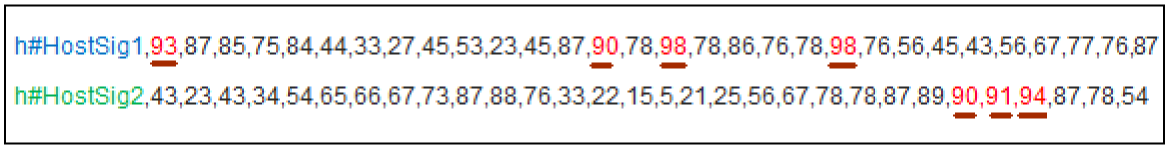
- List all VMs with all cpuUsage
  `vm[@cpuUsage rx b .*]`
- List VMs with cpuUsage = 60
  `vm[@cpuUsage rx b [U60]]`
- List VMs with cpuUsage value in the range of 70 and 100
  `vm[@cpuUsage rx b [U70-U100]]`

Timeseries filter samples:

NOTE: In timeseries filter samples, the underlines show results of the query.

Sample 1: List all Hosts with cpuUsage between 90 and 100

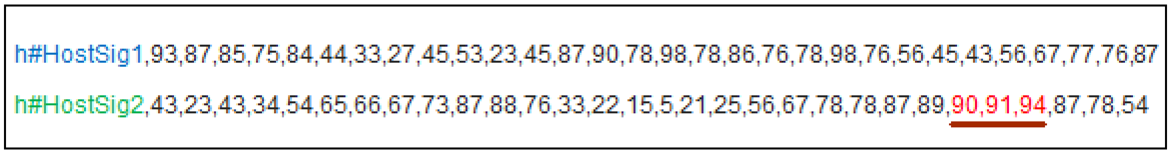
```
h[@cpuUsage rx b [U90-U100]]
```



```
h#HostSig1,93,87,85,75,84,44,33,27,45,53,23,45,87,90,78,98,78,86,76,78,98,76,56,45,43,56,67,77,76,87
h#HostSig2,43,23,43,34,54,65,66,67,73,87,88,76,33,22,15,5,21,25,56,67,78,78,87,89,90,91,94,87,78,54
```

Sample 2: List all Hosts with cpuUsage between 90 and 100 with at least 3 consecutive occurrences

```
h[@cpuUsage rx b [U90-U100]{3,}]
```

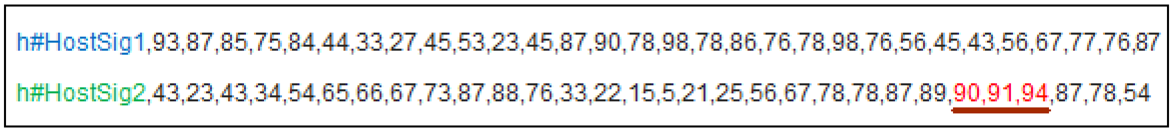


```
h#HostSig1,93,87,85,75,84,44,33,27,45,53,23,45,87,90,78,98,78,86,76,78,98,76,56,45,43,56,67,77,76,87
h#HostSig2,43,23,43,34,54,65,66,67,73,87,88,76,33,22,15,5,21,25,56,67,78,78,87,89,90,91,94,87,78,54
```

Sample 3: List all Hosts with cpuUsage between 90 and 100 for 3 or more consecutive occurrences OR cpuUsagemhz between 70 and 100 for 5 or more consecutive occurrences

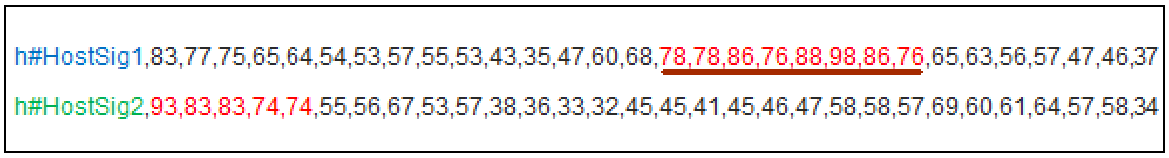
```
h[@cpuUsage rx b [U90-U100]{3,}][@cpuUsagemhz rx b [U70-
U100]{5,}]
```

cpuUsage:



```
h#HostSig1,93,87,85,75,84,44,33,27,45,53,23,45,87,90,78,98,78,86,76,78,98,76,56,45,43,56,67,77,76,87
h#HostSig2,43,23,43,34,54,65,66,67,73,87,88,76,33,22,15,5,21,25,56,67,78,78,87,89,90,91,94,87,78,54
```

cpuUsagemhz:



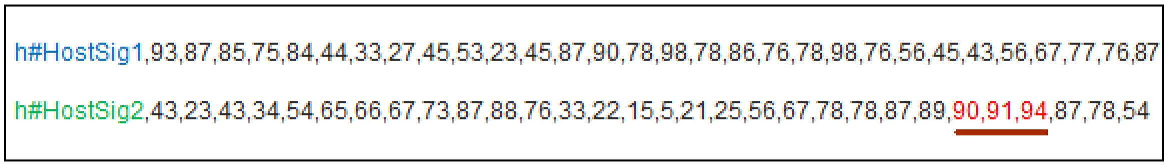
```
h#HostSig1,83,77,75,65,64,54,53,57,55,53,43,35,47,60,68,78,78,86,76,88,98,86,76,65,63,56,57,47,46,37
h#HostSig2,93,83,83,74,74,55,56,67,53,57,38,36,33,32,45,45,41,45,46,47,58,58,57,69,60,61,64,57,58,34
```

In this case, the “OR” operator (default) is used between filters so it returns both Host1 and Host2.

Sample 4: List all Hosts with cpuUsage between 90 and 100 for 3 or more consecutive occurrences AND cpuUsagemhz between 70 and 100 for 5 or more consecutive occurrences

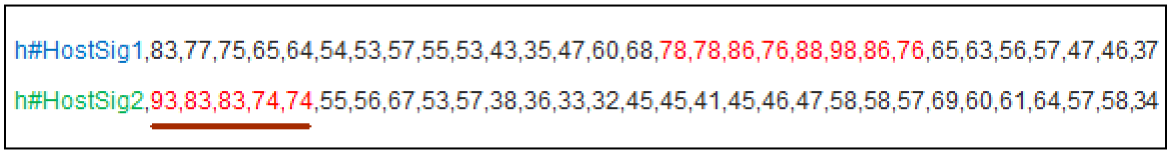
```
h[@cpuUsage rx b [U90-U100]{3,}]&[@cpuUsagemhz rx b [U70-
U100]{5,}]
```

cpuUsage:



```
h#HostSig1,93,87,85,75,84,44,33,27,45,53,23,45,87,90,78,98,78,86,76,78,98,76,56,45,43,56,67,77,76,87
h#HostSig2,43,23,43,34,54,65,66,67,73,87,88,76,33,22,15,5,21,25,56,67,78,78,87,89,90,91,94,87,78,54
```

cpuUsagemhz:



```
h#HostSig1,83,77,75,65,64,54,53,57,55,53,43,35,47,60,68,78,78,86,76,88,98,86,76,65,63,56,57,47,46,37
h#HostSig2,93,83,83,74,74,55,56,67,53,57,38,36,33,32,45,45,41,45,46,47,58,58,57,69,60,61,64,57,58,34
```

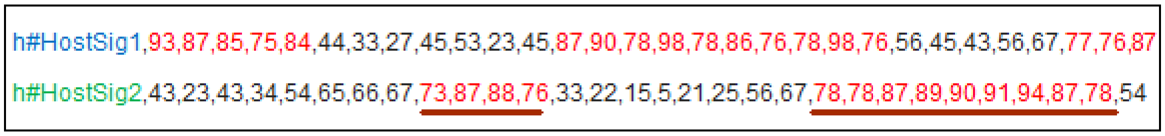
In this case, the “AND” operator is used between filters so it returns Host2 only.

Sample 5: List all Hosts with cpuUsage between 70 and 100 having at least one VM with cpuUsage between 60 and 100

```
h[@cpuUsage rx b [U70-U100]]/&vm[@cpuUsage rx b [U60-U100]]
```

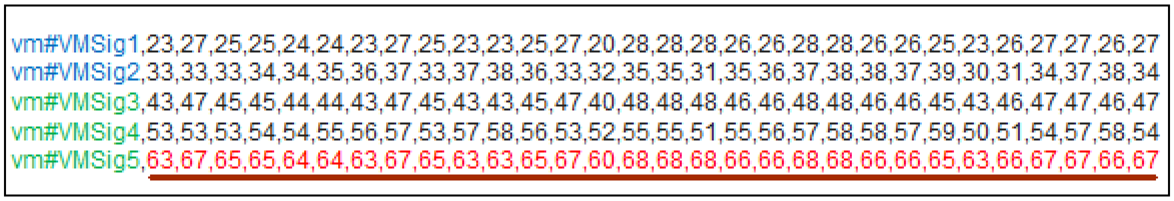
Only Host2 matches the query as VM5 belongs to Host 2. Host1 matches the cpuUsage filter but there is no qualified VM for it.

cpuUsage - Host:



```
h#HostSig1,93,87,85,75,84,44,33,27,45,53,23,45,87,90,78,98,78,86,76,78,98,76,56,45,43,56,67,77,76,87
h#HostSig2,43,23,43,34,54,65,66,67,73,87,88,76,33,22,15,5,21,25,56,67,78,78,87,89,90,91,94,87,78,54
```

cpuUsage - VM:



```
vm#VMSig1,23,27,25,25,24,24,23,27,25,23,23,25,27,20,28,28,28,26,26,28,28,26,26,25,23,26,27,27,26,27
vm#VMSig2,33,33,33,34,34,35,36,37,33,37,38,36,33,32,35,35,31,35,36,37,38,38,37,39,30,31,34,37,38,34
vm#VMSig3,43,47,45,45,44,44,43,47,45,43,43,45,47,40,48,48,48,46,46,48,48,46,46,45,43,46,47,47,46,47
vm#VMSig4,53,53,53,54,54,55,56,57,53,57,58,56,53,52,55,55,51,55,56,57,58,58,57,59,50,51,54,57,58,54
vm#VMSig5,63,67,65,65,64,64,63,67,65,63,63,65,67,60,68,68,68,66,66,68,68,66,66,65,63,66,67,67,66,67
```

3.1.4.2.1 Time windows

A timeseries filter is applied on a range of timeseries data as specified by the start time and end time of a query. The filter will match different subsequences within this range of timeseries data. These are called time windows. A group of such time windows can be given a name, for example:

```
lHost[@#tw#l_user rx b [U50-U100]{5,}].
```

The above example defines a time window named 'tw'. Just defining a time window does not actually alter the results. The results are altered when the time window is referred in another timeseries filter, for example:

```
lHost[@#tw#l_user rx b [U0-U50]{5,}][@^tw^l_iowait rx b [U50-
U100]+]
```

Note the different syntax using '^' for referring to time windows. The above query matches all resources of type lHost where l_user was between 0 and 50 for at least 5 consecutive data points, and *in those time windows* value of l_iowait was between 50 and 100 for at least one data point. It is important to note that this matching is done on a resource-by-resource basis.

Matching across resource filters

Time window can be used across resource filters as well, for example:

```
lHost[@#tw#l_user rx b [U0-U50]{5,}]/lHostDisk[@^tw^l_svctm rx b
[U50-U1000]+].
```

The above query matches all resources of type lHost where l_user was between 0 and 50 for at least 5 consecutive data points. Value of l_svctm attribute for all related lHostDisk was between 50 and 1000 for at least one data point within *those time windows.*

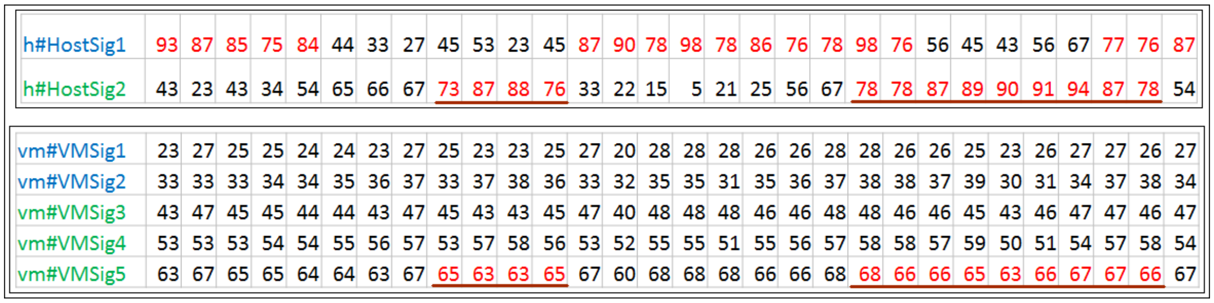
Time window filter samples:

Sample 1: Return all Hosts with cpuUsage between 70 and 100 which have at least one VM with cpuUsage between 60 and 100

```
h[@#tw#cpuUsage rx b [U70-U100]]/&vm[@^tw^cpuUsage rx b [U60-
U100]]
```

In the following examples, a second filter (vm) uses the same time windows (tw) resulting from the first filter (h). It matches Host2 only as VM5 belongs to Host2. Host1 matches the cpuUsage data but there is no qualified VM for it.

cpuUsage – Host and VM



h#HostSig1	93	87	85	75	84	44	33	27	45	53	23	45	87	90	78	98	78	86	76	78	98	76	56	45	43	56	67	77	76	87
h#HostSig2	43	23	43	34	54	65	66	67	73	87	88	76	33	22	15	5	21	25	56	67	78	78	87	89	90	91	94	87	78	54

vm#VMSig1	23	27	25	25	24	24	23	27	25	23	23	25	27	20	28	28	28	26	26	28	28	26	26	25	23	26	27	27	26	27
vm#VMSig2	33	33	33	34	34	35	36	37	33	37	38	36	33	32	35	35	31	35	36	37	38	38	37	39	30	31	34	37	38	34
vm#VMSig3	43	47	45	45	44	44	43	47	45	43	43	45	47	40	48	48	48	46	46	48	48	46	46	45	43	46	47	47	46	47
vm#VMSig4	53	53	53	54	54	55	56	57	53	57	58	56	53	52	55	55	51	55	56	57	58	58	57	59	50	51	54	57	58	54
vm#VMSig5	63	67	65	65	64	64	63	67	65	63	63	65	67	60	68	68	68	66	66	68	68	66	66	65	63	66	67	67	66	67

3.1.4.2.2 Subsequence filtering

Time window based filtering does not further filter the subsequences matched. For example, consider [U90-U100]{5}, which resulted in 10 subsequences. Further filtering, as used in the previous section, either removes all subsequences if no match occurred in the lookup filter or will retain all the subsequences if a minimum of one match occurred.

To further filter on specific subsequences, additional syntax is available. Let's take the same query from previous section and add subsequence filtering to it.

```
lHost[@#tw#l_user rx b [U0-U50]{5,}](tw:ioWaitHigh =
1)[ioWaitHigh@^tw^l_iowait rx b [U50-U100]+]
```

First, notice that a 'filter tag' has been defined on the timeseries filter of attribute l_iowait. Second, this filter tag has been referenced in a subsequence condition added to the timeseries filter of attribute l_user.

A filter tag can be defined on any timeseries filter. The same tag can be used on multiple timeseries filters. It is referenced in a subsequence filter using the syntax <time window>:<filter tag>. Note, the filter tag reference is actually before the filter tag definition. This is the normal usage.

In the above example, for each matching lHost resource and its matching time windows of l_user filter, results include only those subsequences on which the timeseries filter on l_iowait also matches within the same start position and end position of the subsequence.

The subsequence expression value '1' in the filter means that at least one filter needs to match. By using the same filter tag multiple times, the matching can be made even stricter, for example:

```
lHost[@#tw#l_user rx b [U0-U50]{5,}](tw:ioWaitHigh = 2)[ioWaitHigh
@^tw^l_iowait rx b [U50-U1000]+][ioWaitHigh @^tw^l_idle rx b [U70-
U100]+]
```

The subsequence expression value '2' here means that both the filters (on l_iowait and l_idle) need to match for a subsequence of timeseries filters on l_user to be matched.

Matching across resource filters

Subsequence filtering is allowed across resource filters. The syntax is the same as normal subsequence filtering. The difference is that the subsequence expression value takes a different meaning. Let's take the same multiple resource filter query from the time windows section and add subsequence filtering to it:

```
lHost[@#tw#l_user rx b [U0-U50]{5,}](tw:svctmHigh >
1)/lHostDisk[svctmHigh@^tw^l_svctm rx b [U50-U1000]+]
```

In the above example, for each matching lHost resource and its matching time windows of l_user filter, results include only those subsequences in which at least two or more related lHostDisk resources filter match within the same start position and end position of the subsequence.

Therefore, unlike the previous case where the subsequence expression value referred to the number of filters, here it refers to the number of resources matched in other resource filters.

The subsequence expression value supports a few special values besides positive numerical values:

- 'a': All resources in the other resource filters must match. This could be used in the above example, to ensure that all lHostDisk related to that lHost match instead of two or more.
- -n: A negative value means all resources except 'n' must match.

By combining multiple time window definitions and lookups, and multiple filter tags and subsequence expressions, very complex and powerful filtering can be done on timeseries data.

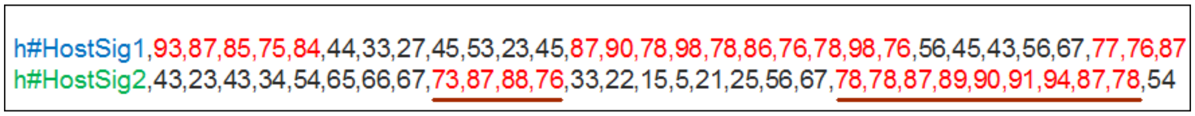
Subsequent filtering samples:

Sample 1: List all Hosts with cpuUsage between 70 and 100 that have at least one VM with cpuUsage between 60 and 100.

```
h[@cpuUsage rx b [U70-U100]](t1 > 0)/vm[t1 @ cpuUsage rx b [U60-
U100]]
```

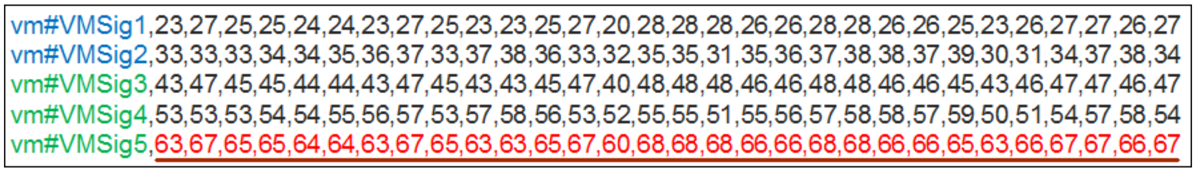
In the following examples, the query matches to Host2 only as VM5 belongs to Host2. Host1 matches the cpuUsage data but there is no qualified VM for it.

cpuUsage - Host:



```
h#HostSig1,93,87,85,75,84,44,33,27,45,53,23,45,87,90,78,98,78,86,76,78,98,76,56,45,43,56,67,77,76,87
h#HostSig2,43,23,43,34,54,65,66,67,73,87,88,76,33,22,15,5,21,25,56,67,78,78,87,89,90,91,94,87,78,54
```

cpuUsage – VM



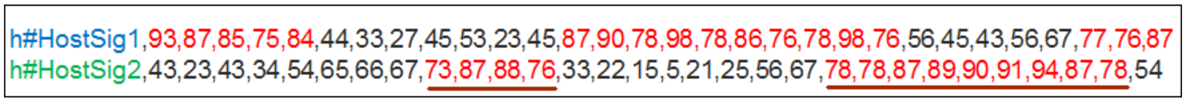
```
vm#VMSig1,23,27,25,25,24,24,23,27,25,23,23,25,27,20,28,28,28,26,26,28,28,26,26,25,23,26,27,27,26,27
vm#VMSig2,33,33,33,34,34,35,36,37,33,37,38,36,33,32,35,35,31,35,36,37,38,38,37,39,30,31,34,37,38,34
vm#VMSig3,43,47,45,45,44,44,43,47,45,43,43,45,47,40,48,48,48,46,46,48,48,46,46,45,43,46,47,47,46,47
vm#VMSig4,53,53,53,54,54,55,56,57,53,57,58,56,53,52,55,55,51,55,56,57,58,58,57,59,50,51,54,57,58,54
vm#VMSig5,63,67,65,65,64,64,63,67,65,63,63,65,67,60,68,68,68,66,66,68,68,66,66,65,63,66,67,67,66,67
```

Sample 2: List all Hosts with cpuUsage between 70 and 100 that have all VMs with cpuUsage between 30 and 100

```
h[@cpuUsage rx b [U70-U100]](t1 = a)/vm[t1 @ cpuUsage rx b [U30-
U100]]
```

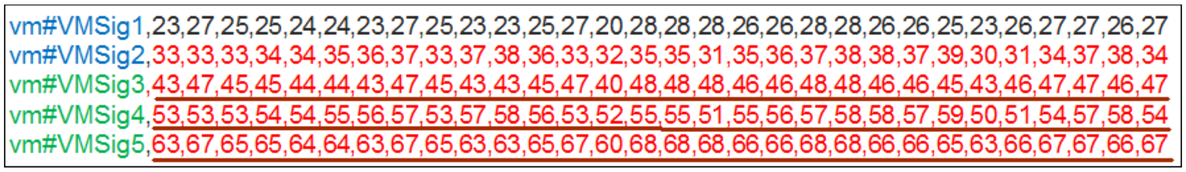
In the following examples, the query matches Host 2 only as VM3, VM4, and VM5 belonging to Host 2 have qualified output. Host1 matches the cpuUsage data, but VM1 doesn't have a qualified output. Therefore, Host1 will not be qualified.

cpuUsage - Host:



```
h#HostSig1,93,87,85,75,84,44,33,27,45,53,23,45,87,90,78,98,78,86,76,78,98,76,56,45,43,56,67,77,76,87
h#HostSig2,43,23,43,34,54,65,66,67,73,87,88,76,33,22,15,5,21,25,56,67,78,78,87,89,90,91,94,87,78,54
```

cpuUsage – VM



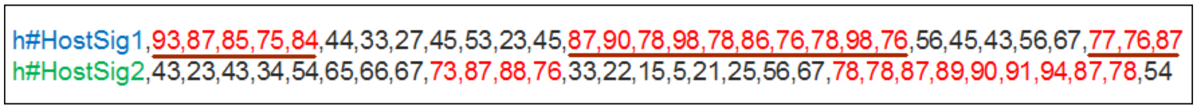
```
vm#VMSig1,23,27,25,25,24,24,23,27,25,23,23,25,27,20,28,28,28,26,26,28,28,26,26,25,23,26,27,27,26,27
vm#VMSig2,33,33,33,34,34,35,36,37,33,37,38,36,33,32,35,35,31,35,36,37,38,38,37,39,30,31,34,37,38,34
vm#VMSig3,43,47,45,45,44,44,43,47,45,43,43,45,47,40,48,48,48,46,46,48,48,46,46,45,43,46,47,47,46,47
vm#VMSig4,53,53,53,54,54,55,56,57,53,57,58,56,53,52,55,55,51,55,56,57,58,58,57,59,50,51,54,57,58,54
vm#VMSig5,63,67,65,65,64,64,63,67,65,63,63,65,67,60,68,68,68,66,66,68,68,66,66,65,63,66,67,67,66,67
```

Sample 3: List all Hosts with cpuUsage between 70 and 100 that have all but one VM with cpuUsage between 30 and 100.

```
h[@cpuUsage rx b [U70-U100]](t1 = -1)/vm[t1 @ cpuUsage rx b [U30-
U100]]
```

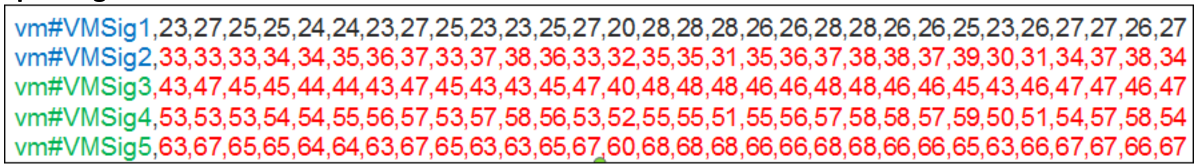
In the following examples, Host1 has 1 out of 2 VMs qualified = (all -1). Therefore, it will be qualified. Host2 has 3 out of 3 VMs qualified. Since all VMs qualified, Host2 will not be qualified. If 2 out of 3 VMs qualified, then Host2 would have been qualified.

cpuUsage - Host:



```
h#HostSig1,93,87,85,75,84,44,33,27,45,53,23,45,87,90,78,98,78,86,76,78,98,76,56,45,43,56,67,77,76,87
h#HostSig2,43,23,43,34,54,65,66,67,73,87,88,76,33,22,15,5,21,25,56,67,78,78,87,89,90,91,94,87,78,54
```

cpuUsage – VM:



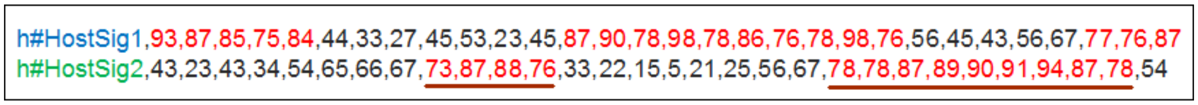
```
vm#VMSig1,23,27,25,25,24,24,23,27,25,23,23,25,27,20,28,28,28,26,26,28,28,26,26,25,23,26,27,27,26,27
vm#VMSig2,33,33,33,34,34,35,36,37,33,37,38,36,33,32,35,35,31,35,36,37,38,38,37,39,30,31,34,37,38,34
vm#VMSig3,43,47,45,45,44,44,43,47,45,43,43,45,47,40,48,48,48,46,46,48,48,46,46,45,43,46,47,47,46,47
vm#VMSig4,53,53,53,54,54,55,56,57,53,57,58,56,53,52,55,55,51,55,56,57,58,58,57,59,50,51,54,57,58,54
vm#VMSig5,63,67,65,65,64,64,63,67,65,63,63,65,67,60,68,68,68,66,66,68,68,66,66,65,63,66,67,67,66,67
```

Sample 4: List all Hosts with cpuUsage between 70 and 100 that have at least one VM with cpuUsage between 60 and 100 AND cpuUsagemhz between 70 and 100

```
h[@cpuUsage rx b [U70-U100]](t1 > 0 & t2 > 0)/vm[t1 @ cpuUsage rx
b [U60-U100]] [t2 @ cpuUsagemhz rx b [U70-U100]]
```

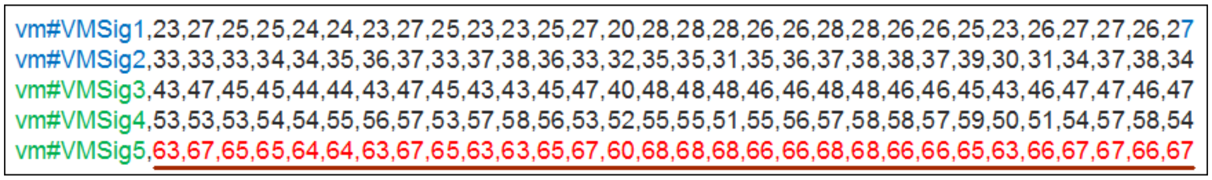
In the following examples, Host2 has at least one VM (VM5) with qualified output.

cpuUsage - Host:



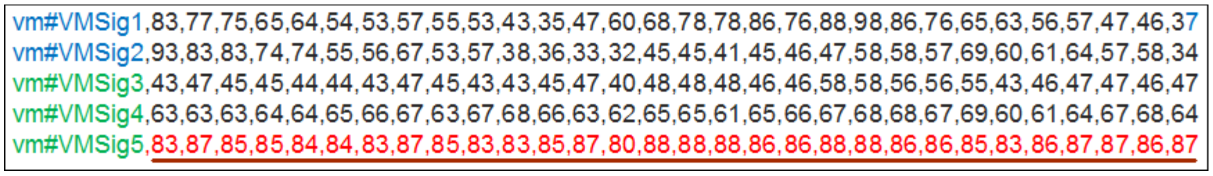
```
h#HostSig1,93,87,85,75,84,44,33,27,45,53,23,45,87,90,78,98,78,86,76,78,98,76,56,45,43,56,67,77,76,87
h#HostSig2,43,23,43,34,54,65,66,67,73,87,88,76,33,22,15,5,21,25,56,67,78,78,87,89,90,91,94,87,78,54
```

cpuUsage – VM:



```
vm#VMSig1,23,27,25,25,24,24,23,27,25,23,23,25,27,20,28,28,28,26,26,28,28,26,26,25,23,26,27,27,26,27
vm#VMSig2,33,33,33,34,34,35,36,37,33,37,38,36,33,32,35,35,31,35,36,37,38,38,37,39,30,31,34,37,38,34
vm#VMSig3,43,47,45,45,44,44,43,47,45,43,43,45,47,40,48,48,48,46,46,48,48,46,46,45,43,46,47,47,46,47
vm#VMSig4,53,53,53,54,54,55,56,57,53,57,58,56,53,52,55,55,51,55,56,57,58,58,57,59,50,51,54,57,58,54
vm#VMSig5,63,67,65,65,64,64,63,67,65,63,63,65,67,60,68,68,68,66,66,68,68,66,66,65,63,66,67,67,66,67
```

cpuUsagemhz –VM:



```
vm#VMSig1,83,77,75,65,64,54,53,57,55,53,43,35,47,60,68,78,78,86,76,88,98,86,76,65,63,56,57,47,46,37
vm#VMSig2,93,83,83,74,74,55,56,67,53,57,38,36,33,32,45,45,41,45,46,47,58,58,57,69,60,61,64,57,58,34
vm#VMSig3,43,47,45,45,44,44,43,47,45,43,43,45,47,40,48,48,48,46,46,58,58,56,56,55,43,46,47,47,46,47
vm#VMSig4,63,63,63,64,64,65,66,67,63,67,68,66,63,62,65,65,61,65,66,67,68,68,67,69,60,61,64,67,68,64
vm#VMSig5,83,87,85,85,84,84,83,87,85,83,83,85,87,80,88,88,88,86,86,88,88,86,86,85,83,86,87,87,86,87
```

3.1.4.2.3 Scalar attribute as timeseries

The scalar attribute as timeseries feature allows you to query the scalar attribute as timeseries and shows the result as a series of data points.

If you want to see the configuration data at regular intervals, then you can query the scalar attributes as timeseries.

Syntax:

```
<R>[@<confAttr> rx b <regex>]
```

Where,

R is resource

confAttr is a scalar metric.

For example: `disk[@usedSpace rx b .*]`
This query returns the usedSpace configuration (scalar) data in a timeseries format at the interval of 1 minute.

Note: Currently, the result is shown in default interval of 1 minute.

4 Query language BNF

The part of query language syntax has been described in Backus-Naur Form with some extensions. The following notations are followed:

- ::= means definition of
- <abcd> means a non-terminal
- { … } means zero or more occurrences
- […] means optional (zero or one occurrence)
- '…' means literal occurrence of the characters represented between quotes
- … | … means 'or'
- <ALLUPPERCASE>: A special non-terminal whose definition is provided outside of BNF
- White space is not allowed between non-terminals or literal occurrences. White space is allowed in syntax only where <SPACE> non-terminal has been explicitly mentioned.

4.1 Query statement

```
query_statement::=<resource_filter> { '/' [ '&'] <resource_filter> }

resource::=['*']<RESOURCE_DEF_NAME><filters>

filters::=  <attribute_filter>
            { '&'<attribute_filter> }

attribute_filter::=config_filter | time_series_filter
```

4.2 Scalar filter

```
config_filter::='[' '='<config_filter_def> {
<config_condition><config_filter_def> } ']'

config_filter_def::=<ATTRIBUTE_ID><SPACE>'rx'<SPACE><REGEX>

config_condition::='OR' | 'AND'
```

4.3 Timeseries filter

```
time_series_filter      ::=   '['[ '*'] [ <filter_tags><SPACE> ] '@' [
<time_window> ]
<ATTRIBUTE_ID>'rx'<data_type><time_series_filter_expression>']'
'['<subsequence_filter>']'

filter_tags::=<filter_tag> [ ','<filter_tag> ]

filter_tag::=<STRING_LITERAL>

time_window::=<time_window_definition>|<time_window_reference>

time_window_definition::='#'<time_window_name>'#'

time_window_reference::='^'<time_window_name>'^'

time_window_name::=<STRING_LITERAL>

data_type::=      'b' | 'd'
```

4.3.1 Timeseries filter expression

```
time_series_filter_expression::=    ‘.*’| { ‘.’ }
‘[’‘U’<INTEGER_LITERAL>‘-’ ‘U’<INTEGER_LITERAL>‘]’ [
<occurrence_definition> ] { ‘.’ }

|     <MODIFIED_REGEX>

occurrence_definition::=‘+’|‘{’<NUMBER_LITERAL>‘,’ [ <NUMBER_LITERAL> ]
‘}’
```

4.4 Subsequence filter

```
subsequence_filter      ::=   ‘(’<subseq_expr> {
<SPACE><subseq_condition_operator><subseq_expr> } ‘)’

subseq_expr ::=
      <subseq_expr_variable><SPACE><subseq_expr_operator><SPACE><subseq
_expr_value>

subseq_expr_operator    ::=   ‘&’ | ‘|’

subseq_expr_variable    ::=   <time_window_name>‘:’<filter_tag>

subseq_expr_operator    ::=   ‘=’ | ‘>’ | ‘<’ | ‘!’

subseq_expr_value ::=   <INTEGER_LITERAL>|      ‘a’
```

4.5 Non-terminals

REGEX: Any regular expression constructed as per JDK 1.7 specifications (http://docs.oracle.com/javase/7/docs/api/java/util/regex/Pattern.html)

MODIFIED_REGEX:A normal regular expression but without string lookups and special syntax for numerical value lookups. Refer to the “Timeseries Filter” section for details.

INTEGER_LITERAL: Any positive or negative number

NUMBER_LITERAL: A positive number

STRING_LITERAL: A string consisting of alphanumeric characters only

RESOURCE_DEF_NAME: Refer to the “Resource Definition” section for valid names

ATTRIBUTE_DEF_NAME: Refer to the “Resource Definition” section for the valid attribute name in the context of resource definition

SPACE: One or white spaces – blank and tab only

4.6 Limitations

To build a query, except \ , all other special characters can be used if they make a meaningful regex.

5 Advanced data processing functions

Advanced data processing functions enable users to perform certain operations without any extra efforts. There are a set of in-built functions, which allow users to perform certain operations like aggregation, roll up, and deriving a new attribute.

Following are the supported advanced data processing functions:

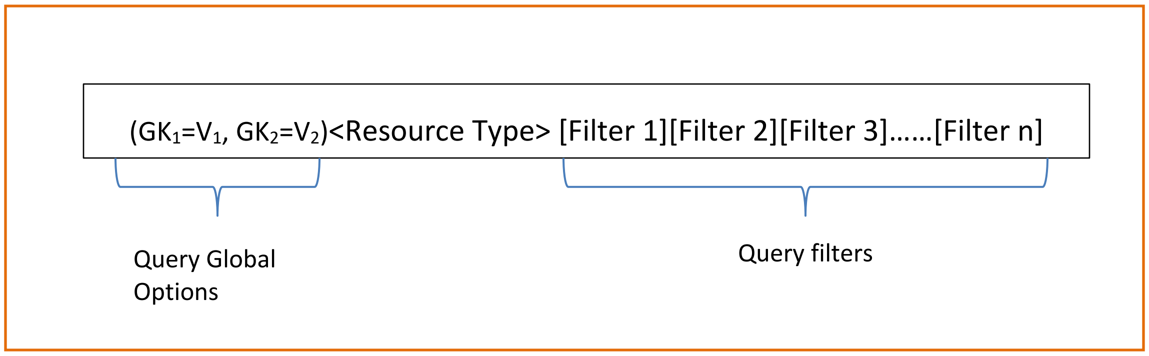
Function	Description
Interval rollup	Method to perform aggregation of timeseries data from lower to higher data interval.
Derived attributes	Method to create custom attribute using two or more attributes of a resource.
Resource rollup	Method to create custom attribute by aggregating data from related subresources to parent resource.
PreProc	Method to perform some specific task before actual processing of filter. For example, conditional processing of filter.

5.1 Query options

To use advanced data processing functions, the user needs to provide some additional options to MQL. These additional inputs are provided to MQL using Query Options. Query options can be categorized as Query Global Options and Query Filter Options.

5.1.1Query global options

Query global options are the settings that influence the behavior of the entire query result. It is applicable to all the filters specified in the query and it must be provided in the beginning of query. The following gives the syntax of Query Global Options.



$(GK_1=V_1, GK_2=V_2)$<Resource Type> [Filter 1][Filter 2][Filter 3]……[Filter n]

Where:

- (): Query Global Options are enclosed in parentheses at the beginning of query.
- (GK_1=V_1, GK_2=V_2): GK_1 and V_1 are a key-value pair. Multiple query global options can be separated by commas.

For example:

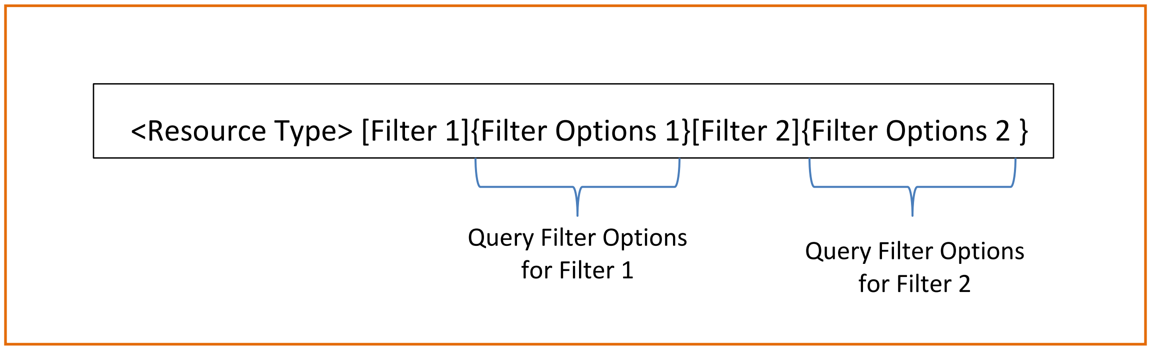
```
(useStrictAggr=true)vm[@cpuUsage rx b
.*]{intervalRollupOp=AVG,outputIntervalInSec=300}
```

Following are the supported Query Global Options:

Query Global Option	Description	Applicable for
useStrictAggr	This Boolean option is used to restrict partial data processing for generating output during interval rollup. The valid values are true and false.	Interval rollup
useRealTime	Helps define whether real-time data should be included in query processing when running a query from the Custom Reports feature in the server. The valid values are true and false. If this option is not specified in the query, real-time data will be included in query processing by default.	All queries **Exception**: If a query includes multiple filters and one of those filters is the interval rollup filter, the real time will not be included in query processing.

5.1.2Query filter options

Query filter options are the settings that influence the behavior of a single filter with which it is associated and must follow the associated filter. The syntax of the Query Filter Options is given below:


<Resource Type> [Filter 1]{Filter Options 1}[Filter 2]{Filter Options 2 }

Where:

- [ ]: Query filter is enclosed in square brackets.
- { }: Query Filter Options are enclosed in curly braces. Each query filter can have Query Filter Options.

For example:
`vm[@cpuUsage rx b .*]`**`{intervalRollUpOp=AVG,outputIntervalInSecs=300}`**

Following are the supported Query Filter Options:

Query Filter Options	Description	Applicable for
inputIntervalInSec	Optional parameter to specify which interval data will be used in calculation. It is useful in cases where data with multiple intervals is present in the Analyzer detail view database for the same time duration.	Interval Rollup/ Derived Attribute/ Resource Rollup
outputIntervalInSec	Parameter to specify the data interval for expected output.	Interval Rollup/ Derived Attribute/ Resource Rollup
intervalRollupOp	Operation to be used while performing interval rollup. Valid values are - SUM|AVG|MIN|MAX	Interval Rollup
inputCounters	List of counter(s) that will be used in creation of output. Additionally, operation can also be specified in case of derived attributes. Valid values for derived attribute operations are - SUM|AVG|DIFF	Derived Attribute / Resource Rollup
resourceRollupOp	Operation to be used while performing resource rollup. Valid values are SUM|AVG|weightedAvg	Resource Rollup
outputUnit	Parameter to specify unit for newly created custom attribute.	Derived Attribute / Resource Rollup
preProc	Function to be performed before computing the filter.	PreProc

5.2 Interval Rollup

Interval Rollup is a technique to merge or aggregate data from a lower interval to a higher interval. Interval roll up is useful when the user is interested in low granularity of data interval.

For example, the user has second-level timeseries data, but while analyzing data for a longer duration, the user might be interested in minute-level granularity. This can be achieved using interval rollup.

This function is applicable only for timeseries data.

Note: Input data interval must be less than or equal to 30 minutes for interval rollup operation.

5.2.1Syntax

$$\text{<Resource Type> [Filter 1]}\underbrace{\text{\{inputCounters=W,intervalRollUpOp=X,outputIntervalInSec=Y,inputIntervalInSec=Z\}}}_{\text{Query Filter Options for Interval Rollup operation}}$$

The following table describes query filter options for interval rollup:

Query Filter Options	Description	Valid Values
intervalRollupOp	Operation to be used for aggregation	SUM/AVG/MIN/MAX
outputIntervalInSec	Interval, in seconds, at which data needs to be rolled up	0 < X <= 60 Where 60 is divisible by X
		60 < X < =3600 Where X is divisible by 60 & 3600 is divisible by X
		3600 < X <= 86400 Where X is divisible by 3600 & 86400 is divisble by X
		X > 86400

		Where X is divisible by 86400
inputIntervalInSec	This is optional. If multiple interval data exists, then this parameter can be used to specify the interval that should be used as input for the rollup operation. By default, data from all intervals will be flattened out and the result will be used as input for rollup.	
inputCounters	Attribute ID used for interval rollup operation. This is optional. By default, the counter specified in the associated timeseries filter will be used for interval rollup.	*W* should be an existing predefine attribute.

5.2.2 Supported operations

The following table describes supported operations for interval Rollup:

Operation	Description
SUM	Addition of all non-data hole values will be reported as aggregated value.
AVG	Arithmetic mean of all non-data hole values will be reported as aggregated value. Data hole values will be ignored during calculation; only non-data holes will be added to get the numerator, and the denominator will also have a count of only non-data hole values.
MIN	Minimum of all non-data hole values will be reported as aggregated value.
MAX	Maximum of all non-data hole values will be reported as aggregated value.

5.2.3 Use case 1

The Analyzer detail view database has minute-level timeseries data for the cpuUsage attribute, but the user wants to analyze the same data on 5-minute or 10-minute level granularity.

By default, partial aggregation of data is allowed. The following table illustrates interval rollup behavior for the above-mentioned queries.

Query Start Time: 2:03:00									
Query		`vm[@cpuUsage rx b .*]{intervalRollUpOp=AVG, outputIntervalInSecs=300}`				`vm[@cpuUsage rx b .*]{intervalRollUpOp=AVG, outputIntervalInSecs=600}`			
Time	**Data with interval 60 sec**	**outputIntervalInSec = 300**				**outputIntervalInSec = 600**			
		SUM	**AVG**	**MIN**	**MAX**	**SUM**	**AVG**	**MIN**	**MAX**
2:00:00									
2:01:00									
2:02:00									
2:03:00	56.50								
2:04:00	41.89								
2:05:00	95.07	375.43	75.09	40.65	99.75				
2:06:00	99.75								
2:07:00	40.65								
2:08:00	47.56								
2:09:00	92.40								
2:10:00	18.15	84.72	16.94	0.14	54.93	456.19	45.62	0.14	97.48
2:11:00	0.14								
2:12:00	54.93								
2:13:00	3.84								
2:14:00	7.66								
2:15:00	97.48	371.47	74.29	63.98	97.48				
2:16:00	71.53								
2:17:00	72.77								
2:18:00	65.72								
2:19:00	63.98								
2:20:00	74.46	263.48	65.87	54.56	74.83	263.48	65.87	54.56	74.83
2:21:00	74.83								
2:22:00	59.63								
2:23:00	54.56								

Aggregated data will be reported at the aligned time intervals; for example, in the 10-minute interval it is aligned to 2:10

All the supported operations for interval rollup have been displayed in the above table for 5-minute and 10-minute rollup. Output data points are aligned to the nearest multiple of the output interval.

Data point at 2:00:00 is not computed using available partial data as the query start time is 2:03:00, which is after 2:00:00. Even though partial aggregation is allowed, moving back from the query time window is not implicit.

This point would have been calculated if the query start time was either at or before 2:00:00. This behavior is illustrated in the next table.

Query Start Time: 2:00:00									
Query		`vm[@cpuUsage rx b .*]{intervalRollUpOp=AVG, outputIntervalInSecs=300}`				`vm[@cpuUsage rx b .*]{intervalRollUpOp=AVG, outputIntervalInSecs=600}`			
Time	Data with interval 60 sec	outputIntervalInSec = 300				outputIntervalInSec = 600			
		SUM	AVG	MIN	MAX	SUM	AVG	MIN	MAX
2:00:00		98.39	49.20	41.89	56.50	473.82	67.69	40.65	99.75
2:01:00									
2:02:00									
2:03:00	56.50								
2:04:00	41.89								
2:05:00	95.07	375.43	75.09	40.65	99.75				
2:06:00	99.75								
2:07:00	40.65								
2:08:00	47.56								
2:09:00	92.40								
2:10:00	18.15	84.72	16.94	0.14	54.93	456.19	45.62	0.14	97.48
2:11:00	0.14								
2:12:00	54.93								
2:13:00	3.84								
2:14:00	7.66								
2:15:00	97.48	371.47	74.29	63.98	97.48				
2:16:00	71.53								
2:17:00	72.77								
2:18:00	65.72								
2:19:00	63.98								
2:20:00	74.46	263.48	65.87	54.56	74.83	263.48	65.87	54.56	74.83
2:21:00	74.83								
2:22:00	59.63								
2:23:00	54.56								

Since, query start time is at 2:00:00, the first data point for both aggregated intervals is computed using partial data.

The user can also force this initial aggregation by setting "***query.allow.move.back.in.timewindow.for.aggr***" to true in the query.properties file under /usr/local/megha/conf/sys/. This will enforce partial aggregation even if aligned start time is before query start time. The following table illustrates this behavior.

Query Start Time: 2:03:00 **query.allow.move.back.in.timewindow.for.aggr: true**									
Query		`vm[@cpuUsage rx b .*]{intervalRollUpOp=AVG, outputIntervalInSecs=300}`				`vm[@cpuUsage rx b .*]{intervalRollUpOp=AVG, outputIntervalInSecs=600}`			
Time	**Data with interval 60 sec**	**Output Interval In Seconds = 300**				**outputIntervalInSec = 600**			
		SUM	**AVG**	**MIN**	**MAX**	**SUM**	**AVG**	**MIN**	**MAX**
2:00:00		98.39	49.20	41.89	56.50	473.82	67.69	40.65	99.75
2:01:00									
2:02:00									
2:03:00	56.50								
2:04:00	41.89								
2:05:00	95.07	375.43	75.09	40.65	99.75				
2:06:00	99.75								
2:07:00	40.65								
2:08:00	47.56								
2:09:00	92.40								
2:10:00	18.15	84.72	16.94	0.14	54.93	456.19	45.62	0.14	97.48
2:11:00	0.14								
2:12:00	54.93								
2:13:00	3.84								
2:14:00	7.66								
2:15:00	97.48	371.47	74.29	63.98	97.48				
2:16:00	71.53								
2:17:00	72.77								
2:18:00	65.72								
2:19:00	63.98								
2:20:00	74.46	263.48	65.87	54.56	74.83	263.48	65.87	54.56	74.83
2:21:00	74.83								
2:22:00	59.63								
2:23:00	54.56								

Partial aggregation is a default behavior. However, this can be overridden by using Query Global Option. User may pass useStrictAggr=true option to restrict partial aggregation of data.

For example:

```
(useStrictAggr=true)vm[@cpuUsage rx b
.*]{intervalRollupOp=AVG,outputIntervalInSec=300}
```

Following table displays the behavior when useStrictAggr is set to true in Query Global Option.

Query Start Time: 2:00:00 **useStrictAggr: true**									
Query		`vm[@cpuUsage rx b .*]{intervalRollUpOp=AVG, outputIntervalInSecs=300}`				`vm[@cpuUsage rx b .*]{intervalRollUpOp=AVG, outputIntervalInSecs=600}`			
	Data with interval 60 sec	**outputIntervalInSec= 300**				**outputIntervalInSec= 600**			
Time		**SUM**	**AVG**	**MIN**	**MAX**	**SUM**	**AVG**	**MIN**	**MAX**
2:00:00									
2:01:00									
2:02:00									
2:03:00	56.50								
2:04:00	41.89								
2:05:00	95.07	375.43	75.09	40.65	99.75				
2:06:00	99.75								
2:07:00	40.65								
2:08:00	47.56								
2:09:00	92.40								
2:10:00	18.15	84.72	16.94	0.14	54.93	456.19	45.62	0.14	97.48
2:11:00	0.14								
2:12:00	54.93								
2:13:00	3.84								
2:14:00	7.66								
2:15:00	97.48	371.47	74.29	63.98	97.48				
2:16:00	71.53								
2:17:00	72.77								
2:18:00	65.72								
2:19:00	63.98								
2:20:00	74.46		This interval is not considered in calculations because useStrictAggr is set to true						
2:21:00	74.83								
2:22:00	59.63								
2:23:00	54.56								

Note: If data of the multiple intervals is present in the Analyzer detail view database for a resource within the same time, then for interval rollup each interval's data will be used if inputIntervalInSec query filter option is not specified. Each interval data will be picked one by one; if there is any data hole after aggregation from data belonging to an interval, only then it will be filled by aggregated data using other intervals.

For example, the Analyzer detail view database have data for 1-minute and 5-minute intervals for the same duration, and the user has requested 10-minute aggregation using AVG operation - in this case all of these interval data will be used in aggregation.

1-minute data	5-minute data	Output after aggregation from 1-minute data	Final output
	97.07		79.22
	61.36		
99.34	65.53	53.74	53.74
81.97			
91.27			
22.55			
32.54			
25.45	41.94		
15.48			
79.31			
34.22			
55.27			

First, 1-minute data is aggregated to get data at 10-minute interval data. Since there was no 1-minute data to be aggregated for the first 10 minutes, 5-minute interval data was used for aggregation in that period.

However, the sequence of intervals is not fixed. It depends on the order of intervals in stored data.

5.2.4 Use case 2

The Analyzer detail view database has minute-level timeseries data for *cpuUsage* attribute, but the user wants to analyze the same data on 5-minute or 10-minute level granularity by using a multiple interval rollup operation such as min, max, and avg.

The user can use multiple filter options for *cpuUsage* having different interval rollup operations. But in that case, the user will not be able to identify which series are computed by using which given operation. We can use the filter options property *inputCounters* to overcome this problem.

For example:

```
vm[@cpuUsage_avg rx b .*]{inputCounters=cpuUsage,
intervalRollUpOp=AVG,outputIntervalInSecs=300}[@cpuUsage_min]{
inputCounters=cpuUsage, intervalRollUpOp=MIN,outputIntervalInSecs=300}
```

Here, cpuUsage is used for interval rollup, and cpuUsage_avg, and cpuUsage_min to show the computed series.

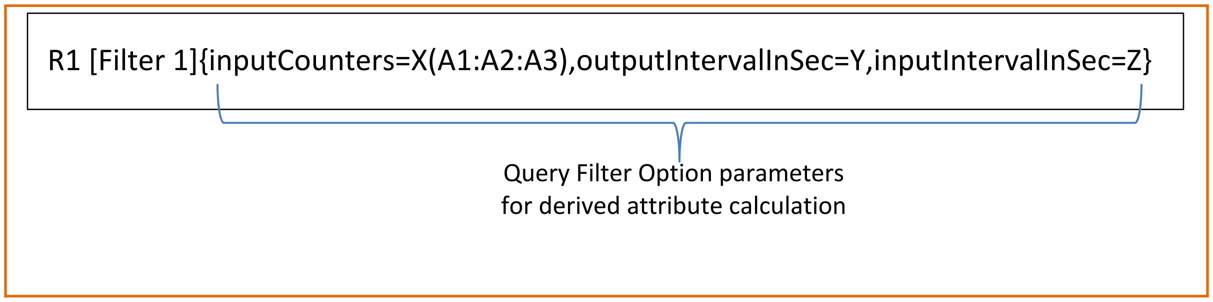
5.3 Derived attributes

New attributes can be computed on the fly from existing stored attributes within MQL.

MQL supports SUM, AVG, DIFF, MULT, DIV, and weightedAVG operations for the computation of derived attributes. These operations can be performed between timeseries attributes or scalar attributes. MULT and DIV operations can also be performed between:

- Timeseries attribute and constant numerical value
- Timeseries attribute and scalar attribute
- Scalar attribute and constant numerical value

5.3.1 Syntax



```
R1 [Filter 1]{inputCounters=X(A1:A2:A3),outputIntervalInSec=Y,inputIntervalInSec=Z}
```

Query Filter Option parameters
for derived attribute calculation

The following table describes query filter options for derived attributes:

Query Filter Options	Description	Valid Values	Remarks
inputCounters	Operation and list of attributes to be used for deriving new attribute	X can be SUM, AVG, DIFF, weightedAVG, MULT, DIV A1, A2, A3 are attributes for Resource R1.	For DIFF, MULT, and DIV operations, only two attributes are permitted.

		For the MULT and DIV operations, A2 can be a numeric constant value. MULT or DIV supports operations between timeseries and scalar attributes. If there is operation between timeseries and scalar attributes, A1 should be timeseries attribute and A2 should be scalar.	
outputIntervalInSec	This is optional. Interval, in seconds, at which output data is expected. If it is not specified, separate series for each available data interval or specified inputInterval will be computed and returned.	Same as interval rollup	Only applicable for timeseries attributes
inputIntervalInSec	As explained above in interval rollup		Applicable only for timeseries attributes

5.3.2 Supported operations

The following table describes supported operations for derived attributes:

Operation	Description
SUM	Addition of non-data hole value for all inputCounter's attributes of a resource will be reported as a derived value.
AVG	Arithmetic mean of non-data hole value for all inputCounter's attributes of a resource will be reported as a derived value.
DIFF	DIFF operation supports two input counters. Subtraction of the second attribute's value from the first attribute value will be reported as a derived value.
weightedAvg	See use case 2
MULT	The MULT operation supports two input counters. Multiplication of a non-data hole value for all inputCounter attributes of a resource are reported as a derived value.
DIV	The DIV operation supports two input counters. Division of a non-data hole value for all inputCounter attributes of a resource are reported as a derived value.

The above-mentioned operations can be performed on both time series and scalar attributes having numeric values. For example, Time series: IOPS, throughput, and so on. Scalar: Total capacity, Free capacity, and so on.

These operations on scalar attributes are supported only through Query API (REST API). Refer to, *Hitachi Ops Center Analyzer detail view REST API Reference Guide* for more information.

The Analyzer detail view's Report Builder feature does not support these operations on the scalar attributes.

5.3.3 Use case

Use case 1

The Analyzer detail view database has `capacityGB` and `freeSpaceGB` attributes for each host, but the user wants to see the difference between these two as `usedcapacity`, which is not stored directly in the Analyzer detail view database.

```
ds[=usedcapacity rx .*]{inputCounters=DIFF(capacityGB:
freeSpaceGB)}
```

The above query retrieves the scalar attributes `capacityGB` and `freeSpaceGB` for each host and reports the difference as `usedcapacity` on each.

For scalar attributes, allowed operations for derived attributes are explained in following table:

Resource	Scalar attribute 1	Scalar attribute 2	Operations				
			SUM	AVG	DIFF	MULT	DIV
R1	12.03	6.7	18.73	9.37	5.33	80.601	1.795522
R2	10.1	8.2	18.3	9.15	1.9	82.82	1.231707

For the DIFF operation, scalar attribute 2 is subtracted from scalar attribute 1. For instance, in the above query, `freeSpaceGB` will be subtracted from `capacityGB`.

For the DIV operation, scalar attribute 1 is divided by scalar attribute 2.

Use case 2

Weighted average of attributes may be required where the general mean of data values is not sufficient, for example, while calculating a derived attribute from LDEV's attributes IOPS and responseTime. It would be meaningful to weight the response time on the basis of IOPS of LDEV at that time instead of taking the general average.

Weighted average:

The weighted arithmetic mean is similar to an ordinary arithmetic mean (the most common type of average), except that instead of each data point contributing equally to the final average, some data points contribute more than others.

$$\mathrm{Avg_w} = \frac{\sum_{i=1}^{n} I_n R_n}{\sum_{i=1}^{n} I_n}$$

Where,
n = repesents the number of data samples
I = represents the weighted attribute
R = represents the other attribute
Conditions for the derived weighted average operation:

Derived weighted average operation works for only two attributes of the same resource.

For example:

```
raidLdev[@weightedResponseTime rx b .*]{ inputCounters=weighted
AVG(IOPS:responseTime),inputIntervalInSec=60}
```

The above query computes the derived attribute "`weightedResponseTime`" by applying the weighted average operation on the IOPS and responseTime attributes.

The following two tables illustrate the weighted average operation on attribute I and R, where I is the weighted attribute:

The following table illustrates input data of attribute I and R for one resource:

Time	Res 1	
	I	R
2:00:00		
2:01:00	84.38	80.05
2:02:00	9.47	70.53
2:03:00	63.87	97.04
2:04:00	76.85	30.23

The following table shows intermediate results and weighted average:

Time	Res 1	∑I	Weighted Average
	IR		
2:00:00			
2:01:00	6754.70	84.38	80.05
2:02:00	665.741	9.47	70.53
2:03:00	6197.9448	63.87	97.04
2:04:00	2323.1755	76.85	30.23

Use case 2

The Analyzer detail view database has readIOPS and writeIOPS for each disk, but the requirement may be to analyze totalIOPS, which is not directly stored in the Analyzer detail view database.

```
disk[@totalIOPS rx b
.*]{inputCounters=SUM(readIOPS:writeIOPS),outputIntervalInSec=60}
```

The above query retrieves the timeseries data of attribute *readIOPS* and *writeIOPS* for each disk and reports the sum of these two as *totalIOPS* on each.

Similar to scalar derived attributes, timeseries attribute can also be derived using the available timeseries attribute on a resource. The following table displays different operations on two timeseries data for a resource to create a derived attribute. For SUM and AVG, more than two attributes can also be used.

Time	Counter 1 Data with interval 60 sec	Counter 2 Data with interval 60 sec	Operation				
			SUM	AVG	DIFF	MULT	DIV
2:00:00							
2:01:00							
2:02:00		95.07	95.07	95.07	-95.07		
2:03:00	56.50	99.75	156.25	78.13	-43.25	5635.88	0.57
2:04:00	41.89	40.65	82.54	41.27	1.24	1702.83	1.03

2:05:00	95.07	47.56	142.62	71.31	47.51	4521.53	2
2:06:00	99.75	92.40	192.15	96.08	7.36	9216.90	1.08
2:07:00	40.65	18.15	58.80	29.40	22.50	737.80	2.24
2:08:00	47.56	56.50	104.06	52.03	-8.94	2687.14	0.84
2:09:00	92.40	41.89	134.29	67.14	50.51	3870.64	2.21
2:10:00	18.15	95.07	113.22	56.61	-76.92	1725.52	0.19
2:11:00	0.14	99.75	99.89	49.94	-99.62	13.97	0
2:12:00	54.93	40.65	95.59	47.79	14.28	2232.90	1.35
2:13:00	3.84	47.56	51.40	25.70	-43.72	182.63	0.08
2:14:00	7.66	74.46	82.11	41.06	-66.80	570.36	0.1
2:15:00	97.48	74.83	172.31	86.15	22.65	7294.43	1.3
2:16:00	71.53	59.63	131.16	65.58	11.90	4265.33	1.2
2:17:00	72.77	54.56	127.34	63.67	18.21	3970.33	1.33
2:18:00	65.72	97.48	163.20	81.60	-31.76	6406.39	0.67
2:19:00	63.98	71.53	135.51	67.75	-7.55	4576.49	0.89
2:20:00	74.46	72.77	147.23	73.61	1.68	5418.45	1.02
2:21:00	74.83	65.72	140.55	70.27	9.11	4917.83	1.14
2:22:00	59.63	63.98	123.61	61.80	-4.34	3815.13	0.93
2:23:00	54.56	47.56	102.12	51.06	7.01	2594.87	1.15

DIFF and DIV operations on timeseries attributes work similarly to scalar attributes.

If outputIntervalInSecs is different from the data interval stored in the Analyzer detail view database and if no intervalRollupOp is specified, output will not be generated. If OutputIntervalInSecs is different from the data interval, the user must specify intervalRollupOp. This behavior is explained in following table:

Time	Counter 1 Data with interval 60 sec	Counter 2 Data with interval 60 sec	OutputIntervalInSec=300 (Interval Rollup Op Not Specified)			OutputIntervalInSec=300 Interval Rollup Op = SUM				
			SUM	AVG	DIFF	Counter 1 data rolled up	Counter 2 data rolled up	SUM	AVG	DIFF
2:00:00										
2:01:00										
2:02:00		95.07	-	-	-					
2:03:00	56.50	99.75	-	-	-					
2:04:00	41.89	40.65	-	-	-	-	-			
2:05:00	95.07	47.56	-	-	-					
2:06:00	99.75	92.40	-	-	-					
2:07:00	40.65	18.15	-	-	-					
2:08:00	47.56	56.50	-	-	-					
2:09:00	92.40	41.89	-	-	-	375.43	256.50	631.92	315.96	118.93
2:10:00	18.15	95.07	-	-	-					
2:11:00	0.14	99.75	-	-	-					
2:12:00	54.93	40.65	-	-	-					
2:13:00	3.84	47.56	-	-	-					
2:14:00	7.66	74.46	-	-	-	84.72	357.49	442.21	221.10	-272.76
2:15:00	97.48	74.83	-	-	-					
2:16:00	71.53	59.63	-	-	-					
2:17:00	72.77	54.56	-	-	-	371.47	358.03	729.51	364.75	13.44

2:18:00	65.72	97.48	-	-	-					
2:19:00	63.98	71.53	-	-	-					
2:20:00	74.46	72.77	-	-	-					
2:21:00	74.83	65.72	-	-	-					
2:22:00	59.63	63.98	-	-	-					
2:23:00	54.56	47.56	-	-	-	263.48	250.02	513.51	256.75	13.46

Use case 3

The Analyzer detail view database stores virtual volume capacity in GB (vvolCapacityInGB) for each logical device, but the user wants to analyze the total capacity in MB, which is not directly stored in the Analyzer detail view database.

```
raidLdev[@vvolCapacityInMB rx b
.*]{inputCounters=MULT(vvolCapacityInGB:
1000),outputIntervalInSec=60}
```

The above query retrieves the timeseries data of attribute *vvolCapacityInGB* for each logical device and reports the division *totalCapacityInGB* and 1000 as *totalCapacityInMB* on each of them.

The following table displays division and multiplication operations on timeseries data for a resource with numeric constant value to create a derived attribute.

Time	Counter 1 Data with interval 60 sec (Timeseries)	Operation	
		MULT by 1.5	DIV by 0.5
2:00:00			
2:01:00			
2:02:00			
2:03:00	56.50	84.75	113.00
2:04:00	41.89	62.84	83.78
2:05:00	95.07	142.61	190.14
2:06:00	99.75	149.63	199.50
2:07:00	40.65	60.98	81.30
2:08:00	47.56	71.34	95.12
2:09:00	92.40	138.60	184.80
2:10:00	18.15	27.23	36.30
2:11:00	0.14	0.21	0.28
2:12:00	54.93	82.40	109.86
2:13:00	3.84	5.76	7.68

2:14:00	7.66	11.49	15.32
2:15:00	97.48	146.22	194.96
2:16:00	71.53	107.30	143.06
2:17:00	72.77	109.16	145.54
2:18:00	65.72	98.58	131.44
2:19:00	63.98	95.97	127.96
2:20:00	74.46	111.69	148.92
2:21:00	74.83	112.25	149.66
2:22:00	59.63	89.45	119.26
2:23:00	54.56	81.84	109.12

Use case 4

The Analyzer detail view database stores speed in GB (*speedInGB)* for each port, but the user wants to see the port speed in MB*,* which is not stored directly in the Analyzer detail view database.

```
raidPort[=speedInMB rx .*]{inputCounters=MULT(speedInGB:1000)}
```

The above query retrieves scalar attributes' *speedInGB* for each port and reports the multiplication of *speedInGB and 1000* as *speedInMB* on each of them.

For scalar attribute, allowed operations for derived attributes with constant numeric value are explained in the following table:

Resource	**Scalar attribute 1**	**Operations with 1.5**	
		MULT	**DIV**
R1	12.03	18.045	8.02
R2	10.1	15.15	6.733333

Note: Attribute ID specified for derived attributes may or may not be present in the Analyzer detail view database schema. However, it is recommended to use a predefined attribute ID for this operation.

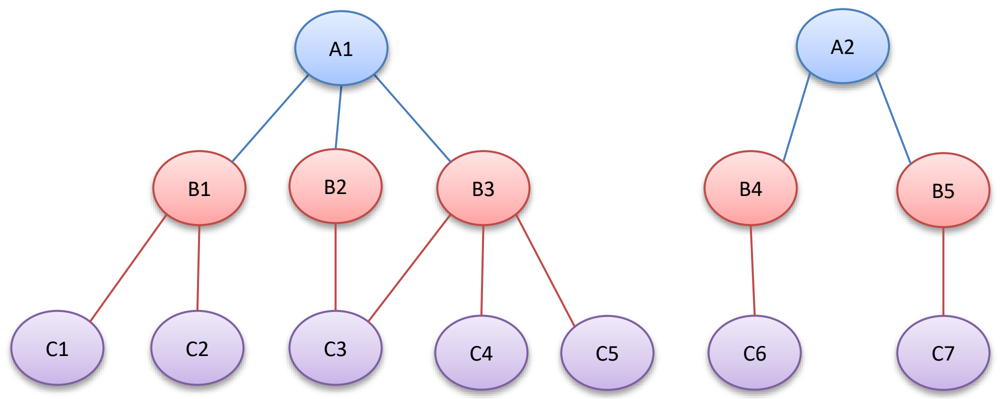
5.4 Resource Rollup

Analyzer detail view consolidates the attribute's value from all related resources at any level to the parent resource using specified attributes.

This can be useful in abstracting overwhelming details of individual resources by presenting data analysis on a higher level. Sometimes, the user needs to see the details at a higher level instead of its detailed view. For example, instead of looking into each LDEV counter, one might be interested to view it at the pool level. In this case, since the counter is actually present at the lower level, we should add up the values of all comprising resources to the upper level resource.

Example:

Let us consider a scenario where resources from type A, B, and C are related as shown in the following diagram.



Resource relation hierarchy between resources of type A,B, and C.

Using the Resource Rollup feature, the user can aggregate and view data from B1, B2, and B3 at A1 and B4, and B5 at A2 using query filter options. In addition, the user can also view data from C type resources at A1 and A2.

5.4.1 Syntax

```
A[=name rx  .*]&[@attribute rx b.+]
{inputCounters=B/C.attr,resourceRollupOp=avg}
```

B/C indicates a relation path from resource type A.

Query Syntax for Multilevel Resource Rollup

The above query will roll up the timeseries attribute `attr` from all related resources of type C reachable from resources of type A via resources of B.

To explain the above statement let us consider relation hierarchy from the above diagram.

`attr` timeseries counters of C1, C2, C3, C4, and C5 will be rolled up to the A1 resource by averaging out data from all resources (C1, C2, C3, C4, and C5) at each timestamp. Even though

A1 has no direct relation with any of these resources of type C, they were reachable through intermediate resource B1, B2, and B3 of resource type B, as shown in the above diagram.

This feature allows the user to roll up data from any (directly or indirectly) related resources if a viable path exists between them.

As you can see, Resource C3 is reachable through two different paths:

A1 -> B2 -> C3, and

A1 -> B3 -> C3.

Measures will be taken by query processing to ensure that data is not considered twice (or more in case of more reachable paths).

If any resource is reachable from more than one path for the same time window, data from that resource will be considered only **ONCE** *for that time window to ensure data correctness.*

The following table describes query filter options for resource rollup:

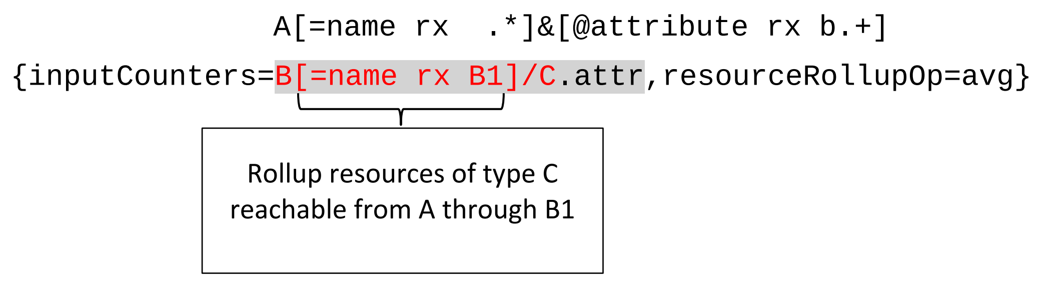
Query filter options	Description	Valid values	Remarks
resourceRollUpOp	Used for rolling up data from subresources	X can be SUM|AVG|MIN|MAX| weightedAvg	
inputCounters	List of attribute(s) and optional operations for rollup	B/C is a relation path from A. 'attr' is attribute of resource type C.	May be clubbed with Derived attribute if required – <Derived Operation>(B/C.attr1:attr2)
outputIntervalInSec	This is optional. Same as interval rollup. If it is not specified, separate series for each available data interval or specified inputInterval will be computed and returned.		Only applicable for timeseries attributes

Query filter options	Description	Valid values	Remarks
inputIntervalInSec	Same as interval rollup.		Only applicable for timeseries attributes

5.4.1.1 Resource filtering

There may be cases where the user does not want to view data being rolled up from every related subresource. One may want to apply certain filters to limit the resources which are used for resource rollup. To support this requirement, multilevel resource rollup allows Scalar and Relation filters to include only a subset of related resources in rollup computation.

Scalar Filtering



```
              A[=name rx  .*]&[@attribute rx b.+]
{inputCounters=B[=name rx B1]/C.attr,resourceRollupOp=avg}
```

Query Syntax forMultilevel Resource Rollup with Scalar filtering

Scalar filters can be applied at any level in the relation path specified in the `inputCounters` parameter. This will restrict the reachable leaf-level resources from root.

For example, in the above scenario, due to scalar filtering at resource path B, the reachable C resources are only C1 and C2. Therefore, only timeseries data from these resources will be rolled up to A1. No data will be found at resource A2 as it is not related to resource B1.

Relation filtering

Under certain circumstances, the user may need to apply some filtering at the relationship level. For example:

'Rollup resources of type C to A which are reachable through B and also are related to resource type D'.

This need can be specified using Relation filtering.

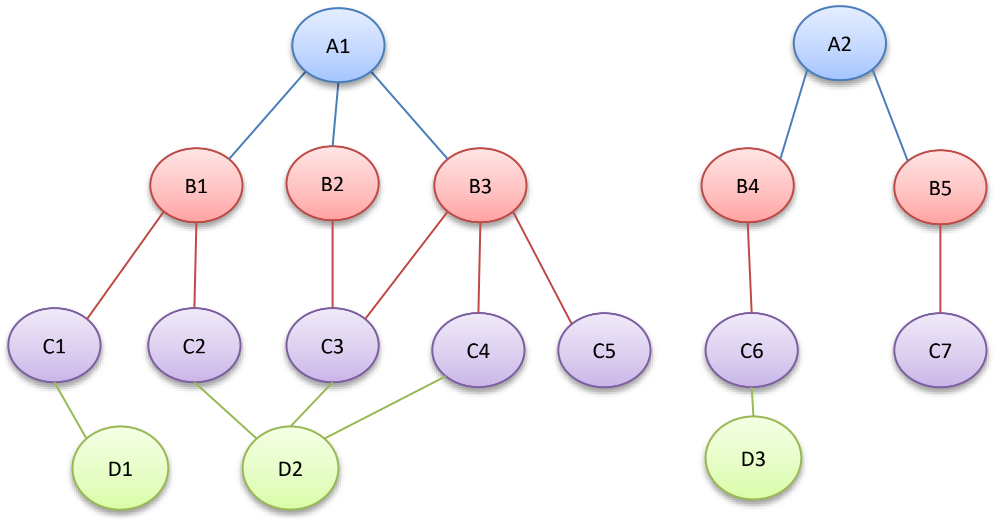
Relation filters are newly added and are currently supported only inside multilevel resource rollup. They cannot be used outside Query filter options like other filters such as scalar and timeseries.

```
              A[=name rx  .*]&[@attribute rx b.+]
{inputCounters=B/C[/D.name rx .*].attr,resourceRollupOp=avg}
```

Only consider those resources of type C which are related to Resource of type D

Query Syntax for Multilevel Resource Rollup with Relation filtering

The above query may limit C resources from participating in resource rollup if they are not related to any resource of type D.



Resource relation between resources of type A,B C, and D.

Let us consider the above relation hierarchy to understand relation filtering,

As only C1, C2, C3, and C4 are reachable from A1 and also have relation with resource D1 and D2 of type D, only the data from these resources will be used in resource rollup. C5 will be filtered out even though it is reachable from A1 through B3 as it does not have relation with any resource of type D. Similarly, at A2, data from only C6 will be rolled up.

Multiple relation filtering or scalar filtering can be applied at any level. Use ‘&’ for Logical AND of filters.

5.4.2 Supported operations

The following table describes supported operations for resource rollup:

Operation	Description
SUM	Addition of non-data hole values for each related subresource attribute.
AVG	Arithmetic mean of non-data hole values for each related subresource attribute.
MIN	Minimum of non-data hole values for each related subresource attribute.
MAX	Maximum of non-data hole values for each related subresource attribute.
weightedAvg	Explained later in use case 2.

The above operations can be performed on both timeseries and scalar attributes. Only scalar attributes having numerical values can be used.

5.4.3 Use case

Use case: 1

The Analyzer detail view database has a pool with three associated LDEVs, each having corresponding utilization values. This can be rolled up at the pool level by averaging all LDEV utilization.

```
raidPool[@totalUtilization rx b .*]{resourceRollupOp=avg,
inputCounters=raidLdev.utilization, inputIntervalInSec=60}
```

The above query rolls up LDEVs utilization to the pool level by averaging utilization.

The following table shows timeseries data of attribute 1 for three resources. These values can be rolled up to its parent resource using *resourceRollupOp*.

Time	Attribute 1			Parent resource	
	Resource 1	Resource 2	Resource 3	SUM	AVG
2:00:00					
2:01:00	56.50	99.75	18.15	174.40	58.13
2:02:00	41.89	40.65	56.50	139.04	46.35
2:03:00	95.07	47.56	41.89	184.52	61.51
2:04:00	99.75	92.40	95.07	287.22	95.74

inputCounters for resource rollup can also be derived from the subresource’s attributes.

For example:

```
raidPool[@totalIOPS rx b .*] {resourceRollupOp=avg,
inputCounters=SUM(raidLdev.readIOPS:writeIOPS),inputIntervalInSec=60}
```

In the above query, first *readIOPS* and *writeIOPS* will be added to get *totalIOPS* at each *raidLdev* level. Once *totalIOPS* is derived for each *raidLdev*, it will be rolled up to its parent pool using average operation.

The following table displays rollup of attributes derived from attribute1 and attribute2 present at the sublevel resource.

Time	**attribute (C1)**		**Attribute(C 2)**		**Derived attribute = SUM(R.C1:C2)**		**Parent resource**	
	Resource		**Resource**		**Resource**		**SUM**	**AVG**
	1	**2**	**1**	**2**	**1**	**2**		
2:00:00								
2:01:00	56.50	99.75	22.95	63.75	79.45	163.50	242.95	121.48
2:02:00	41.89	40.65	91.71	94.57	133.60	135.22	268.82	134.41
2:03:00	95.07	47.56	32.61	42.97	127.68	90.53	218.21	109.10
2:04:00	99.75	92.40	16.02	35.77	115.77	128.17	243.94	121.97

Use case 2:

Weighted average of attributes may be required where the general mean of data values is not sufficient, for example, while rolling up *responseTime* from LDEVs to pool. It would be meaningful to weight the response time on basis of IOPS of LDEV at that time instead of taking the general average.

Weighted average:

The weighted arithmetic mean is similar to an ordinary arithmetic mean (the most common type of average), except that instead of each of the data points contributing equally to the final average, some data points contribute more than others.

$$\text{Avg}_\text{w} = \frac{\sum_{i=1}^{n} I_n R_n}{\sum_{i=1}^{n} I_n}$$

Where:
n = number of data samples
I = represents the weighted attribute
R = represents the other attribute
Conditions for resource rollup weighted average operation:

- Weighted average rollup is a variant of resource rollup which requires two counters from a sublevel resource to contribute for each data point.

- Weighted rollup operation works for only two attributes.
- No need to specify derived operation in *inputCounters*.

For example:

```
raidPool[@weightedResponseTime rx b .*]{ resourceRollupOp=weightedAvg,
inputCounters=(raidLdev.IOPS:responseTime),inputIntervalInSec=60}
```

The above query rolls up LDEVs *responseTime* to pool level by cumulating each LDEV responseTime weighted by its IOPS.

The following two tables illustrate weighted average operation on attribute I and R where I is the weighted attribute.

The following table illustrates input data of attribute I and R for three resources.

Time	Res 1		Res 2		Res 3	
	I	R	I	R	I	R
2:00:00						
2:01:00	84.38	80.05	1.99	89.94	19.11	0.43
2:02:00	9.47	70.53	70.60	5.48	66.18	86.83
2:03:00	63.87	97.04	84.89	72.10	68.45	79.61
2:04:00	76.85	30.23	45.27	52.93	1.21	34.72

The following table shows intermediate results and weighted average.

Time	Res 1	Res 2	Res 3	∑IR	∑I	Weighted average
	IR	IR	IR			
2:00:00						
2:01:00	6754.70	179.19	8.31	6942.20	105.49	65.81
2:02:00	667.86	387.09	5745.73	6800.68	146.24	46.50
2:03:00	6197.30	6120.59	5449.69	17767.58	217.21	81.80
2:04:00	2322.89	2396.11	42.03	4761.03	123.32	38.61

Note:

- Resource rollup can be performed from any related resources.
- Analyzer detail view creates an attribute definition for rolled up attributes, if an attribute definition is not defined. However, it is recommended to use a predefined attribute ID for a rolled up attribute.
- In weightedAvg, attributes must be specified as *inputCounters* from the same subresource. In two attributes, the second attribute is weighed upon using the first attribute**.**

Use case: 3

The Analyzer detail view database has a pool with 10 associated LDEVs, each having corresponding utilization values and only some have a parity group. So, if we want to consider only those LDEVs in rolled up which have a parity group, then the rolled up query will be:

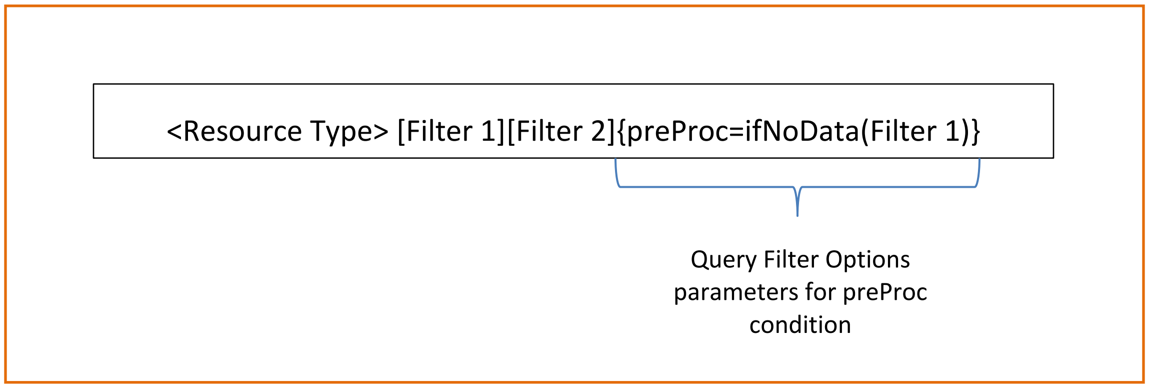
```
raidPool[@utilization rx b .+]{
resourceRollupOp=avg,inputCounters=raidLdev[=parityGroup rx
.+].utilization}
```

5.5 preProc

PreProcessing is a feature that allows performing a certain task before actually processing a filter. This allows making a decision such as whether or not to process the filter. It is useful for performing certain actions before evaluating filter output.

For example, there may be two attributes defined for a resource but either is required for analysis. In this case, output of one attribute filter is only computed if the other attribute value is not present in the Analyzer detail view database. To achieve this, the user can use the preProc condition as a query filter option.

5.5.1Syntax



```
<Resource Type> [Filter 1][Filter 2]{preProc=ifNoData(Filter 1)}
```

Where:

- **ifNoData**: Function that checks whether Filter1 result data is present or not. If Filter1 output data is present, then Filter 2 won't be processed.
- Presently only **ifNoData** method is supported for the preProc condition.

5.5.2Use case

Data for the *totalIOPS* attribute might or might not be present for an LDEV resource depending on the collection mechanism. If it is not present, then compute by adding readIOPS and writeIOPS.

```
raidLdev[@totalIOPS rx b .*] [@derivedTotalIOPS rx b
.*]{preProc=ifNoData(totalIOPS),inputCounters=SUM(readIOPS:writeIOPS),outpu
tIntervalInSec=60}
```

The above query will first compute *totalIOPS* for *raidLdev,* and it will calculate *derivedtotalIOPS* only if *totalIOPS* is not present in the Analyzer detail view database. *derivedtotalIOPS* will be derived by adding the *readIOPS* and *writeIOPS* attribute value.

6 Advanced features

6.1 Query Join

This feature allows MQL to relate disjoint resources by allowing the user to query resources, which do not have relation specified in the DB usually based on some scalar attribute.

Users may want to correlate few resources and view the entire or part of the infrastructure. However, data or resource to compose this view might come from different data subsets, and there might be cases where these resources from different data subsets do not have relation specified amongst them. In this case, these resources would be disjoint.

However, logically such resources can be related to each other in the real world but due to lack of relation specification in the Analyzer detail view DB, the query won't be able to fetch these resources. The Query Join feature overcomes this limitation by allowing the user to query resources, which do not have relation specified in the DB.

6.1.1Syntax

```
R1/^R2
```

Where R1 and R2 do not have direct relation in the Analyzer detail view DB.

In this query, all R2 resources will be returned as related resource for each R1 resource.

**This is not a general use-case.

```
R1[=!ref!scalarAttr1 rx <regex>]/^R2[=scalarAttr2 rx :ref]
```

Where ‘**R2’** is unrelated to ‘**R1**’.

R2 will be filtered for having same ***scalarAttr2*** as **R1**’s ***scalarAttr1*** attribute.

The following table describes query filter options applicable to Query Join:

Query filter options	Descriptions	Valid values
trType	Specifies the transformation type that the matching pattern would undergo before application	c2c/r2s where, c2c is character to character transformation r2s is regex to String transformation.
trFrom	In case of **trType c2c**, it represents a list of characters, which will be replaced by corresponding character in **trTo** parameter or null (if no corresponding character is found)	List of characters, if trType = c2c
	In case of **trType r2s**, it represents a regex pattern to be replaced by string in **trTo** for all occurances in input. It should be enclosed in double quotes (“”).	Regex Pattern, if trType = r2s
trTo	In case of **trType c2c**, it represents a list of characters with which corresponding character of **trFrom** will be replaced. It is an optional parameter. In this case, the characters in **trFrom** will be completely removed from input.	List of characters, if trType = c2c.
	In case of **trType** r2s, it represents a string, which relpaces all the occurances of text matching regex specified in **trFrom**. It should be enclosed in double quotes (“”).	Text string, if trType=r2s

In addition to basic filtering based on scalar attribute regex matching, some extra processing may be required. Here are few such syntaxes.

It is possible that values for scalar attributes at R1 and R2 have similar but not exactly same values. For example, the case (uppercase/lowercase letters) of these values can be different. In this scenario, we need to compare while ignoring case. This can be achieved with the following query syntax.

```
R1[=!ref!scalarAttr1 rx <regex>]/^R2[=scalarAttr2 rx (?i) :ref]
```

The value of scalarAttr2 for R2 will undergo transformation before being matched with the scalar attribute value from R1.

`trType=c2c` specifies that the scalarAttr2 value needs to go with character to character transformation. This can be achieved with the following query syntax.

```
R1[=!ref!scalarAttr1 rx <regex>]/^R2[=scalarAttr2 rx :ref] {
trType=c2c,trFrom=":",trTo="."}
```

`trFrom` can take a list of characters and replace each one of them with the corresponding index character from **`trTo`** before matching. In above example **`':'`** will be replaced by **`'.'`** before matching scalarAttr2 value with scalarAttr1.

If no corresponding character is found for replacement in the target then the character is replaced by null.

```
R1[=!ref!scalarAttr1 rx <regex>]/^R2[=scalarAttr2 rx :ref] {
trType=r2s,trFrom="netApp_",trTo="x"}
```

Another value for **`trType`** is **`r2s,`** in which case a regex is specified in **`trFrom`** and that is replaced by the string mentioned in **`trTo`** before matching.

6.1.2 Use case

The Analyzer detail view database may have switch and storage data, which are not related explicitly in the DB. However, they may be related in the real world. Therefore, to find this relation, you can use scalar attribute values from resources of these two data subsets.

Let's say the WWN value from RaidPort from storage and fabCiscoEndPort of switch are the same.

- Then the user may exploit the commonality of this value to deduce a relationship between switch and storage data as shown in following query:

  ```
  fabCiscoEndPort[=!ref!wwn rx .*]/^raidPort[=wwn rx :ref]
  ```

  This query will return all raidPorts having the same WWN value as of end port as its related resource.

- It might also be possible that values of scalar attribute are not exactly the same. However similar, in such case, the user may use filter options to modify values to match before they are matched.

  For example:

  ```
  fabCiscoEndPort[=!ref!wwn rx .*]/^raidPort[=wwn rx
  :ref]{trType=c2c,trFrom=".",trTo=":"}
  ```

The above query will match the raidPort WWN value with the endPort WWN value after substituting . (dot) with : (colon) in the endPort WWN value.

- The user may also use regex replacement if required, as displayed in following example:

```
fabCiscoEndPort[=!ref!wwn rx .*]/^raidPort[=wwn rx
:ref]{trType=r2s,trFrom=”\s”,trTo=”:”}
```

This query will replace all white space with colon from the end port WWN value before matching it with the RAID port’s WWN value.

6.2 Synthetic attribute

Synthetic attributes are computed/synthesized on the server by aggregating data from other attributes present in the server DB.

Synthetic Attributes do not have their corresponding data stored directly in the server DB. Their value is computed by applying aggregations on data present for other metrics in the server DB.

Synthetic Attribute definitions are defined in AttributeDef.xml. When queried for such metric, MQL will expand internally using the definition specified in XML to aggregate, and produce the expected result.

6.2.1 Syntax

6.2.1.1 Definition

One can define Synthetic Attribute in AttributeDef.xml as in the following example:

```
<AttributeDef id="<newAttrId>" name="<Display Name>” type="timeseries" unit="<unit>”
synthetic="true” outInterval=”<outputInterval>” inputInterval=”<input Interval>”
intervalRollupOp=<op> resourceRollupOp="<op>" derivedAttrOp=”<op>”  counterList="<input
counter list>" resPath="<relation path>"/>
```

Where,

XML Attribute	Description
id	Unique identifier for the attribute
name	Display name for the attribute
type	Attribute type, valid values are scalar and timeseries. However, currently synthetic attributes are supported only for the timeseries attribute.
unit	Unit for the attribute
synthetic	This XML attribute should be true to specify that this definition is for synthetic attributes

XML Attribute	Description
outInterval	Parameter to specify the Output timeseries interval, in seconds; it should be used for interval rollup
inputInterval	Optional parameter to specify if any particular interval data layer should be used for aggregations
intervalRollupOp	Parameter to specify which operation should be used for interval rollup , valid values are SUM/AVG/MIN/MAX
resourceRollupOp	Parameter to specify which operation should be used for resource rollup; valid values are SUM/AVG/MIN/MAX/weightedAvg
derivedAttrOp	Parameter to specify which operation should be used for derived attribute; valid values are SUM/AVG/DIFF/weightedAvg
counterList	Comma-separated list of counters that are collected directly by probe on which operations need to be performed to get the desired output
resPath	Optional parameter to specify the relational path (with filters, if required) to the resource at which counters specified in counterList are available.

6.2.1.2 Usage

The user can use the Synthetic Attribute as any other static attribute definition in a query. For example:

```
R1[@<synAttrId> rx b .*]
```

The above query when executed will look up the synAttrId definition and will then internally expand to evaluate the metric value based on configurations specified in its definition.

6.2.2 Use case

Synthetic Attribute for interval rollup

```
AttributeDef id="cpuUsage_rolledUp" name="CPU Usage – 1 hr"
type="timeseries" unit="Percent" synthetic="true" outInterval="3600"
inputInterval="60" intervalRollupOp="AVG" counterList="cpuUsage”/>
```

Synthetic Attribute for derived attribute

```
AttributeDef id="writeIOPS" name="Write IOPS" type="timeseries" unit="KBps"
synthetic="true" derivedAttrOp="DIFF" counterList="totalIOPS,readIOPS"/>
```

Synthetic Attribute for resource rollup

```
AttributeDef id="totalIOPS" name="Total IOPS" type="timeseries" unit="KBps"
synthetic="true" resourceRollupOp="SUM" counterList="totalIOPS"
resPath="raidLdev"/>
```

Synthetic Attribute for interval rollup + derived attribute + resource rollup

```
AttributeDef id="totalIOPS" name="Total IOPS" type="timeseries" unit="KBps"
synthetic="true" derivedAttrOp="SUM" outInterval="3600"
intervalRollupOp="SUM" resourceRollupOp="SUM"
counterList="writeIOPS,readIOPS" resPath="raidLdev"/>
```