European Network of
Transmission System Operators
for Electricity

THE INTRODUCTION OF DIFFERENT TIME SERIES POSSIBILITIES (CURVETYPE) WITHIN ENTSO-E ELECTRONIC DOCUMENTS

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APPROVED DOCUMENT
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TABLE OF CONTENTS

1 INTRODUCTION 5

2 ENTSO-E TIME SERIES USE 6

3 CALCULATION OF THE POSITION OF AN INTERVAL IN TIME 7

4 CURVETYPE 8

4.1 A01 – SEQUENTIAL FIXED SIZE BLOCKS (DEFAULT) 10
4.2 A02 – POINT 12
4.3 A03 – VARIABLE SIZED BLOCK 14
4.4 A04 – OVERLAPPING BREAKPOINT 16
4.5 A05 – NON-OVERLAPPING BREAKPOINT 19

5 THE HANDLING OF GAPS 21

TABLE OF FIGURES

FIGURE 1: BASIC TIME SERIES LAYOUT 6
FIGURE 2: SEQUENTIAL FIXED SIZE BLOCKS 10
FIGURE 3: POINTS 12
FIGURE 4: VARIABLE SIZED BLOCKS 14
FIGURE 5: OVERLAPPING BREAKPOINTS 16
FIGURE 6: NON-OVERLAPPING BREAKPOINTS 19
FIGURE 7: TIMESERIES GAP EXAMPLE 21
FIGURE 8: TIMESERIES GAP AND OVERLAP EXAMPLE 22
FIGURE 9: TIMESERIES GAP AND OVERLAP DESCRIPTION 22

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Revision History

Version	Release	Date	Paragraph	Comments
0	0	2009/09/30		Document release
1	0	2009/11/20		Comments from EDI WG members. Document approved by ENTSO-E Market Committee on 2009/12/11.
1	1	2011/05/05		Precision on the use of gaps and typing errors corrections. Approved by Market Committee on 2011-05-17.
1	2	2019/03/28		Updates in chapters 2 and 3 to have into account the current ESMP CIM standards. Approved by MC.
1	3	2021/06/01		When the resolution is zero, as it could be for point values (format PT0S), the formula for how to calculate the maximum number of repetitions of the Point class will give an undefined result. Clarifications were added to the document. Approved by MC.

1 INTRODUCTION

In 2001, ETSO Task Force Electronic Data Interchange (EDI) identified a requirement to handle time series for electricity transactions. These transactions concerned exchange of energy/power blocks with a constant time interval. For each time interval, the quantity value in the class "Interval" of the time series was either:

- A constant power in MW on the time interval [t0, t1[[1]
- An energy value in MWh for the time interval [t0, t1[

These are only examples and the quantity value is depending upon the business process requirements, energy, power, water flow, temperature, price, etc. The same applies also for the data type, e.g. integer value, real with a given number of decimal, etc.

Since this first definition, new business requirements have appeared requiring time series capable of handling:

- Variable time intervals;
- The transmission of unrelated information for points in time;
- Ramping;
- Variable sized blocks.

In order to satisfy these new business requirements and not to disrupt the current method of handling time series information a study was carried out which not only kept in mind the original philosophy of handling time series but also addressed the new requirements.

The results of the study concluded that the existing time series method could optimally answer all the identified cases with the simple addition of an attribute to identify to sort of curve that was being provided.

This document outlines how the addition of a type of curve can address the requirements initially requested.

ENTSO-E recommends having a constant resolution when different Period classes are provided within one time series.

This implementation ensures the compatibility with all the existing documents developed within ENTSO-E CIM EG, ENTSO-E WG-EDI and the former organisation ETSO TF EDI.

[1] Notation convention:

- [t0, t1] means that the period is such that t0 ≤ t ≤ t1
- [t0, t1[means that the period is such that t0 ≤ t < t1
-]t0, t1] means that the period is such that t0 < t ≤ t1
-]t0, t1[means that the period is such that t0 < t < t1

2 ENTSO-E TIME SERIES USE

ENTSO-E uses a standardised set of ESMP CIM (IEC 62325-351) classes to provide time series information. This layout takes basic form outlined in figure 1.

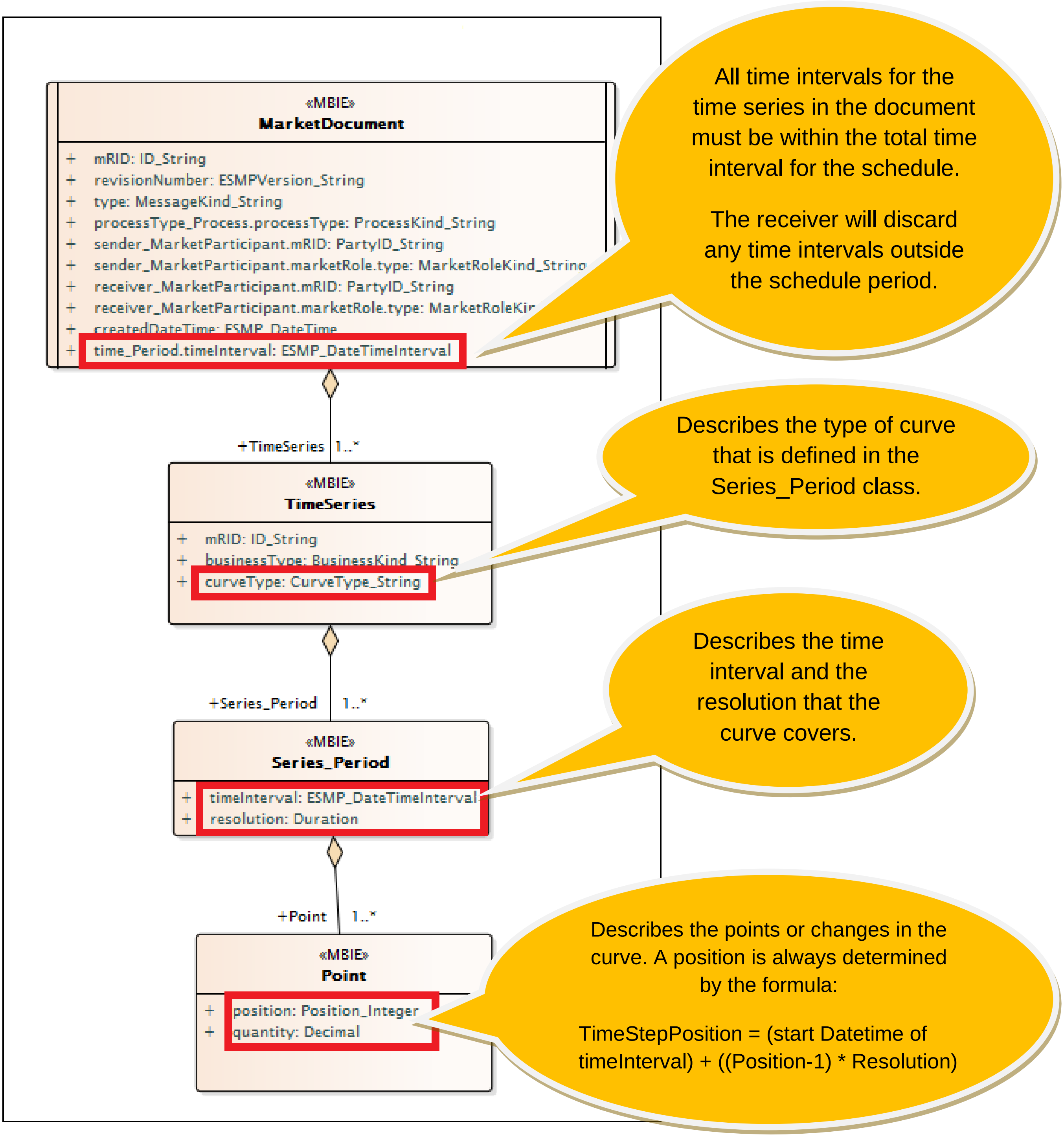

FIGURE 1: BASIC TIME SERIES LAYOUT

It's needed to associate a timeInterval attribute to the MarketDocument class to specify the total time interval covered by the document. All time intervals for the time series in the document must be within the total time interval associated to the MarketDocument class.

The Time Series class contains all the details describing what the time series represents. Amongst all the time series descriptive information there is an attribute called "CurveType". This attribute is used to describe the type of curve that is being provided for the Time Series in question.

If the "CurveType" attribute is omitted in the XML instance a default value of "sequential fixed size blocks" shall be understood. This ensures that compatibility is maintained with existing implementations.

The Series_Period class provides the information defining the time interval that is covered and the resolution of the time step within the Period.

The Point class provides all the content for a given time step which is identified by the attribute "Position". The attribute "Position" always begins at the value "1". The maximum number of repetitions of the Point class is determined assuming that all variables are expressed as an integer number of Resolution units by the formula:

$$\frac{EndDateTime - StartDateTime}{Resolution}.$$

However, the effective number of Intervals depends on the CurveType element contents.

Note: The formula above is only valid when the resolution is higher than 0. If the resolution is zero, only one repetition of the Point class is allowed.

3 CALCULATION OF THE POSITION OF AN INTERVAL IN TIME

The exact time position within a Series_Period class shall be calculated in the following manner:

$$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

with *Pos* being the Position value of the Point class.

For example: if there was a Time Interval with 2009-01-01T22:00/2009-01-02T22:00 and a Resolution of PT30M, The TimeStepPosition for a Pos with the value of 9 would be 2009-01-02T02:00, i.e. the interval [02:00, 02:30[for a sequential fixed size blocks "CurveType".

This formula is true in all cases of the use of the ENTSO-E Time Series principles.

It must be borne in mind that by convention the start date and time is included whereas the end date and time is excluded, i.e. [start date and time, end date and time[. For CurveType "A04" and CurveType "A05", the end date and time although excluded must be included to define the possible ramp. This will be defined within the detailed description of the time series.

The time is always represented as the horizontal axe of the curve whereas the vertical axe is represented by the quantity.

4 CURVETYPE

In all five different types of curve have been identified to date. These are:

1. **Sequential fixed size blocks (A01)**: The curve is made of successive Intervals of time (Blocks) of constant duration (size), where the size of the Blocks is equal to the Resolution of the Period. The TimeStepPosition of each Interval is equal to:

   $$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

   with Pos being the Position attribute value of the Point class.

   The number of Intervals of a Period must be equal to: $\frac{EndDateTime - StartDateTime}{Resolution}$

   All Intervals to cover the TimeInterval of a Period must be present.

   The value of the Qty remains constant within each Block.

   The formula above is only valid when the resolution is higher than 0.

2. **Points (A02)**: The curve is made of successive instants of time (Points). Each Point is determined as follows:

   $$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

   with Pos being the Position attribute value of the Point class.

   All Points must be within the Period TimeInterval.

   The Qty of each Interval corresponds only to the value at the $TimeStepPosition$.

   Note: If the resolution is zero, only one repetition of the Point class is allowed.

3. **Variable sized Blocks (A03)**: The curve is made of successive Intervals of time (Blocks) of variable duration (size), where the end date and end time of each Block are equal to the start date and start time of the next Interval. For the last Block the end date and end time of the last Interval would be equal to EndDateTime of TimeInterval. The TimeStepPosition of each Interval is equal to:

   $$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

   with Pos being the Position attribute value of the Point class.

   All Intervals to cover the TimeInterval of a Period must be present.

   The value of the Qty remains constant within each Block.

4. **Overlapping Breakpoints (A04)**: The curve is made of successive Intervals of time of variable duration (size), where the end date and end time of each interval are equal to the start date and start time of the next Interval. The TimeStepPosition of each Interval is equal to:

   $$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

   with Pos being the Position attribute value of the Point class.

All Intervals to cover the TimeInterval of a Period must be present.

The value of the Qty at instant t evolves linearly with the time within a TimeInterval as follows:

$$Qty(t) = \frac{Qty_{end} - Qty_{start}}{TimeStepPosition_{end} - TimeStepPosition_{start}} * (t - TimeStepPosition_{start}) + Qty_{start}$$

where the “start” and “end” index refers respectively to the current Position and to the next Position provided in the Timeseries. This formula is to be applied only for the time inside a given Period (the $\text{TimeStepPosition}_{\text{end}}$ and the $\text{TimeStepPosition}_{\text{start}}$ cannot be the same), overlapping breakpoints are identified by a change of period.

For the last interval, the TimeStepPositionend must be equal to the EndDateTime of TimeInterval.

5. **Non-overlapping Breakpoints (A05)**: This curve is a restriction of the previous one, i.e. overlapping breakpoints; the restriction is that a single Period is allowed. Thus, the $\text{TimeStepPosition}_{\text{end}}$ of a TimeInterval and the $\text{TimeStepPosition}_{\text{start}}$ of a TimeInterval cannot be the same. All the other conditions apply.

These are described in the following paragraphs.[2]

[2] The examples, hereafter enclosed, are for a UTC time period of one day 2009-09-09T00:00/2009-09-10T00:00Z, depending upon the local time to be considered, the expression of the day may vary with the time saving periods. Moreover, the time period may vary depending upon the business requirements (such as for intraday processes, etc.).

4.1 A01 – SEQUENTIAL FIXED SIZE BLOCKS (DEFAULT)

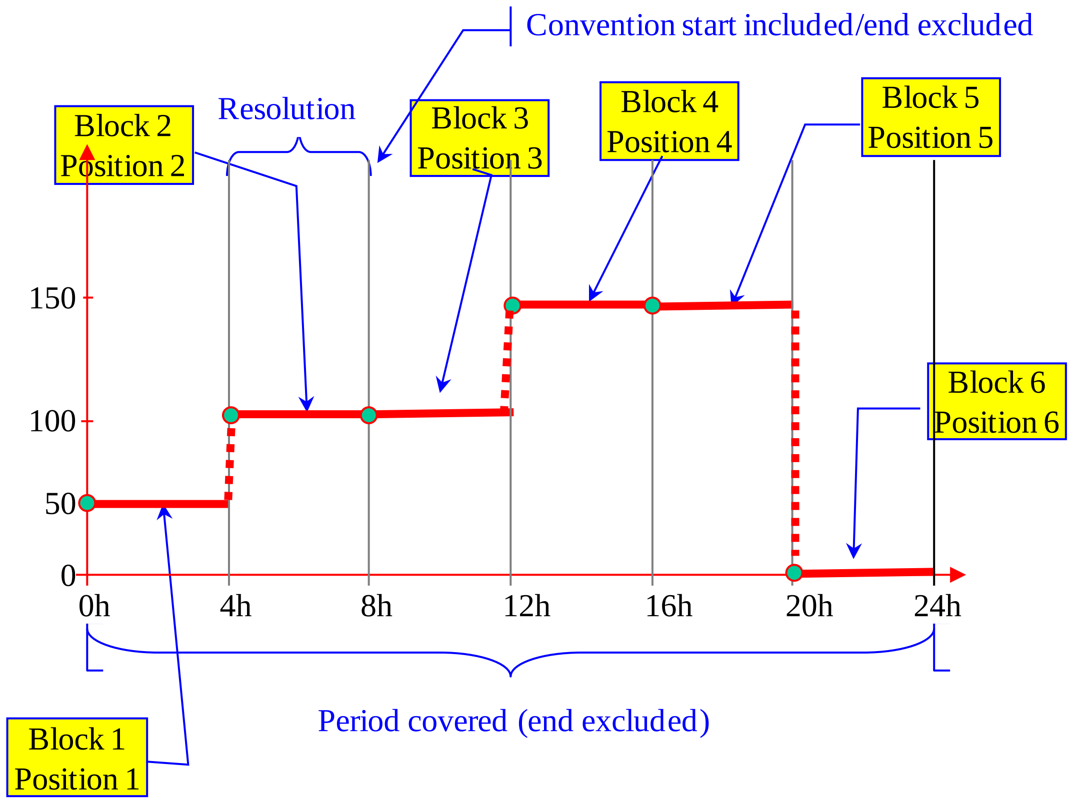

FIGURE 2: SEQUENTIAL FIXED SIZE BLOCKS

The CurveType A01 corresponds to a Period where all the interval positions are present within the TimeInterval. The resolution corresponds to the interval. Consequently the number of intervals must be equal to $\frac{EndDateTime - StartDateTime}{Resolution}$.

This corresponds to the current use of the TimeSeries for the ENTSO-E ESS, ESP, ERRP and ECAN uses. It is consequently considered as the default value for the CurveType should the element not be present.

In the example shown in Figure 2, there is a 24 hour day with a 4 hour resolution.

Applying the formula for a TimeInterval 2009-09-09T00:00/2009-09-10T00:00Z

$$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

The following positions are obtained:

1 = (2009-09-09T00:00 + ((1-1) * PT4H) = 00:00 + ((0) *4)

2 = (2009-09-09T00:00 + ((2-1) * PT4H) = 00:00 + ((1) *4)

3 = (2009-09-09T00:00 + ((3-1) * PT4H) = 00:00 + ((2) *4)

4 = (2009-09-09T00:00 + ((4-1) * PT4H) = 00:00 + ((3) *4)

5 = (2009-09-09T00:00 + ((5-1) * PT4H) = 00:00 + ((4) *4)

6 = (2009-09-09T00:00 + ((6-1) * PT4H) = 00:00 + ((5) *4)

Consequently there are 6 intervals:

1) Covering the interval [0h00, 04h00[for a constant block of 50MW;
2) Covering the interval [4h00, 08h00[for a constant block of 100MW;
3) Covering the interval [08h00, 12h00[for a constant block of 100MW;
4) Covering the interval [12h00, 16h00[for a constant block of 150MW;
5) Covering the interval [16h00, 20h00[for a constant block of 150MW;
6) Covering the interval [20h00, 24h00[for a constant block of 0MW.

This induces the following rules:

- ✓ Each position identifies the start of a block;
- ✓ All positions must be provided, i.e. all intervals covering the TimeInterval of a Period shall be present;
- ✓ The value of the Qty remains constant within each block;
- ✓ The block is represented by the position on the horizontal axe and the quantity on the vertical axe;
- ✓ This corresponds to the current time series method and shall be considered as the default value.

4.2 A02 – Point

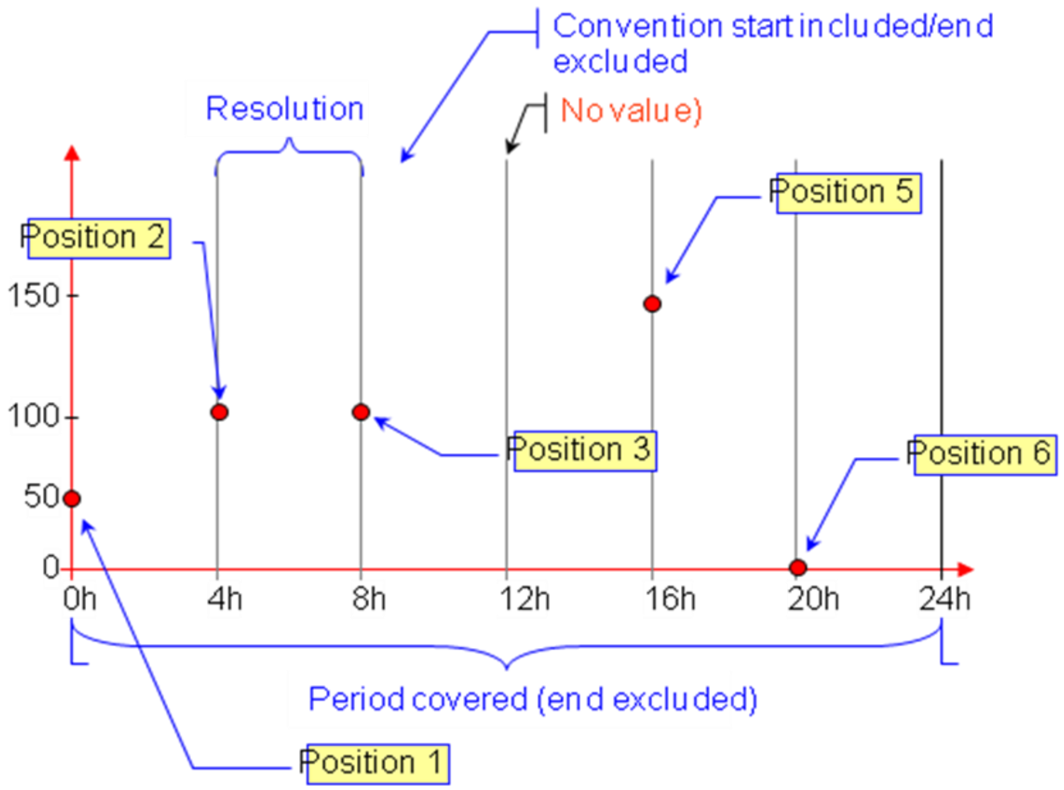

Figure 3: Points

The CurveType A02 corresponds to a Period where only the Interval positions that have data are present within Time Interval. The resolution corresponds to the smallest expected interval between two Points. In the case of meter readings it could be for example 1 hour. There is no direct relation between 1 Point and the Next. Only the Interval position where the Point is represented shall be provided. The number of Points possible is not directly defined, but must be inferior to $\frac{EndDateTime - StartDateTime}{Resolution}$.

In the example in Figure 3, the smallest resolution has been defined as 4 hours. This indicates that a reading is not expected in an interval less than 4 hours. The position provides the exact time of the reading. In the example it can be seen that there are 5 readings corresponding to positions 1, 2, 3, 5 and 6.

Applying the formula for a TimeInterval 2009-09-09T00:00/2009-09-10T00:00Z

$$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

The following positions are obtained:

1 = (2009-09-09T00:00 + ((1-1) * PT4H) = 00:00 + ((0) *4)

2 = (2009-09-09T00:00 + ((2-1) * PT4H) = 00:00 + ((1) *4)

3 = (2009-09-09T00:00 + ((3-1) * PT4H) = 00:00 + ((2) *4)

5 = (2009-09-09T00:00 + ((5-1) * PT4H) = 00:00 + ((4) *4)

6 = (2009-09-09T00:00 + ((6-1) * PT4H) = 00:00 + ((5) *4)

Consequently there are 5 interval elements that represent the time of the readings (a reading every 4 hours). The fourth reading is absent from the electronic document which signifies that no reading took place.

1) At 0h00- where the reading value was 50MW;
2) At 4h00 where the reading value was 100MW;
3) At 08h00 where the reading value was 100MW;
5) At 16h00 where the reading value was 150MW;
6) At 20h00 where the reading value was 0MW.

There is no relational significance between each reading other than the relation induced by the resolution This consequently induces the following rules:

- ✓ Each position represents a point defined by the quantity on the vertical axe and the position time on the horizontal axe;
- ✓ The quantity is the value at a given point in time, it is the business rules that have to define the meaning of this quantity;
- ✓ Only points with a value are provided.

In the special case when only one point value is exchanged, it is allowed to specify the EndDateTime as the same as StartDateTime. There will then be only one repetition of the Point class.

Note: If the resolution is zero, also then only one repetition of the Point class is allowed.

4.3 A03 – VARIABLE SIZED BLOCK

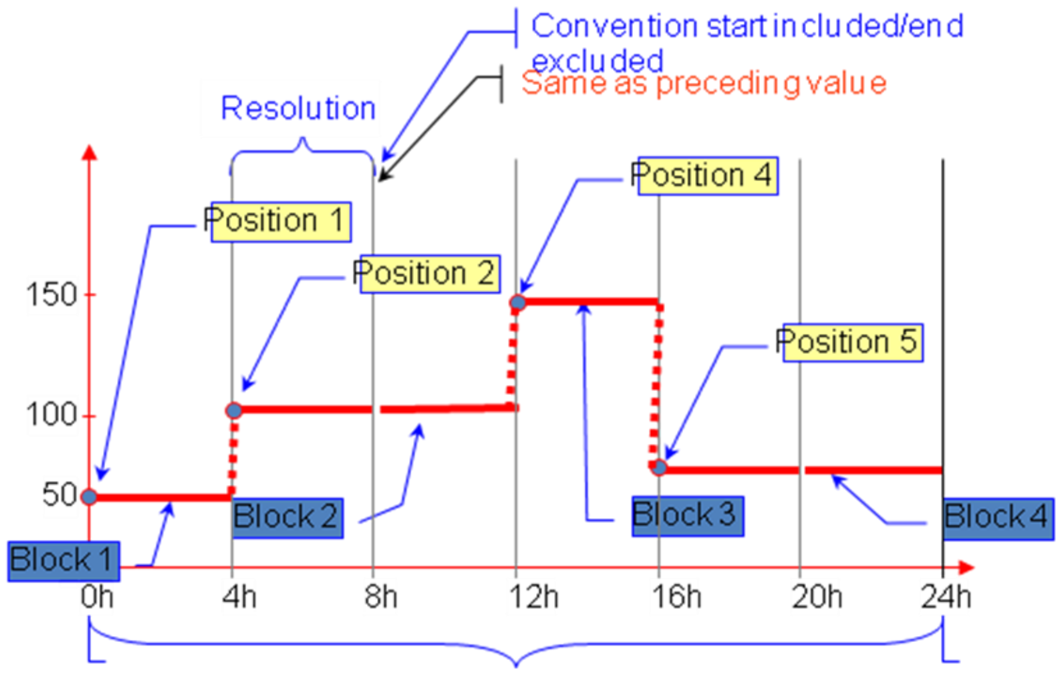

FIGURE 4: VARIABLE SIZED BLOCKS

The CurveType A03 differs from A01 in that only the position where a block change occurs is provided. Consequently all positions are not provided. This is useful in cases where the quantity is stable over a long period of time.

In the example in Figure 4, the first block begins at 00h00 for 50 megawatts. The second block begins at 04h00 for 100 megawatts. This also implies that the first block terminates at 04h00. The third block begins at 12h00 for150 megawatts. This also implies that the second block terminates at 12h00. The fourth block begins at 16h00 for 50 megawatts and since there is no other block presented it carries right through to the end of the day

Applying the formula for a TimeInterval 2009-09-09T00:00/2009-09-10T00:00Z

$$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

The following positions are obtained:

1 = (2009-09-09T00:00 + ((1-1) * PT4H) = 00:00 + ((0) *4)

2 = (2009-09-09T00:00 + ((2-1) * PT4H) = 00:00 + ((1) *4)

4 = (2009-09-09T00:00 + ((4-1) * PT4H) = 00:00 + ((3) *4)

5 = (2009-09-09T00:00 + ((5-1) * PT4H) = 00:00 + ((4) *4)

1) Covering the interval [0h00, 04h00[with a value of 50MW;
2) Covering the interval [4h00, 12h00[with a value of 100MW;
4) Covering the interval [12h00, 16h00[with a value of 150MW;

5) Covering the interval [16h00, 24h00[with a value of 50MW.

This induces the following rules:

- ✓ Each position identifies the start of a block;
- ✓ The end of the block is the start of the next block (except for the last one);
- ✓ The last block extends to the end of the TimeInterval;
- ✓ Only positions where a block change occurs are provided;
- ✓ The value of the Qty remains constant within each block;
- ✓ The block represents the start position on the horizontal axe and the quantity on the vertical axe.

4.4 A04 – OVERLAPPING BREAKPOINT

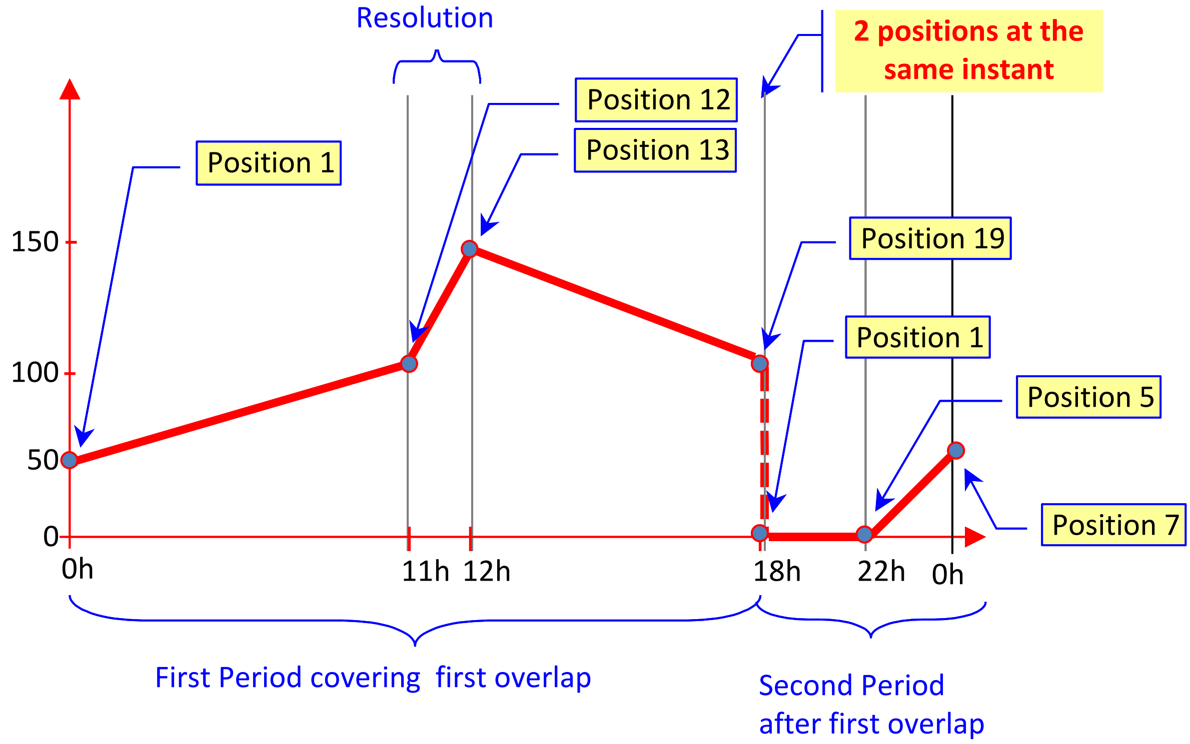

FIGURE 5: OVERLAPPING BREAKPOINTS

The CurveType A04 corresponds to the definition of breakpoints which differs from the CurveType A02, "Points", insofar as there is a direct relation between a point, its predecessor and its successor.

Between one point and the next a straight line shall be drawn representing the evolution of the use of a quantity over time. The value of the Qty at instant t evolves linearly with the time within a TimeInterval as follows:

$$Qty(t) = \frac{Qty_{end} - Qty_{start}}{TimeStepPosition_{end} - TimeStepPosition_{start}} * (t - TimeStepPosition_{start}) + Qty_{start}$$

where the "start" and "end" index refers respectively to the current Position and to the next Position provided in the Timeseries. This formula is to be applied only for the time inside a given Period (the $TimeStepPosition_{end}$ and the $TimeStepPosition_{start}$ cannot be the same), overlapping breakpoints are identified by a change of period.

Only the points where there is a change in ramp (breakpoint) are provided.

The resolution granularity should be equal to the smallest granularity expected.

In the example in Figure 5, the initial position of the period is at 00h00 for 50 megawatts. The resolution represents 1 hour. The first breakpoint occurs at 11h00 for 100 megawatts which is represented by position 12. This signifies that there is a line drawn between the two points representing a slope going from 50 megawatts to 100 megawatts. There are no positions between the 1st position and the 12th position. The second breakpoint occurs at 12h00 (position 13) with a change to 150 megawatts. The third breakpoint occurs at 18h00 (occurrence of an overlap for this time, position 19 of the first Series_Period class) with a change to 100 megawatts. There immediately follows at 18h00 (the second occurrence for this time, position 1 of the following Series_Period class) a reduction down to 0 megawatts. The next breakpoint occurs at 22h00 (position 5 of the second Series_Period class) with the start of an increase in quantity. The last breakpoint occurs at 24h00 (position 7 of the second Series_Period class) where at the end of the period the quantity has moved to 50 megawatts.

Applying the formula for the first TimeInterval 2009-09-09T00:00/2009-09-10T18:00Z and assuming a resolution of 1 hour.

$$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

The following positions are obtained:

1 = (2009-09-09T00:00 + ((1-1) * PT1H) = 00:00 + ((0) *1)

12 = (2009-09-09T00:00 + ((12-1) * PT1H) = 00:00 + ((11) *1)

13 = (2009-09-09T00:00 + ((13-1) * PT1H) = 00:00 + ((12) *1)

19 = (2009-09-09T00:00 + ((19-1) * PT1H) = 00:00 + ((18) *1)

1) At 0h00 the value is 50MW;
12) At 11h00 the value is 100MW (indicating that between 00:00 and 11:00 there is an increasing value going from 50 to 100MW);
13) At 12h00 the value is 150MW (indicating that between 11:00 and 12:00 there is an increasing value going from 100 to 150MW);
19) At 18h00 the value is 100MW (indicating that between 12:00 and 18:00 there is a decreasing value going from 150 to 100MW);

Applying the formula for the second TimeInterval 2009-09-09T18:00/2009-09-10T00:00Z and assuming a resolution of 1 hour.

$$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

The following positions are obtained:

1 = (2009-09-18T00:00 + ((1-1) * PT1H) = 18:00 + ((0) *1)

5 = (2009-09-18T00:00 + ((5-1) * PT1H) = 18:00 + ((4) *1)

7 = (2009-09-18T00:00 + ((7-1) * PT1H) = 18:00 + ((6) *1)

1) At 18h00 the value is 0MW; the change of period indicates that there is an overlap and that the last value of the previous period provides indication on the ramp;
5) At 22h00 the value is 0MW (indicating that between 18h00 and 22:00 the value remained at 0MW);
7) At 00h00 the value is 50MW (indicating that between 22:00 and 00:00 there is an increasing value going from 0 to 50MW);

This induces the following rules:

- ✓ Each position identifies a breakpoint;
- ✓ Each breakpoint is tied to the next breakpoint with a straight line;
- ✓ Only positions where a breakpoint occurs are provided;
- ✓ The breakpoint is represented by time on the horizontal axe and the quantity on the vertical axe;
- ✓ When there are overlapping breakpoint, consecutive Series_Period classes must be used and the end date and time of the first period must equal the start date and time of the following overlapping period;
- ✓ For each TimeInterval, the position value of the EndDateTime shall be provided, i.e. the time interval includes the end date and time.

4.5 A05 – NON-OVERLAPPING BREAKPOINT

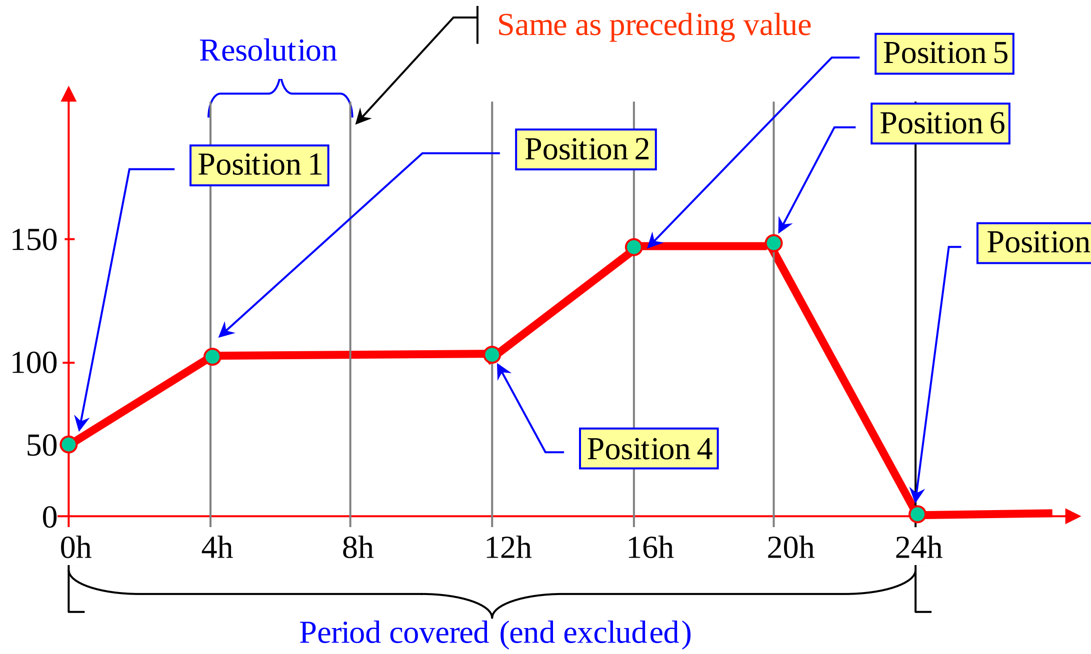

FIGURE 6: NON-OVERLAPPING BREAKPOINTS

The CurveType A05 corresponds to a Period where only the breakpoint positions are present. Only the points representing a power value level change are present within Interval for the Period. Each Breakpoint marks the end of the previous breakpoint. The resolution corresponds to the smallest interval where a power level change may occur. This is a similar curve type to the CurveType A04 except that overlapping breakpoints are not allowed.

The value of the Qty at instant t evolves linearly with the time as follows:

$$Qty(t) = \frac{Qty_{end} - Qty_{start}}{TimeStepPosition_{end} - TimeStepPosition_{start}} * (t - TimeStepPosition_{start}) + Qty_{start}$$

where the “start” and “end” index refers respectively to the current Position and to the next Position provided in the Timeseries. The $TimeStepPosition_{end}$ of a TimeInterval and the $TimeStepPosition_{start}$ of a TimeInterval cannot be the same.

Applying the formula for a TimeInterval 2009-09-09T00:00/2009-09-10T00:00Z and assuming a resolution of 4 hours.

$$TimeStepPosition = StartDateTimeofTimeInterval + (Resolution * (Pos - 1))$$

The following positions are obtained:

1 = (2009-09-09T00:00 + ((1-1) * PT4H) = 00:00 + ((0) *4)

2 = (2009-09-09T00:00 + ((2-1) * PT4H) = 00:00 + ((1) *4)

4 = (2009-09-09T00:00 + ((4-1) * PT4H) = 00:00 + ((3) *4)

5 = (2009-09-09T00:00 + ((5-1) * PT4H) = 00:00 + ((4) *4)

6 = (2009-09-09T00:00 + ((6-1) * PT4H) = 00:00 + ((5) *4)

7 = (2009-09-09T00:00 + ((7-1) * PT4H) = 00:00 + ((6) *4)

1) At 0h00 the value is 50MW;
2) At 04h00 the value is 100MW (indicating that between 00:00 and 04:00 there is an increasing value going from 50 to 100MW);
4) At 12h00 the value is 100MW (indicating that between 04:00 and 12:00 the value is stable at 100MW);
5) At 16h00 the value is 150MW (indicating that between 12:00 and 16:00 there is an increasing value going from 100 to 150MW);
6) At 20h00 the value is 150MW (indicating that between 16h00 and 20:00 the value is stable at 150MW);
7) At 24h00 the value is 0MW (indicating that between 20h00 and 00:00 there is a decreasing value going from 150 to 0MW);

This induces the following rules:

- ✓ Each position identifies a breakpoint;
- ✓ Each breakpoint is related to the next with a straight line;
- ✓ Only positions where a breakpoint occurs are provided;
- ✓ The point is represented by time on the horizontal axe and the quantity on the vertical axe;
- ✓ The position value of the EndDateTime shall be provided, i.e. the time interval includes the end date and time.

5 THE HANDLING OF GAPS

Gaps represent a period in time where no information of the time variable Qty is sent. The exact meaning, in physical terms, of this lack of information depends upon the rules agreed for the business process where the time variable is used. In particular it must not be assumed, unless specifically agreed, that the lack of information is equivalent to assign the value "zero" to the Qty element.

It can concern only certain CurveTypes, i.e. A03, A04 and A05.

Gap shall not be used with CurveType A01 in order to ensure compatibility with the previous implementation.

When using CurveType A02, only the positions having values are provided, thus implicitly gaps are managed.

A gap is represented by the presence of at least two disjoint Series_Period classes within a given time series, i.e. the end date and time of the first period is different from the start date and time of the following period. The end date and time of the Period shall be considered as the start date and time for the gap and the start date and time of the following Period shall be considered as the end date and time for the gap.

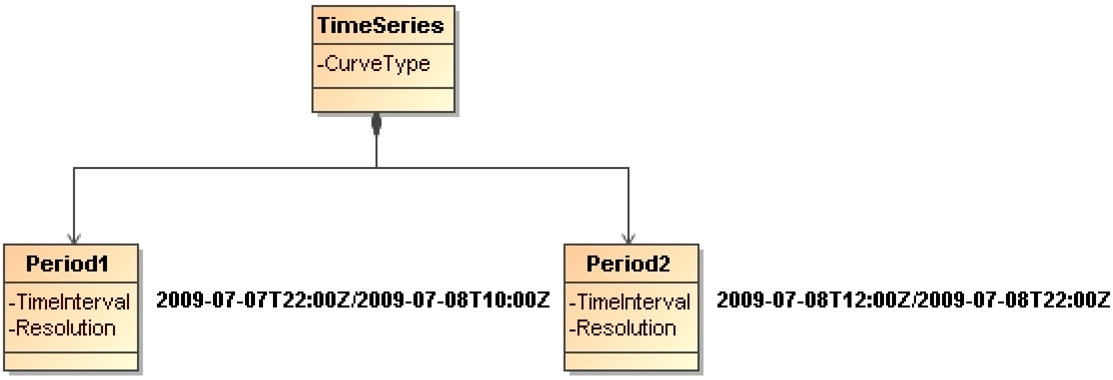

FIGURE 7: TIMESERIES GAP EXAMPLE

In the example in Figure 7, it can be seen that the first Period goes from 22h00 on the 7th of July to 10h00 on the 8th of July. The second Period goes from 12h00 on the 8th of July to 22h00 on the 8th of July. Consequently it can be seen that the gap goes from 10h00 on the 8th of July to 12h00 on the 8th of July.

The gap itself therefore can be expressed as 2009-07-08T10:00Z/2009-07-08T12:00Z. During the whole of this Period no information is being provided.

In addition, hereafter is included an example with gap and overlapping points using the CurveType A04:

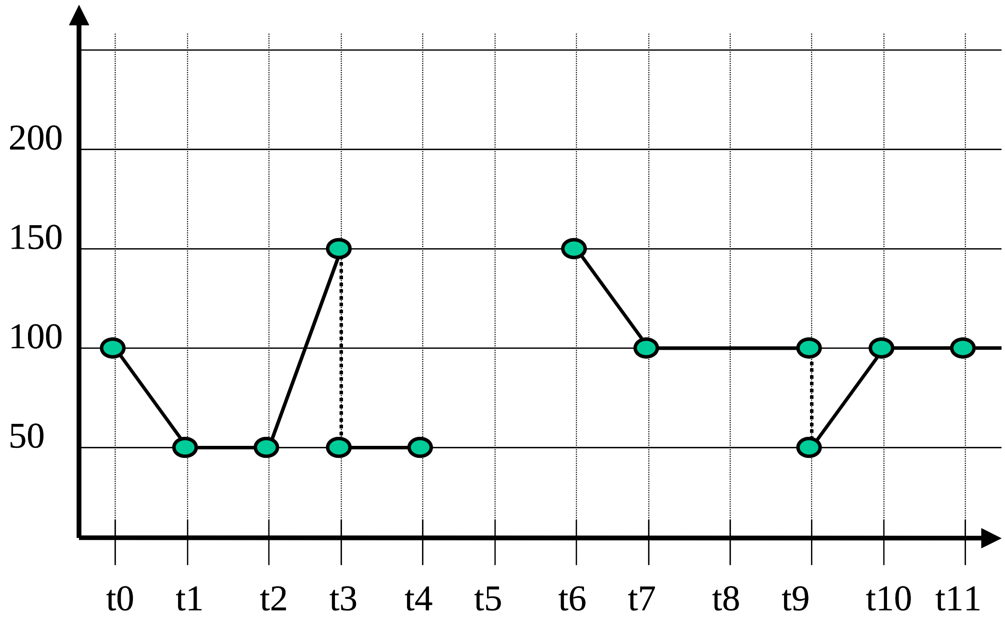

FIGURE 8: TIMESERIES GAP AND OVERLAP EXAMPLE

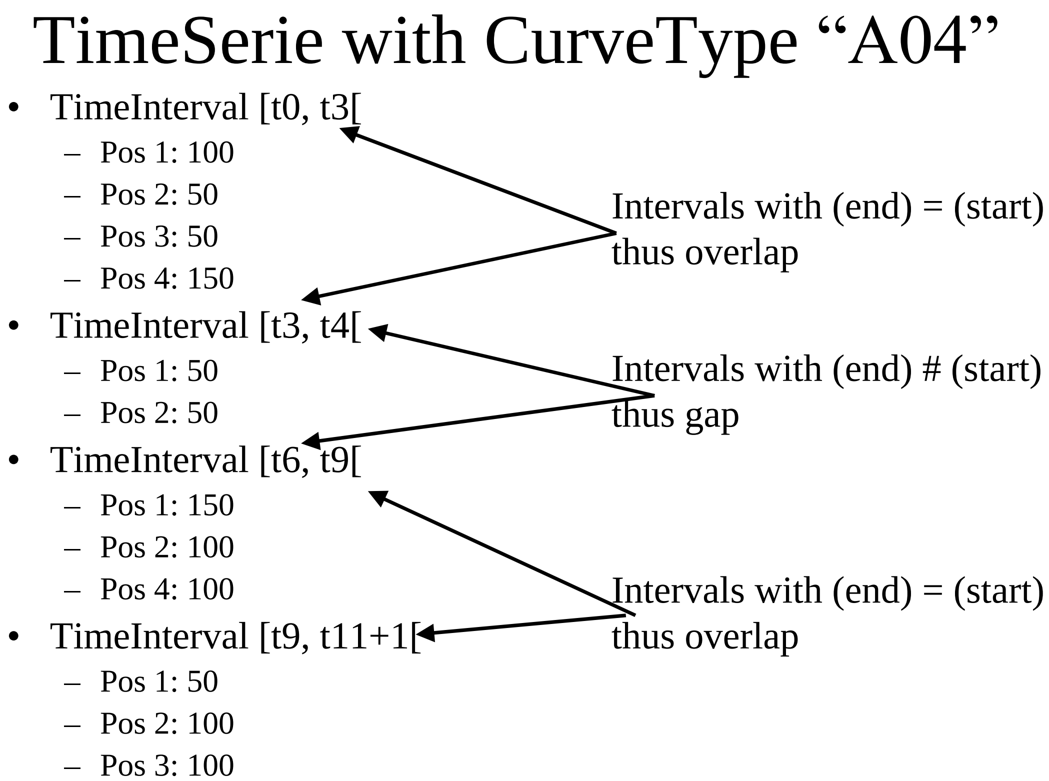

FIGURE 9: TIMESERIES GAP AND OVERLAP DESCRIPTION