WFCatalog Web Service Specification

Version 0.22
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Purpose

To specify a web service interface for the exchange of waveform metadata[1], including QC. The specification defines service name, query parameters and expected results. Also, it contains the supported data quality metrics and their descriptions.

Service Characteristics

Versioning

The service is versioned according the following three digit (x.y.z) pattern:
SpecMajor.SpecMinor.Implementation

where the fields have the following meaning:

SpecMajor: The major specification version, all implementations sharing this SpecMajor value will be backwards compatible with all prior releases. Values are integers starting at 1.

SpecMinor: The minor specification version, incremented when optional parameters or behaviour is added to the previous specification but backwards compatibility is maintained with the previous major versions, i.e. all 1.# service versions will be compatible with version 1.0. Values are integers starting at 0.

Implementation: The implementation version, an integer identifier specific to the data centre implementation. Useful to track service updates for bug fixes, etc. but with no implication on conformance to the specification.

Together the *SpecMajor* and *SpecMinor* versions imply a minimum expected behaviour of a given service. This versioning scheme allows clients to expect specific behaviour based on the SpecMajor version, while allowing the extension of the service with optional parameters while maintaining backwards compatibility. Each version number is service specific, there is no

1 See appendix II

implication that SpecMajor version numbers across services are related.

Calling pattern

The service will be invoked using a subset of REST and HTTP methods. In particular HTTP GET and HTTP POST methods are supported.

Service path and port

The following base URI pattern is to be used at each data centre implementing the service:

<site>/<relativepath>/**wfcatalog**/<majorversion>/

where majorversion is an integer value specifying the major specification version supported by the service.
A site is the domain name of the data centre hosting the web service. For instance, the base URI for version 1 of the service running at ORFEUS would be: www.orfeus-eu.org/ws/wfcatalog/1

The service should be available on TCP/IP port 80

Service methods

The service must support the following methods:

query – to submit a data request
version – to request the full service version (*SpecMajor.SpecMinor.Implementation*)
application.wadl – to request a WADL for the interface

Minimum functionality

Implementations of this service interface should support all methods specified as required. Additionally, interfaces should conform to the calling patterns and expected results identified in this document to be considered conform with the specification. The service definition includes required and optional parameters; an implementation must support the required parameters to be considered conform. The optional parameters supported by any given implementation should be specified in the WADL returned by the service.

Service responses

No data selected

If a properly formatted request is submitted but would result in no data being returned, the service will return a HTTP status 204 (No Content).

Result set limitations

Limitations on the amount of information returned for any given request may be imposed independently for the service by each data centre.
If a client submits a request that would result in a data set beyond the service limit the service should return an **HTTP status 413** (Request Entity Too Large)

Error messages

All errors reported to the client, either HTTP 4xx or 5xx status codes, should include an error

message transmitted as MIME type text/plain using the following pattern:

```
---------------------------------------------------------------------------------------------------------------
Error <CODE>: <SIMPLE ERROR DESCRIPTION>
<MORE DETAILED ERROR DESCRIPTION>
Usage details are available from <SERVICE DOCUMENTATION URI>
Request:
<SUBMITTED URL>
Request Submitted:
<UTC DATE TIME>
Service version:
<3-LEVEL VERSION>
---------------------------------------------------------------------------------------------------------------
```

WADL

The WADL documents returned by the service should follow these guidelines:

- All public parameters supported by an interface shall be documented in the WADL
- Parameters supported by the interface shall be documented using the long version of the parameter name and not the abbreviated version.
- Parameters not included in the specification (data centre specific extensions) shall be documented with a type and a short description

HTTP Status codes

The following table includes a list of common status codes returned by the web service.

Code	Description
200	Successful request, results follow
204	Request was properly formatted and submitted but no data matches the selection
400	Bad request due to improper specification, unrecognised parameter, parameter value out of range, etc.
413	Request would result in too much data being returned or the request itself is too large. Returned error message should include the service limitations in the detailed description. Service limits should be documented in the WADL
500	Internal server error
503	Service temporarily unavailable, used in maintenance mode

Table 1

Request Parameters

Table 2 describes the request parameters for the service

Parameter	Type	Support	Description	Default
net[work]	string	Required	Select the network code. Supports lists	[Any]

			and wildcards[see next paragraph]	
sta[tion]	string	Required	Select the station code. Supports lists and wildcards[see next paragraph]	[Any]
loc[ation]	string	Required	Select the location identifier. Supports lists and wildcards [see next paragraph]	[Any]
cha[nnel]	string	Required	Select the channel code. Supports lists and wildcards[see next paragraph]	[Any]
start[time]	ISO 8601	Required	Limit to results starting on or after the specified start time[2]	[Any]
end[time]	ISO 8601	Required	Limit to results ending on or before the specified end time[3]	[Any]
format	string	Optional	Specifies the desired output format. Valid values: json	json
include	string	Required	Choose the level of detail of the results. See section “Results level of detail” E.g: `include=sample` or `include=all`	default[4]
gran[ularity]	string	Required	Define the level of granularity for metric computation. Eg: day, hour, month. Minimum supported granularity is day.	day
minimumlength / minlen	float	Optional	Limit results to continuous data segments of a minimum length specified in seconds, and include information about these segments	[Any]
longestonly	boolean	Optional	Limit results to the longest continuous segment per channel, and include information about this segment	FALSE
csegments	boolean	Optional	Include information about continuous segments	FALSE
[metric_filter]	Metric dependent	Required	Limit the results to streams that satisfy a filter on a specific metric value. [metric_filter] is a place-holder applicable to any[5] specific metric defined in Table3. Multiple occurrences separated by '&' can be specified. See section “Metrics parameters extensions” for a detailed explanation. E.g.: `sample_max=10` or `sample_max_lt=10&sample_max_gt=3` or `sample_max=10&sample_mean=-5`	[Any]

Table 2

2 Rounded down to the previous granule
3 Rounded up to the next granule
4 See Table 3
5 Except: data_quality_flags, activity_flags, io_and_clock_flags

Wildcards and list in constraint parameters

Some constraint parameters, indicated in the Table 2, support the use of wildcards. Two types of wildcards are defined:

* - Matches 0 to many characters
? - Matches any single character

Lists

Some constraints parameters, indicated in the Table 2, are allowed to hold multiple values comma separated. E.g.:`include=sample_stdev,sample_rms;` or `channel=BHZ,BHN,BHE`

Time parameter

The *`starttime`* parameter should be interpreted as selecting any data or information at times on or later than the value specified. Similarly, the *`endtime`* selects any data or information at times on or prior to the value specified. The selection shall include any data intersecting with the specified time range.

Waveform characteristics and metrics

The following entries, defined in Table 3, shall be available and supported by the service. For detailed metrics definitions see Appendix I.

Name	Description
Mseed header	
quality*	SEED quality indicator. E.g.: D, R, Q, M
sample_rate*	List containing unique sample rates
record_length*	List containing unique record lengths
encoding*	List containing unique encodings
num_records*	Number of records
Sample metrics	
num_samples*	Number of samples
sample_max	Maximum value of all the samples
sample_min	Minimum value of all the samples
sample_stdev	Standard deviation of all the samples
sample_rms	Root mean square value of all the samples
sample_mean	Average value of all the samples
sample_median	50^{th} percentile of all the samples
sample_lower_quartile	25^{th} percentile of all the samples

sample_upper_quartile	75th percentile of all the samples
num_gaps*	Total number of gaps
num_overlaps*	Total number of overlaps
max_gap*	Largest gap in seconds
max_overlap*	Largest overlap in seconds
sum_gaps*	Sum of all the gaps in seconds
sum_overlaps*	Sum of all the overlaps in seconds
percent_availability*	Percentage of available data
MSEED header metrics	
timing_quality_mean	Average of the timing quality percentage value
timing_quality_median	50th percentile of all timing quality percentage value
timing_quality_lower_quartile	25th percentile of all timing quality percentage value
timing_quality_upper_quartile	75th percentile of all timing quality percentage value
timing_quality_max	Maximum of all timing quality percentage value
timing_quality_min	Minimum of all timing quality percentage value
timing_correction	Percentage of data for which field 16 in the record header is non-zero
data_quality_flags	Data quality flags percentages. It works only with `include`. E.g.: `include=data_quality_flags` will return all the percentages for each data quality flag.
amplifier_saturation	Percentage of data for which the bit 0 in the Data Quality Flag byte is set to ‘1’
digitizer_clipping	Percentage of data for which the bit 1 in the Data Quality Flag byte is set to ‘1
spikes	Percentage of data for which the bit 2 in the Data Quality Flag byte is set to ‘1
glitches	Percentage of data for which the bit 3 in the Data Quality Flag byte is set to ‘1
missing_padded_data	Percentage of data for which the bit 4 in the Data Quality Flag byte is set to ‘1
telemetry_sync_error	Percentage of data for which the bit 5 in the Data Quality Flag byte is set to ‘1
digital_filter_charging	Percentage of data for which the bit 6 in the Data Quality Flag byte is set to ‘1
suspect_time_tag	Percentage of data for which the bit 7 in the

	Data Quality Flag byte is set to ‘1
activity_flags	Activity flags percentages. It works only with `include.` E.g.: `include=activity_flags` will return all the percentages for each activity flag.
calibration_signal	Percentage of data for which the bit 0 in the Activity Flag byte is set to ‘1
time_correction_applied	Percentage of data for which the bit 1 in the Activity Flag byte is set to ‘1
event_begin	Percentage of data for which the bit 2 in the Activity Flag byte is set to ‘1
event_end	Percentage of data for which the bit 3 in the Activity Flag byte is set to ‘1
positive_leap	Percentage of data for which the bit 4 in the Activity Flag byte is set to ‘1
negative_leap	Percentage of data for which the bit 5 in the Activity Flag byte is set to ‘1
event_in_progress	Percentage of data for which the bit 6 in the Activity Flag byte is set to ‘1
io_and_clock_flags	I/O and clock flags percentages. It works only with `include.` E.g.: `include=io_and_clock_flags` will return all the percentages for each I/O and Clock flag.
station_volume	Percentage of data for which the bit 0 in the I/O and Clock Flag byte is set to ‘1
long_record_read	Percentage of data for which the bit 1 in the I/O and Clock Flag byte is set to ‘1
short_record_read	Percentage of data for which the bit 2 in the I/O and Clock Flag byte is set to ‘1
start_time_series	Percentage of data for which the bit 3 in the I/O and Clock Flag byte is set to ‘1
end_time_series	Percentage of data for which the bit 4 in the I/O and Clock Flag byte is set to ‘1
clock_locked	Percentage of data for which the bit 5 in the I/O and Clock Flag byte is set to ‘1

Table 3

* These are returned by default

Results level of detail

The service provides a number of metrics and characteristics by default.
Additional features can be requested using the parameter `include`.

Level name	Description
default[6]	Includes all the default entries
sample	Includes default + all sample metrics
header	Includes default + all MSEED header metrics
all	Includes all metrics

Metrics parameters extensions

The query URL could contain `value=`*X* to retrieve only metrics with that value, or `value_gt=`*X* for metrics that exceed *X*.

The available extensions for parameter names are:

- `_eq` - Equal (the default if no extension is used).
- `_ne` - Not equal.
- `_gt` - Greater than.
- `_ge` - Greater than or equal.
- `_lt` - Less than.
- `_le` - Less than or equal.

This extension mechanism enables selection of parameters with values between an interval specified by the user. E.g.: `sample_max_ge=100&sample_max_le=500` would return all the samples with max value belonging to [100,500].

Behaviour of the service

The **version** method shall return the implementation version as simple text string using the MIME type `text/plain`.

The **application.wadl** method shall return a WADL conform description of the service using MIME type `application/xml`.

The **query** method shall return the results fulfilling a user query in the proper format according to the `format` parameter. The default MIME type is `application/json`.
The default format of the returned payload represents a *waveform metadata* object according to the JSON schema provided in Appendix II.
Queries can be submitted using either HTTP GET or POST methods.

For the HTTP GET method, the parameters are specified as `key=value` separated by "`&`" and may not be specified more than once.

For the HTTP POST method, the parameter must be submitted as part of a POST body. The

6 See Table 3

parameters *network*, *station*, *location*, *channel*, *starttime*, *endtime* may be repeated as many times as necessary, all other parameters should be specified as `key=value` pairs on separate lines following this pattern:

```
parameter1=value
parameter2=value
NET STA LOC CHA STARTTIME ENDTIME
NET STA LOC CHA STARTTIME ENDTIME
NET STA LOC CHA STARTTIME ENDTIME
```

All rules for parameters apply equally whether specified using GET or POST methods. However when using POST no blank spaces are allowed as value, use "--" instead.

Examples

```
QUERY = www.orfeus-eu.org/ws/wfcatalog/1/query?network=NL&station=HGN&cha=BHZ&start=2001-01-02&end=2001-01-03&csegments=true&include=all
```


```
[{
	"miniseed_header_percentages": {
		"data_quality_flags": {
			"suspect_time_tag": 0,
			"spikes": 0,
			"amplifier_saturation": 0,
			"glitches": 0,
			"telemetry_sync_error": 0,
			"missing_padded_data": 0,
			"digital_filter_charging": 0,
			"digitizer_clipping": 0
		},
		"activity_flags": {
			"event_in_progress": 0,
			"positive_leap": 0,
			"negative_leap": 0,
			"calibration_signal": 0,
			"event_begin": 0,
			"event_end": 0,
			"time_correction_applied": 0
		},
		"io_and_clock_flags": {
			"short_record_read": 0,
			"station_volume": 0,
			"long_record_read": 0,
			"end_time_series": 0,
			"start_time_series": 0,
			"clock_locked": 0
		},
		"timing_correction": 0,
		"timing_quality_mean": null,
		"timing_quality_median": null,
		"timing_quality_min": null,
		"timing_quality_max": null,
		"timing_quality_lower_quartile": null,
		"timing_quality_upper_quartile": null
```

```
},
"sample_rms": 755.5320646257303,
"sample_rate": [40],
"waveform_format": "miniSEED",
"sum_overlaps": 0,
"quality": "D",
"num_overlaps": 0,
"sum_gaps": 79862.40000009537,
"num_gaps": 2,
 "num_records": 224,
"max_overlap": null,
"sample_stdev": 746.0162835391818,
"location": "",
"channel": "BHZ",
"encoding": ["STEIM1"],
"station": "HGN",
"num_samples": 261504,
"sample_upper_quartile": 576,
"record_len": [4096],
"sample_median": 90,
"start_time": "2001-01-02T00:00:00.000Z",
"percent_availability": 7.566666666556287,
"sample_lower_quartile": -355,
"network": "NL",
"end_time": "2001-01-03T00:00:00.000Z",
"waveform_type": "seismic",
"max_gap": 52214.40000009537,
"sample_mean": 119.53411802496329,
"sample_max": 3454,
"sample_min": -3641,
"version": "1.0.0",
"producer": {
       "name": "Orfeus Data Center - KNMI/ODC",
       "agent": "ObsPy",
       "created": "2016-05-02T13:48:36.710Z"
},
"c_segments": [{
       "sample_rms": 511.4226264414561,
       "end_time": "2001-01-03T00:00:00.000Z",
       "sample_rate": 40,
       "num_samples": 70656,
       "sample_upper_quartile": 241,
       "start_time": "2001-01-02T23:30:33.600Z",
       "sample_median": -73,
       "segment_length": 1766.375,
       "sample_lower_quartile": -394,
       "sample_stdev": 505.67458796656433,
       "sample_mean": -76.46119225543478
}, {
       "sample_rms": 827.846074592661,
       "end_time": "2001-01-02T09:00:19.200Z",
       "sample_rate": 40,
       "num_samples": 190848,
       "sample_upper_quartile": 712,
       "start_time": "2001-01-02T07:40:48.000Z",
       "sample_median": 189,
       "segment_length": 4771.175,
       "sample_lower_quartile": -332,
```

```
                "sample_stdev": 805.2504836461063,
                "sample_mean": 192.0957620724346
        }]
}]
```


QUERY = www.orfeus-eu.org/ws/wfcatalog/1/query?network=NL&station=HGN&cha=BHZ&start=2001-01-02&end=2001-01-03&include=sample


```
[{
        "sample_rms": 755.5320646257303,
        "sample_rate": [40],
        "waveform_format": "miniSEED",
        "sum_overlaps": 0,
        "quality": "D",
        "num_overlaps": 0,
        "sum_gaps": 79862.40000009537,
        "num_gaps": 2,
        "num_records": 120,
        "max_overlap": null,
        "sample_stdev": 746.0162835391818,
        "location": "",
        "channel": "BHZ",
        "encoding": ["STEIM1"],
        "station": "HGN",
        "num_samples": 261504,
        "sample_upper_quartile": 576,
        "record_len": [4096],
        "sample_median": 90,
        "start_time": "2001-01-02T00:00:00.000Z",
        "percent_availability": 7.566666666556287,
        "sample_lower_quartile": -355,
        "network": "NL",
        "end_time": "2001-01-03T00:00:00.000Z",
        "max_gap": 52214.40000009537,
        "sample_mean": 119.53411802496329,
        "sample_max": 3454,
        "sample_min": -3641,
        "version": "1.0.0",
        "producer": {
                "name": "Orfeus Data Center - KNMI/ODC",
                "agent": "ObsPy",
                "created": "2016-05-02T13:50:24.966Z"
        }
}]
```


QUERY = www.orfeus-eu.org/ws/wfcatalog/1/query?network=NL&station=HGN&cha=BHZ&start=2001-01-02&end=2001-01-03&include=header


```
[{
        "miniseed_header_percentages": {
                "data_quality_flags": {
                        "suspect_time_tag": 0,
                        "spikes": 0,
                        "amplifier_saturation": 0,
                        "glitches": 0,
                        "telemetry_sync_error": 0,
```

```
                "missing_padded_data": 0,
                "digital_filter_charging": 0,
                "digitizer_clipping": 0
            },
            "activity_flags": {
                "event_in_progress": 0,
                "positive_leap": 0,
                "negative_leap": 0,
                "calibration_signal": 0,
                "event_begin": 0,
                "event_end": 0,
                "time_correction_applied": 0
            },
            "io_and_clock_flags": {
                "short_record_read": 0,
                "station_volume": 0,
                "long_record_read": 0,
                "end_time_series": 0,
                "start_time_series": 0,
                "clock_locked": 0
            },
            "timing_correction": 0,
            "timing_quality_mean": null,
            "timing_quality_median": null,
            "timing_quality_min": null,
            "timing_quality_max": null,
            "timing_quality_lower_quartile": null,
            "timing_quality_upper_quartile": null
        },
        "sample_rate": [40],
        "waveform_format": "miniSEED",
        "sum_overlaps": 0,
        "quality": "D",
        "num_overlaps": 0,
        "num_records": 120,
        "sum_gaps": 79862.40000009537,
        "num_gaps": 2,
        "max_overlap": null,
        "location": "",
        "channel": "BHZ",
        "encoding": ["STEIM1"],
        "station": "HGN",
        "num_samples": 261504,
        "record_len": [4096],
        "start_time": "2001-01-02T00:00:00.000Z",
        "percent_availability": 7.566666666556287,
        "network": "NL",
        "end_time": "2001-01-03T00:00:00.000Z",
        "max_gap": 52214.40000009537,
        "version": "1.0.0",
        "producer": {
            "name": "Orfeus Data Center - KNMI/ODC",
            "agent": "ObsPy",
            "created": "2016-05-02T13:51:58.662Z"
        }
}]
```

Appendix I: Quality metrics definition

The data quality metrics supported by this version of the WFCatalog API are compliant to the proposal for standardisation for FDSN v2.0 by Reinoud Sleeman. The proposal is included below.

Proposal for FDSN standardization of waveform quality metrics

v2.0 - 21 October 2016

Knowledge of quality of seismic waveform data and related metadata is essential for any scientific analysis and interpretation of the data. Automated processes to calculate data quality parameters are required (a) to handle huge amounts of data, (b) to enable data centers to automatically monitor changes or variations in data quality over different time scales and (c) to provide services to the research community to search for and harvest the best quality data based on these parameters.

Currently, parallel developments are on-going (e.g. IRIS DMC, ORFEUS EIDA) to calculate data quality parameters and use these in different services. This document proposes the standardization of a number of basic metrics of which most are common in both systems.

Quality parameters are calculated for a time windowed time series. In the following a time series is considered to belong to a data stream uniquely identified by a SEED network code, stations code, channel code, location code and data header/quality indicator (D|R|Q|M).

In this proposal two types of metrics are defined: those based on series of sample values and those based on the SEED data record headers.

Waveform data archived in SEED files typically do not start and/or end at pre-defined, fixed times, e.g. midnight or 00:00:00.0, and no standard exists within FDSN to do this. Therefore, calculating sample value metrics in a file that loosely fits a pre-defined, fixed time window does not yield appropriate results. The approach in this proposal therefore is to define the sample value metrics in a defined time window of length 24 hours (starting at 00:00:00.0) independent of the archive structure. This proposal first provides the definitions to relate the sample value metrics to the data, independent of the archive format. Similarly, data records do not start or end exactly on pre-defined, fixed times. In this proposal, header based metrics use the first record that (partially) fits the time window and ignores the last record that (partially) fits the time window (see definitions below).

Definitions

Data (dis)continuity, gap and overlap

A sample value at time t represents a continuous signal within time window [t, t+Δt), in which Δt is the sample interval between two adjacent samples as defined by the sample rate factor

and the sample rate multiplier in the data record (header, fields 10 and 11) that contains the sample at time t. When the actual sample rate in blockette 100 is available this value should be used instead.

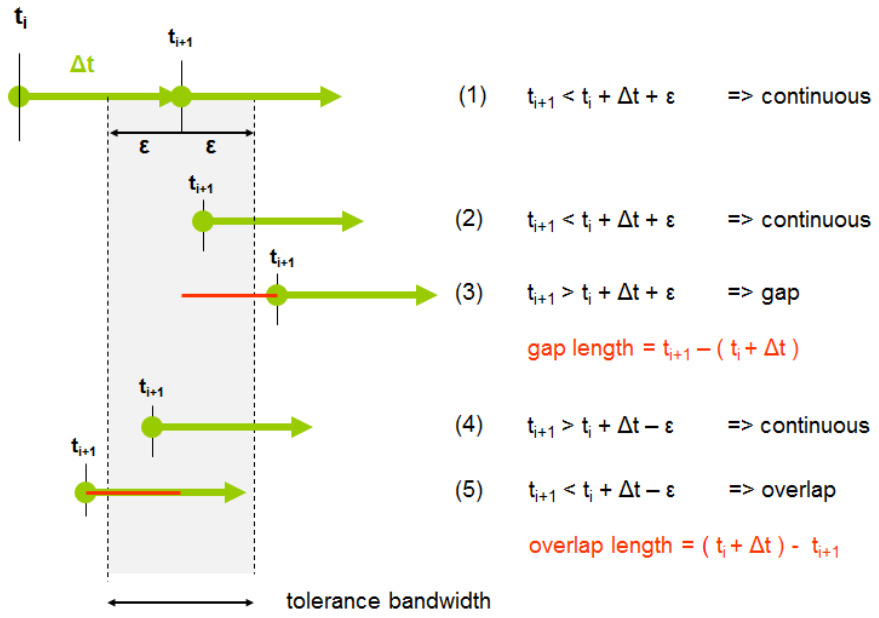
A continuous (discrete) time series is defined as a time series in which the time interval between two adjacent samples (a) is constant (Δt) or (b) does not differ from this constant by more than a certain time tolerance (ε). The tolerance value is defined here as 50% of the sampling rate.

Continuity condition between two samples: $\Delta t - \varepsilon <= t_{i+1} - t_i <= \Delta t + \varepsilon$.

A *discontinuity* thus occurs when (a) the time interval between two adjacent samples (with corresponding times t_i and t_{i+1}) exceeds the sample rate interval (Δt) by more than the (sampling rate dependent) time tolerance ε: $|t_{i+1} - (t_i + \Delta t)| > \varepsilon$ or (b) when the sampling rate between 2 samples changes with respect to the previous 2 samples by more than the tolerance value (50% of the sampling rate).

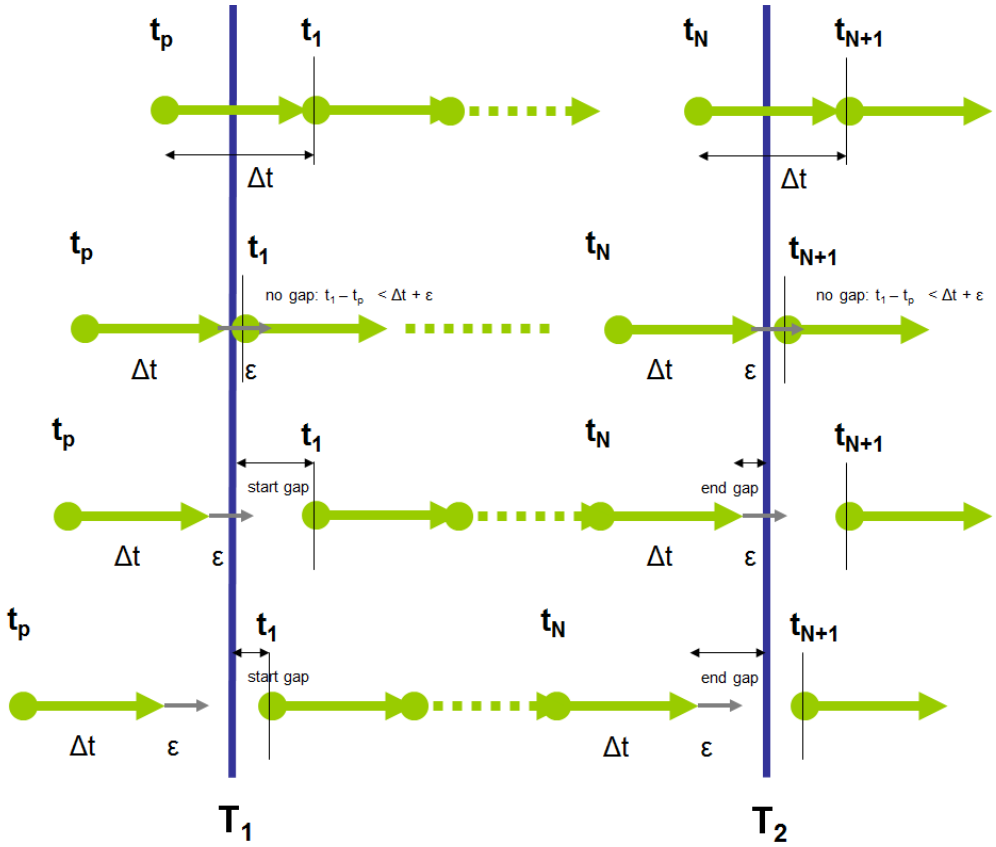
A *gap* is a positive valued discontinuity, an *overlap* is a negative valued discontinuity.

Gap condition:	$t_{i+1} - t_i > \Delta t + \varepsilon$	with gap length:	$t_{i+1} - t_i - \Delta t$
Overlap condition:	$t_{i+1} - t_i < \Delta t - \varepsilon$	with overlap length:	$t_i + \Delta t - t_{i+1}$



Within a time window [T_1, T_2) a time series may have a start time t_1 (defined by the first sample in [T_1, T_2)) later than T_1 or an end time t_N (defined by the last sample) before T_2. In cases that T_1 or T_2 intercept a gap in the continuous (discrete) time series a start gap or end gap is defined within [T_1, T_2). When the actual sample rate in blockette 100 is available in time window [T1, T2) the mode of these values in these blockettes should be used as sample rate Δt.

Start gap:	$t_1 - T_1$	when $t_1 - T_1 > 0$	and $t_1 - t_p > \Delta t + \varepsilon$
End gap:	$T_2 - (t_N + \Delta t)$	when $T_2 - t_N > \Delta t$	and $t_{N+1} - t_N > \Delta t + \varepsilon$



Record start time, record end time and record length

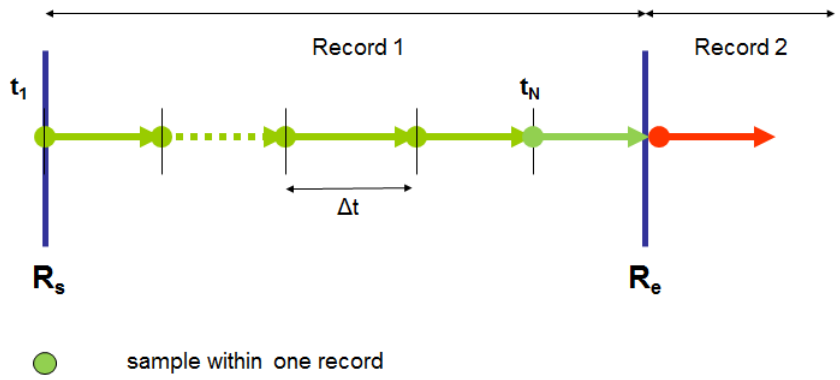
Data in SEED format is stored in records. Each SEED record contains a continuous time series. Gaps or overlaps in data may occur between records.

The **start time** $\mathbf{R_s}$ of a mini-SEED record is the time t_1 of the first sample in the record (including time correction if applicable).

The **end time** $\mathbf{R_e}$ of a record is defined by the end of the time interval represented by the last sample (N) in the record (including time correction if applicable): $t_N + \Delta t$

The time interval of a record containing N samples is thus defined as: $[\mathbf{R_s}, \mathbf{R_e}) = [t_1, t_N + \Delta t)$.

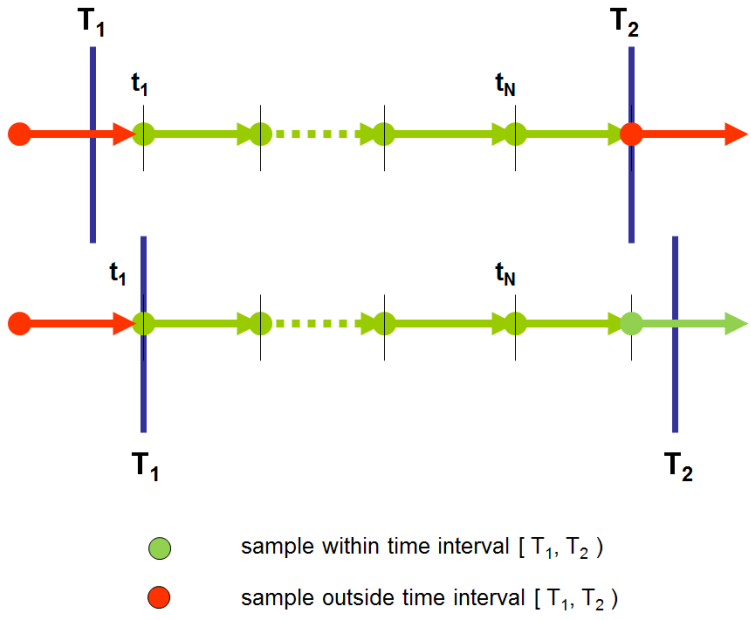
The **length** of a record is $\mathbf{R_e} - \mathbf{R_s} = t_N - t_1 + \Delta t$



Metrics calculation in time window

Two types of metrics are defined, one type based on samples/values, and one type based on mini-SEED data record header.

Sample based metrics are calculated within a time window [T_1, T_2). Time T_1 is included, time T_2 is excluded.



Samples at t=T_1 are included in the sample based metrics calculations, samples at t=T_2 are excluded. In other words, all samples with time t for which $T_1 \leq t < T_2$ are included.

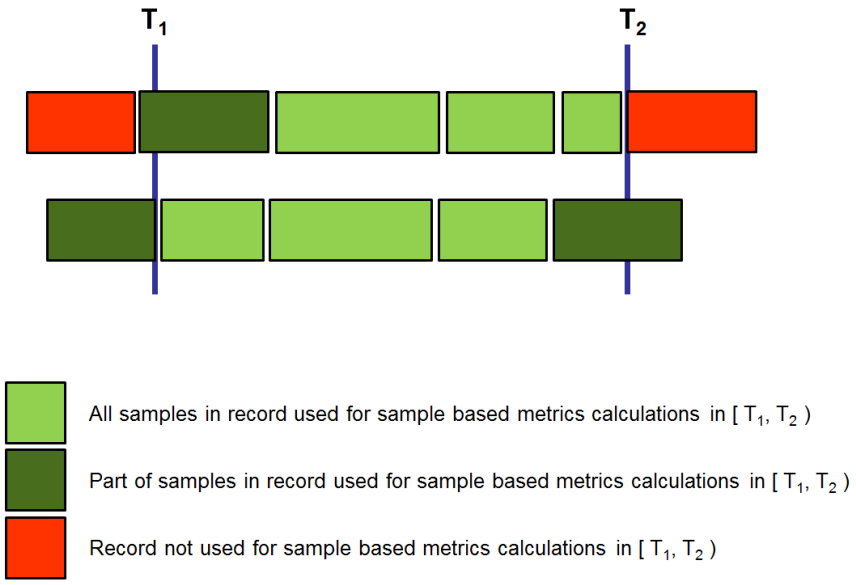
Therefore:

Data records for which $\mathbf{R_e \leq T_1}$ are not used in the sample based metrics calculations.

Data records for which $\mathbf{R_s \geq T_2}$ are not used in the sample based metrics calculations.

Data records for which $\mathbf{T_1 < R_e < T_2}$ are (partially) used in the sample based metrics calculations. In these records the samples are used with time **t** for which $\mathbf{t \geq T_1}$.

Data records for which $\mathbf{T_1 \leq R_s < T_2}$ are (partially) used in the sample based metrics calculations. In these records the samples are used with time **t** for which $\mathbf{t < T_2}$.



Record based metrics are calculated within a time window $[T_1, T_2)$. Time T_1 is included, time T_2 is excluded.

Data records for which $R_e \leq T_1$ are not used in the record based metrics calculations.

Data records for which $R_s \geq T_2$ are not used in the record based metrics calculations.

Metrics based on sample values

The following metrics are calculated from all sample values within time window $[T_1, T_2)$.

- **sample_mean**

Average value of all samples $(x_1, .., x_N)$.

$$mean = \frac{1}{N}\sum_{i=1}^{N} x_i$$

- **sample_max**

Maximum value of all samples $(x_1, .., x_N)$.

- **sample_min**

Minimum value of all samples $(x_1, .., x_N)$.

- **sample_median**

Median value of all samples $(x_1, .., x_N)$. The middle value of the sorted samples.
The 50-th percentile of all samples $(x_1, .., x_N)$.

- **sample_stdev**

The standard deviation (or RMS variance) of all samples $(x_1, .., x_N)$.

$$stdev = \sqrt{\sum_{i=1}^{N} \frac{(x_i - mean)^2}{N}}$$

- **percent_availability**

Data availability is the percentage of data available in a time window $[T_1, T_2)$. It is the length of the time window minus the sum of all gaps in this time window, relative to the length of the time window $[T_1, T_2)$.

$$percent\_availability = 100 \times \frac{(T_2 - T_1) - sum\_gaps}{T_2 - T_1}$$

Metrics based on mini-SEED data record header

The following metrics are extracted from header flags in data records fitting time window **$[T_1, T_2)$.** A flag in the record header of a SEED record applies to all samples in the data record.

- **amplifier_saturation**

Number of records fitting time window $[T_1, T_2)$ for which bit 0 in the Data Quality Flag byte is set to '1'.

- **digitizer_clipping**

Number of records fitting time window $[T_1, T_2)$ for which bit 1 in the Data Quality Flag byte is set to '1'.

- **spikes**

Number of records fitting time window $[T_1, T_2)$ for which bit 2 in the Data Quality Flag byte is set to '1'.

- **glitches**

Number of records fitting time window $[T_1, T_2)$ for which bit 3 in the Data Quality Flag byte is set to '1'.

- **missing_padded_data**

Number of records fitting time window $[T_1, T_2)$ for which bit 4 in the Data Quality Flag byte is set to '1'.

- **telemetry_sync_error**

Number of records fitting time window $[T_1, T_2)$ for which bit 5 in the Data Quality Flag byte is set to '1'.

- **digital_filter_charging**

Number of records fitting time window $[T_1, T_2)$ for which bit 6 in the Data Quality Flag byte is set to '1'.

- **suspect_time_tag**

Number of records fitting time window $[T_1, T_2)$ for which bit 7 in the Data Quality Flag byte is set to '1'.

- **calibration_signal**

Number of records fitting time window $[T_1, T_2)$ for which bit 0 in the Activity Flag byte is set to '1'.

- **event_begin**

Number of records fitting time window [T_1, T_2) for which bit 2 in the Activity Flag byte is set to '1'.

- **event_end**

Number of records fitting time window [T_1, T_2) for which bit 3 in the Activity Flag byte is set to '1'.

- **event_in_progress**

Number of records fitting time window [T_1, T_2) for which bit 6 in the Activity Flag byte is set to '1'.

- **clock_locked**

Number of records fitting time window [T_1, T_2) for which bit 5 in the I/O & Clock Flag byte is set to '1'.

- **timing_correction**

Number of records fitting time window [T_1, T_2) for which field 16 (“Time correction”) in the record header is non-zero.

- **timing_quality**

Average of the timing quality percentage value stored in miniSEED blockettes 1001. Value is NULL if not present in the data records.

num_gaps

The number of gaps in time interval [T_1, T_2).

num_overlaps

The number of overlaps in time interval [T_1, T_2).

max_gap

Largest gap in seconds in time interval [T_1, T_2).

max_overlap

Largest overlap in seconds in time interval [T_1, T_2).

Appendix II: Waveform Metadata (WFMetadata) JSON Schema

```
{
	"id": "wfmetadata-schema-uri",
	"$schema": "http://json-schema.org/draft-04/schema#",
	"title": "Waveform Metadata Json Schema",
	"description": "This schema represents Waveform Metadata characterising traces
with their QC",
	"type": "object",

	"properties": {
		"wfmetadata_id": {
			"description": "Unique identifier of the metadata document. This can
be a DOI, a Handle or any other type of PID",
			"$ref": "#/definitions/stringLiteral",
			"format": "uri"
		},
		"producer": {
			"description": "The producer of this document. For instance it can
be: a software, a person or an organization",
			"type": "object",
			"additionalProperties": {
				"$ref": "#/definitions/agent"
			}
		},
		"waveform_type": {
			"description": "Describes the type of waveform. E.g.: seismic,
infrasound",
			"$ref": "#/definitions/stringLiteral",
			"additionalProperties": false

		},
		"waveform_format": {
			"description": "Describes the waveform format. E.g.: miniSEED",
			"type": {
			 "enum":["miniSEED"]
			},
			"additionalProperties": false

		},
		"version": {
			"description": "The version of the metadata document. E.g.: 1.0.0",
			"type": {
			"enum":["1.0.0"]
			},
			"additionalProperties": true
		},
		"start_time": {
			"description": "Start time of the window used for metric computation
for this entry in UTC",
			"$ref": "#/definitions/timeLiteral"
		},
		"end_time": {
```

```
                    "description": "End time of the window used for metric computation
for this entry in UTC",
                    "$ref": "#/definitions/timeLiteral"
             },
             "network": {
                    "description": "Network code",
                    "$ref": "#/definitions/stringLiteral",
                    "pattern": "[A-Z0-9]{1,6}"
             },
             "station": {
                    "description": "Station code",
                    "$ref": "#/definitions/stringLiteral",
                    "pattern": "[A-Z0-9]{1,5}"
             },
             "channel": {
                    "description": "Channel code",
                    "$ref": "#/definitions/stringLiteral",
                    "pattern": "[A-Z0-9]{3}"
             },
             "location": {
                    "description": "Location code",
                    "$ref": "#/definitions/stringLiteral",
                    "pattern": "[A-Z0-9]{0,2}"
             },
             "quality": {
                    "description": "SEED quality indicator. This is SEED format
specific",
                    "type": {
                    "enum": [
                           "D",
                           "R",
                           "Q",
                           "M"
                    ]},
                    "additionalProperties": false
             },
             "sample_rate": {
                    "description": "Array of unique sample rates",
                    "type": "array",
                    "minItems": 1,
                    "items": {
                           "$ref": "#/definitions/positiveDouble"
                    },
                    "uniqueItems": true,
                    "additionalProperties": false
             },
             "num_samples": {
                    "description": "Number of data samples",
                    "$ref": "#/definitions/positiveInteger"
             },
             "encoding": {
                    "description": "Array of unique encodings. E.g.in SEED: int32, int64,
float32, float64, opaque (for log channels).",
                    "type": "array",
                    "minItems": 1,
                    "items": {
                           "$ref": "#/definitions/stringLiteral"
                    },
```

```
                "uniqueItems": true,
                "additionalProperties": false
            },
            "num_records": {
            "description": "Number of records. This is SEED format specific",
            "$ref": "#/definitions/positiveInteger"
            },
            "record_length": {
                "description": "Array of unique record lengths. This is SEED format
specific",
                "type": "array",
                "minItems": 1,
                "items": {
                    "$ref": "#/definitions/positiveInteger"
                },
                "uniqueItems": true,
                "additionalProperties": false
            },
            "num_gaps": {
                "description": "Number of data gaps",
                "$ref": "#/definitions/positiveInteger"

            },
            "max_gap": {
                "description": "Duration of the largest gap in seconds",
                "$ref": "#/definitions/positiveDouble"
            },
            "num_overlaps": {
                "description": "Number of data overlaps",
                "$ref": "#/definitions/positiveInteger"
            },
            "max_overlap": {
                "description": "Duration of the largest overlap in seconds",
                "$ref": "#/definitions/positiveDouble"
            },
            "sum_gaps": {
                "description": "Total duration of gaps in seconds",
                "$ref": "#/definitions/positiveDouble"
            },
            "sum_overlaps": {
                "description": "Total duration of overlaps in seconds",
                "$ref": "#/definitions/positiveDouble"
            },
            "sample_max": {
                "description": "Maximum sample value",
                "$ref": "#/definitions/numberLiteral"
            },
            "sample_min": {
                "description": "Minimum sample value",
                "$ref": "#/definitions/numberLiteral"
            },
            "sample_mean": {
                "description": "Mean of the sample values",
                "$ref": "#/definitions/numberLiteral"
            },
            "sample_rms": {
                "description": "Rms of the sample values",
                "$ref": "#/definitions/positiveDouble"
```

```
		},
		"sample_lower_quartile": {
			"description": "Lower quartile of the sample values",
			"$ref": "#/definitions/numberLiteral"
		},
		"sample_upper_quartile": {
			"description": "Upper quartile of the sample values",
			"$ref": "#/definitions/numberLiteral"
		},
		"sample_median": {
			"description": "50th percentile of the sample values",
			"$ref": "#/definitions/numberLiteral"
		},
		"sample_stdev": {
			"description": "Standard deviation of the sample values",
			"$ref": "#/definitions/positiveDouble"
		},
		"miniseed_header_percentages": {
			"type": "object",
			"properties": {
			"timing_correction": {
				"description": "Percentage of data for which field 16 in the
record header is non-zero",
				"$ref": "#/definitions/numberLiteral"
			},
			"timing_quality_mean": {
				"description": "Mean of the timing quality percentage values
stored in mSEED blockettes 1001",
				"$ref": "#/definitions/numberLiteral"
			},
			"timing_quality_min": {
				"description": "Minimum of the timing quality percentage
values stored in mSEED blockettes 1001",
				"$ref": "#/definitions/numberLiteral"
			},
			"timing_quality_max": {
				"description": "Maximum of the timing quality percentage
values stored in mSEED blockettes 1001",
				"$ref": "#/definitions/numberLiteral"
			},
			"timing_quality_median": {
				"description": "The 50th percentile of all timing quality
percentage values stored in mSEED blockettes 1001",
				"$ref": "#/definitions/numberLiteral"
			},
			"timing_quality_lower_quartile": {
				"description": "The 25th percentile of all timing quality
percentage values stored in mSEED blockettes 1001",
				"$ref": "#/definitions/numberLiteral"
			},
			"timing_quality_upper_quartile": {
				"description": "The 75th percentile of all timing quality
percentage values stored in mSEED blockettes 1001",
				"$ref": "#/definitions/numberLiteral"
			},
				"data_quality_flags": {
					"type": "object",
					"properties": {
```

```
                                        "amplifier_saturation": {
                                                "description": "Percentage of data for
which bit 0 in the DQ flag is set to 1",
                                                "$ref": "#/definitions/positivePercentage"
                                        },
                                        "digitizer_clipping": {
                                                "description": "Percentage of data for
which bit 1 in the DQ flag is set to 1",
                                                "$ref": "#/definitions/positivePercentage"
                                        },
                                        "spikes": {
                                                "description": "Percentage of data for
which bit 2 in the DQ flag is set to 1",
                                                "$ref": "#/definitions/positivePercentage"
                                        },
                                        "glitches": {
                                                "description": "Percentage of data for
which bit 3 in the DQ flag is set to 1",
                                                "$ref": "#/definitions/positivePercentage"
                                        },
                                        "missing_padded_data": {
                                                "description": "Percentage of data for
which bit 4 in the DQ flag is set to 1",
                                                "$ref": "#/definitions/positivePercentage"
                                        },
                                        "telemetry_sync_error": {
                                                "description": "Percentage of data for
which bit 5 in the DQ flag is set to 1",
                                                "$ref": "#/definitions/positivePercentage"
                                        },
                                        "digital_filter_charging": {
                                                "description": "Percentage of data for
which bit 6 in the DQ flag is set to 1",
                                                "$ref": "#/definitions/positivePercentage"
                                        },
                                        "suspect_time_tag": {
                                                "description": "Percentage of data for
which bit 7 in the DQ flag is set to 1",
                                                "$ref": "#/definitions/positivePercentage"
                                        }
                                },
                                "required":[
                                        "amplifier_saturation",
                                        "digitizer_clipping",
                                        "spikes",
                                        "glitches",
                                        "missing_padded_data",
                                        "telemetry_sync_error",
                                        "digital_filter_charging",
                                        "suspect_time_tag"
                                        ]

                        },
                        "activity_flags": {
                                "type": "object",
                                "properties": {
                                        "calibration_signal": {
                                                "description": "Percentage of data for
```

```
which bit 0 in the Activity flag is set to 1",
                                        "$ref": "#/definitions/positivePercentage"
                                    },
                                    "time_correction_applied": {
                                        "description": "Percentage of data for
which bit 1 in the Activity flag is set to 1",
                                        "$ref": "#/definitions/positivePercentage"
                                    },
                                    "event_begin": {
                                        "description": "Percentage of data for
which bit 2 in the Activity flag is set to 1",
                                        "$ref": "#/definitions/positivePercentage"
                                    },
                                    "event_end": {
                                        "description": "Percentage of data for
which bit 3 in the Activity flag is set to 1",
                                        "$ref": "#/definitions/positivePercentage"
                                    },
                                    "positive_leap": {
                                        "description": "Percentage of data for
which bit 4 in the Activity flag is set to 1",
                                        "$ref": "#/definitions/positivePercentage"
                                    },
                                    "negative_leap": {
                                        "description": "Percentage of data for
which bit 5 in the Activity flag is set to 1",
                                        "$ref": "#/definitions/positivePercentage"
                                    },
                                    "event_in_progress": {
                                        "description": "Percentage of records for
which bit 6 in the Activity flag is set to 1",
                                        "$ref": "#/definitions/positivePercentage"
                                    }
                                },
                                "required":[
                                    "calibration_signal",
                                    "time_correction_applied",
                                    "event_begin",
                                    "event_end",
                                    "positive_leap",
                                    "negative_leap",
                                    "event_in_progress"
                                    ]

                            },
                            "io_and_clock_flags": {
                                "type": "object",
                                "properties": {
                                    "station_volume": {
                                        "description": "Percentage of records for
which bit 0 in the I/O and Clock flag is set to 1",
                                        "$ref": "#/definitions/positivePercentage"
                                    },
                                    "long_record_read": {

                                       "description": "Percentage of records for
which bit 1 in the I/O and Clock flag is set to 1",
                                        "$ref": "#/definitions/positivePercentage"
```

```
                                        },
                                        "short_record_read": {
                                              "description": "Percentage of records for
which bit 2 in the I/O and Clock flag is set to 1",
                                              "$ref": "#/definitions/positivePercentage"
                                        },
                                        "start_time_series": {
                                              "description": "Percentage of records for
which bit 3 in the I/O and Clock flag is set to 1",
                                               "$ref": "#/definitions/positivePercentage"
                                        },
                                        "end_time_series": {
                                              "description": "Percentage of records for
which bit 4 in the I/O and Clock flag is set to 1",
                                              "$ref": "#/definitions/positivePercentage"
                                        },
                                        "clock_locked": {
                                              "description": "Percentage of records for
which bit 5 in the I/O & Clock flag is set to 1",
                                              "$ref": "#/definitions/positivePercentage"
                                        }
                                  },
                                  "required":[
                                        "station_volume",
                                        "long_record_read",
                                        "short_record_read",
                                        "start_time_series",
                                        "end_time_series",
                                        "clock_locked"
                                        ]

                            }
                      },
                      "required":[
                           "timing_correction",
                           "timing_quality_mean",
                           "timing_quality_min",
                           "timing_quality_max",
                           "timing_quality_median",
                           "timing_quality_lower_quartile",
                           "timing_quality_upper_quartile",
                           "data_quality_flags",
                           "activity_flags",
                           "io_and_clock_flags"
                           ]

            },
            "percent_availability": {
                  "description": "Percentage of available data samples",
                  "$ref": "#/definitions/positiveDouble"
            },

            "c_segments": {
                  "description": "Continuous segments within the requested time
interval",
                  "type": "array",
                  "items": {
                        "type": "object",
```

```
                        "properties": {
                            "sample_rate": {
                                    "description": "Sample rate in the continuous
segment",
                                    "$ref": "#/definitions/positiveDouble"
                                },

                            "sample_min": {
                                    "description": "Minimum of samples in a
continuous segment",
                                    "$ref": "#/definitions/numberLiteral"
                                },
                                "sample_max": {
                                    "description": "Maximum of samples in a
continuous segment",
                                    "$ref": "#/definitions/numberLiteral"
                                },
                            "sample_mean": {
                                    "description": "Mean of the sample values in a
continuous segment",
                                    "$ref": "#/definitions/numberLiteral"
                                },
                                "sample_rms": {
                                    "description": "Rms of the sample values in a
continuous segment",
                                    "$ref": "#/definitions/positiveDouble"
                                },
                                "sample_lower_quartile": {
                                    "description": "Lower quartile of the sample
values in a continuous segment",
                                    "$ref": "#/definitions/numberLiteral"
                                },
                                "sample_upper_quartile": {
                                    "description": "Upper quartile of the sample
values in a continuous segment",
                                    "$ref": "#/definitions/numberLiteral"
                                },
                                "sample_median": {
                                    "description": "50th percentile of the sample
values in a continuous segment",
                                    "$ref": "#/definitions/numberLiteral"
                                },
                                "start_time": {
                                    "description": "Time of the first sample of the
segment in UTC",
                                    "$ref": "#/definitions/timeLiteral"
                                },
                                "end_time": {
                                    "description": "Time of the last sample of the
segment in UTC",
                                    "$ref": "#/definitions/timeLiteral"
                                },
                                "num_samples": {
                                    "description": "Number of data samples in the
continuous segment",
                                    "$ref": "#/definitions/positiveInteger"
                                },
                                "sample_stdev": {
```

```
                                        "description": "Standard deviation of samples in
the continuous segment",
                                        "$ref": "#/definitions/positiveDouble"
                                    },
                                    "segment_length": {
                                        "description": "Length in seconds of the specific
continuous segment",
                                        "$ref": "#/definitions/numberLiteral"
                                    }
                                },
                                "required":[
                                    "sample_rate",
                                    "start_time",
                                    "end_time",
                                    "num_samples",
                                    "segment_length"
                                    ]
                        }
                }

        },
        "definitions": {
                "agent": {
                        "$ref": "#/definitions/entity"
                },
                "typedLiteral": {
                        "type": "object",
                        "properties": {
                                "$": {
                                        "type": "string"
                                },
                                "type": {
                                        "type": "string",
                                        "format": "uri"
                                },
                                "lang": {
                                        "type": "string"
                                }
                        },
                        "required": ["$"],
                        "additionalProperties": false
                },
                "stringLiteral": {
                        "type": "string",
                        "additionalProperties": false
                },
                "numberLiteral": {
                        "oneOf":[
                        {"type": "number"},
                        {"type": "null"}
                        ],
                        "additionalProperties": false
                },
                "booleanLiteral": {
                        "type": "boolean",
                        "additionalProperties": false
                },
                "timeLiteral": {
```

```
        "type": "string",
        "format": "date-time",
        "additionalProperties": false
},
"literalArray": {
        "type": "array",
        "minItems": 1,
        "items": {
                "anyOf": [{
                        "$ref": "#/definitions/stringLiteral"
                }, {
                        "$ref": "#/definitions/numberLiteral"
                }, {
                        "$ref": "#/definitions/booleanLiteral"
                }, {
                        "$ref": "#/definitions/typedLiteral"
                }]
        }
},
"attributeValues": {
        "anyOf": [{
                "$ref": "#/definitions/stringLiteral"
        }, {
                "$ref": "#/definitions/numberLiteral"
        },
       {
                "$ref": "#/definitions/timeLiteral"
        },
        {
                "$ref": "#/definitions/booleanLiteral"
        }, {
                "$ref": "#/definitions/typedLiteral"
        }, {
                "$ref": "#/definitions/literalArray"
        }]
},
"entity": {

        "title": "entity",
        "additionalProperties": {
                "$ref": "#/definitions/attributeValues"
        }
},
"positiveInteger": {
        "oneOf":[
        {"type": "integer",
        "minimum": 0,
        "exclusiveMinimum": false},
        {"type": "null" }
        ],
        "additionalProperties": false
},
"positiveDouble": {
"oneOf":[
        {"type": "number",
        "minimum": 0,
        "exclusiveMinimum": false},
        {"type": "null" }
```

```
                        ],
                        "additionalProperties": false
                },
                "positivePercentage": {
                        "oneOf":[
                        {"type": "number",
                        "minimum": 0,
                        "maximum": 100,
                        "exclusiveMinimum": false,
                        "exclusiveMaximum": false},
                        {"type": "null" }
                        ],
                        "additionalProperties": false
                }
        },
        "required": [
                "producer",
                "version",
                "waveform_format",
                "start_time",
                "end_time",
                "network",
                "station",
                "channel",
                "location",
                "sample_rate",
                "max_gap",
                "max_overlap",
                "percent_availability",
                "num_samples",
                "num_gaps",
                "num_overlaps",
                "sum_gaps",
                "sum_overlaps"
        ]
}
```