# PUBLIC TRANSPORT
# NETWORK TIMETABLE EXCHANGE
# (NeTEx)

# FRAMEWORK

## CEN TC278/WG3/SG9 NeTEx PT001

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# INTRODUCTION

The NeTEx (Network Timetable Exchange) standard is a CEN standard for exchanging public transport data, split into three parts [N1], [N2], [N3]. This white paper gives a short overview of some generic aspects of NeTEx that are common to all functional parts of NeTEx. It covers framework concepts – further common capabilities are provided by certain reusable components, described in a separate white paper [W4].

The common constructs provide powerful data management capabilities, and at the same time help to reduce complexity by giving a significant degree of reuse at both the design and the implementation level. In a nutshell they make NeTEx simpler to use and easier implement.

## AUDIENCE

The paper is intended to convey a high level view sufficient for a technical manager to appreciate the capabilities of NeTEx, and omits all detailed considerations - for a detailed description please see the full CEN NeTEx specification, in particular Part 1 [N1], from which sections of this paper are taken.

# THE NeTEx FRAMEWORKS

The NeTEx schemas provide a modular format for exchanging transport data from many different stakeholders. Since any useful description of transport services is multifaceted in time and space, such data is inherently complex, requiring many interdependent model elements some of which are composite, and furthermore subject to change over time, requiring metadata to manage a continuous integration of compatible versions. In order to simplify both the implementation of systems, and also to reduce the cognitive load of understanding the format, NeTEx adopts a uniform approach to many common aspects of data management such as versioning, identity (the means of uniquely distinguishing each element within and between systems), data aggregation, etc., all variously described through a framework. The uniform approach makes it straightforward to enforce important integrity checks, such as for uniqueness and for referential integrity, using built in XML mechanism, reducing the amount of programming needed to validate data exchanged in NeTEx format.

The framework provides both common universal properties for all elements (such as identity and versioning), and a number of different design patterns of abstract object types for specific purposes which are specialized to create coherent elements with common properties. An example of a simple framework object, is the point; many different types of spatially located element are found in transport; such as route points, stops, vehicle monitoring points, points of interest, etc. The framework provides a generic POINT type with standards based GIS coordinates; such points are specialized variously in the NeTEx functional domains to create different specific point types such as a SCHEDULED STOP POINT, a ROUTE POINT, etc. A slightly more complex example is the point and link sequence; different types of paths through the transport networks can all be described as sequences of points and or links of different types, for example routes, route timings, vehicle journeys etc. NeTEx provides a number of specializations of POINT AND LINK SEQUENCE, each describing a specific type of path and each of which has additional specific properties (and semantics), but is subject to common design pattern constraining its use. For example, a JOURNEY PATTERN is a point sequence of the stops visited by a vehicle executing a timetabled service – it can be considered as both an ordered set of SCHEDULED STOP POINTS, and as an ordered set of SERVICE LINKs, where each link must connect between two different successive stops.
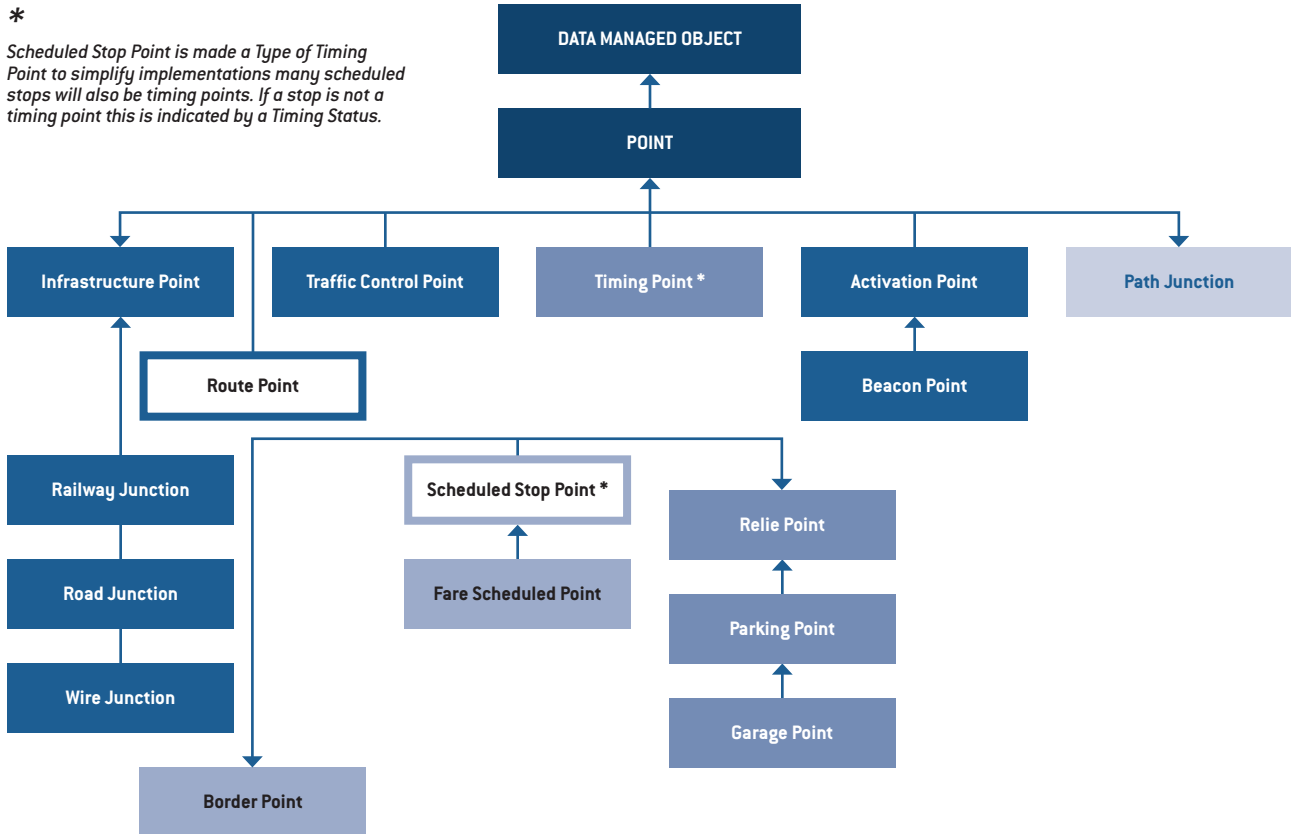
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*Scheduled Stop Point is made a Type of Timing Point to simplify implementations many scheduled stops will also be timing points. If a stop is not a timing point this is indicated by a Timing Status.*



*Figura 2 - Examples of different types of NeTEx Point*

The primary advantage of using a framework is simplicity; only a relatively small number of components and common design patterns need to be grasped in order to understand much of the model, and elements need be described only by their differences from the base elements. Implementation is similarly simplified. Furthermore, evolution of the model at the framework level is extremely powerful in that changes made to the framework apply automatically everywhere they are resolved in the model. The framework also prescribes consistent naming conventions for elements, attributes and relationships, making it easier to identify entities and relate them to the specification.

# NeTEx FRAMEWORK FEATURES

## VERSIONING

Information systems for public transport operation typically require the exchange of many different types of data, produced by different organisations or operating divisions, and are subject to a multi-stage lifecycle, from planning through to production and the realization of the transport services in real-time. For example, in an urban network, stop data might come from the authority, bus timetable data from the bus operators contracted to provide bus services, metro data from the metro operators of each line, rail timetable data from the rail operators, etc. These data are continuously evolving and are subject to a variety of different validity conditions as to when they are current, and as to which data is needed for a particular purpose. NeTEx includes uniform **versioning** and **validity** mechanism to address these requirements; the mechanisms are part of the NeTEx framework and that can be applied to all data elements throughout their various lifecycles.

The NeTEx **versioning** model allows successive versions of data elements to be identified, allowing the fine grained identification of just those elements that have changed, and the auditing of changes. All NeTEx elements are specializations of DATA MANAGED OBJECT, an abstract element with detailed version attributes so that every single object can be individually version managed if desired, with its own creation date, last modification date, version number etc recorded, supporting the exchange and retention of complete histories of objects. Furthermore, references to other objects can also be versioned so that for composite data sets that comprise a number of related elements it is possible to be precise as to which version of each referenced element is required (even if the referenced element is omitted), and giving an importing system the ability to resolve version references. The use of explicit versions also makes it possible to use XMLs built in referential integrity mechanisms to check for completeness of XML documents without any additional implementation programming.

The NeTEx **version frame** mechanism provides a versionable container that allows a coherent and complete set of related elements to be exchanged, that is, compatible versions of elements that do not contain unresolved references. For example, "all the stops making up the Berlin transport network", "all the journeys making up the London - Paris timetable", or "the Autumn 2015 network tariffs". NeTEx provides a number of different types of frame each for a different type of data, for example SITE FRAME for stop date, TIMETABLE FRAME for timetable date, FARE FRAME for fare data, etc., that. The generic version frame provides common properties, and each different type of frame follows a common design pattern as to what how the elements contained in the frame must behave. Frames can themselves be aggregated using a COMPOSITE FRAME, allowing frames of several different data types to be treated as a single coherent whole.

Since pragmatically, actual systems that contain data to be exchanged differ in the sophistication of their support for versioning, the NeTEx mechanisms are furthermore designed so that they may be used either just in a course grained manner at the level of the whole data set (as when say the timetable as a whole has a version number but the journeys and stops in it do not), or if full version support is available, in a more powerful way at the level of the individual data element, with every change tracked.

The NeTEx **validity** model allows conditions to be attached to elements as to when they are current or the circumstances in which they should be used. Validity conditions can be attached to specific elements and also, through version frames, to whole sets of objects so that it is possible to be explicit about the exact conditions governing the coherence and relevance of data. This makes it possible for systems both to express the currency conditions for data they require when requesting data, and to describe the validity of data that is returned by a system. Validity conditions can be expressed using a number of reusable temporal elements, for example "valid on weekdays", "valid in the winter season", or as specific properties of elements, for example "valid when train classification is an express train", "valid on market days" - or a combination. The rovision of a uniform system of temporal validity conditions greatky simplifies the integration of data.

## SUMMARY OF NeTEx VERSION FRAME TYPES

When data is requested from a system that supports NeTEx, it is output as an XML document containing one or more version frame elements. NeTEx provides nine different types of version frame, one of these, the composite frame is used to aggregate other frame types, the others are each concerned with exchanging a particular type of functionally related data.

**Table 1 NeTEX version Frames**

| PART | NAME | DESCRIPTION |
|---|---|---|
| Part1 Framework | RESOURCE FRAME | Used to exchange common reference data such as operators, modes, facilities, day types, calendars, equipment, vehicle types, etc. |
| | GENERAL FRAME | Can be used to exchange any arbitrary user defined set of coherent elements – an extension mechanism. |
| | COMPOSITE FRAME | Used to group other frames for exchange as a single document. |
| Part1 Functional | INFRASTRUCTURE FRAME | Used to exchange details of the road and rail elements making up the underlying network, along with restrictions on using them with specific vehicles. Also locates different points dedicated to the vehicle and crew changeover. |
| | SERVICE FRAME | Used to exchange the basic description of a transport network; stops, lines and routes of a transport including stops and connection, along with the timing. |
| | SITE FRAME | Used to exchange information detailed places and sites such as stations, points of interest parking, including navigation paths and access restrictions. |
| Part 2 Functional | TIMETABLE FRAME | Used to exchange timetables, including journeys, journey parts and couplings, planned interchanges, service facilities, etc. |
| Part3 Functional | FARE FRAME | Used to exchange fare data, including fare structures, fare products, fare restrictions, sales packages, pricing parameters, prices. |
| | SALES TRANSACTION FRAME | Used to exchange descriptions of customers and their purchases. |

## IDENTIFIERS, UNIQUENESS OF REFERENCE AND NAMESPACES

The task of gathering, collating and aggregating data for a public transport network necessarily must be distributed among many different organisations, especially when creating data sets for large cities, regions, or whole countries. Computer systems require unique identifiers to distinguish each individual data element as it appears serialised in an exchange format. The data sets covered by NeTEx are large and belong to many different stakeholders, each of whom may have their own system of identifying elements.

In order to be able to integrate data repeatedly from many diverse systems, it must be possible to give each object a globally unique persistent identifier regardless of its data source. NeTEx is designed to support large scale data integration, and supports uniqueness though the use of namespaces, based on domain and path strings (as familiarly seen in urls), a readily available and well established existing global standard to provide domain names which may be used as the prefixes of labels. Thus for example, a UK bus stop might be identified within the NaPTAN domain, as "naptan.org.uk:21407867", or a German rail timetable as "farhplan.db.de:1234" (or perhaps "db.de/fahrplan:1234". Every NeTEx element in a document is given a unique identifier and NeTEx XML schema enforces well defined uniqueness constraints. To avoid verbose repetition, namespaces can be declared at a version frame level and overridden on individual elements only as necessary.

Identifiers are unique within each type of NeTEx object. Thus for example, the TIMING POINT with id of "hde:123" is different from the ROUTE POINT with an id of "hde:123", since they are different classes of element. Multiple identifier aliases, for example to support mappings to legacy system identifiers are also supported, so it is possible to make repeated "round trip" exchanges of data without ambiguity.

Where data management is distributed, some degree of central coordination is needed to agree who is responsible for which type of data, to agree common interfaces, and in certain cases to agree the partition of code namespaces so that data coded to a common standard can be aggregated without clashes as to the unique identifiers. This can be done through the NeTEx responsibility model.

## RESPONSIBILITY MANAGEMENT

NeTEx data will be used in data management environments that may have a complex organisational structure. For instance, different organisations may be responsible for different types of data, and different organisations or departments may each add, change or remove information in a complex workflow. Plans may be made, revised, forwarded, enriched, combined with other plans and forwarded again to other users for execution and distribution. The participating organisations may be strictly PT concerns such as bus operators, or be external entities, such as governmental departments or management agents. To address this, NeTEx has a flexible organisational and responsibility model that can be configured to enable a wide variety of different workflows. The model in effect defines metadata as to the ownership and use of data that can be used to help manage the data – NeTEx does not of itself define processes or tools for implementing workflows.

The responsibility model allows each data object to be give an owner and a data source, and a set of rights associated with various organisations. Responsibilities can in turn be associated with an administrative model of organisations and departments defined using NeTEx's reusable components (cf. Reusable Components White Paper).

The responsibility model makes it possible:

- To define operational responsibility for the real-life entities that are described by the information. For example it can specify which organisation is responsible for planning and maintenance of the physical stop, or the services at the stop.
- To define data management related responsibilities for the information itself. E.g. functional or technical IT data management regarding a set of produced, collected or forwarded plan information. This can be used to identify who needs to be contacted to correct or amend data.

If used, the responsibility model can be applied to achieve the following goals:

- Provide as part of the passenger information the contact information of agencies or help-desks to turn to in case of reservations, questions, complaints, etc.
- Provide IT and PT related responsibility information for the purpose of management, assessment, etc. activities concerning quality management of data.
- Associate Intellectual Property Rights with individual data elements or groups of elements.
- Implement the delegation of data management: a receiving system can check the authorizations in relation to responsibility for provided data and see if the provider is authorised to manage that data. This concept can be used to protect data from being changed by the wrong parties.

## SUMMARY OF GENERIC FRAMEWORK COMPONENTS

The NeTEx framework has a small set of abstract elements which are specialised to create the actual concrete elements of the NeTEx format. The elements specify common attributes and imply the existence of specific behaviour in their subtype elements.

### Generic Framework elements

The following provide basic abstract elements for NeTEx function:

- DATA MANAGED OBJECT element: provides common version management and responsibility properties. It is the ur object for all NeTEx elements.
- VERSION FRAME element: provides a properties and behaviour of a version frame, a container for holding other elements for exchange. It is specialised as a number of different concrete frames as listed in Table 1 above.

### Design pattern Framework components

The following abstract elements can be specialised to create elements with particular desired properties that will interact in specific roles with other elements:

- GROUP OF ENTITies element: provides abstract properties for elements that reference a set of other entities, (for example a ZONE includes a set of POINT references) a means of grouping elements and is used as abstract supertype for many different aggregates.
- The POINT & LINK model provides abstract elements for defining 0D points and 1D links.
- The LINK SEQUENCE model provides elements to defining graphs of points or links as commonly found in layered PT models.
- The ZONE model provides a model for defining 2D zones (with possible 0D point centroid).
- The PROJECTION model provides a means of defining mappings between different graphs of POINTs and LINKs, so that for example a transport route (a schematic view of a vehicle path) may be mapped to a road infrastructure element.
- The PLACE element provides a model for defining named places and links between them, including their relationship to COUNTRies. It can have spatial and navigation properties.
- The ASSIGNMENT element provides common behaviour for dependent ancillary elements which assign additional and often alternative sets of attributes to other entities.
- TYPE OF VALUE is used where the choice of values of attributes is restricted to a discrete "code set" of named values but the set itself needs to be extensible; this is specialised to create specific sets of values whose use can be validated using the XML validator. A VALUE SET is used to group value definitions.

# ACKNOWLEDGEMENT

# FURTHER READING

## THE NeTEx STANDARD

[N1]　NeTEx-Part 1: *Public Transport Network Topology exchange format, CEN/TS 16614-1:2014*
[N2]　NeTEx-Part 2: *Public Transport Scheduled Timetables exchange format, CEN/TS 16614-2:2014*
[N3]　NeTEx-Part 3: *Fare Information exchange format, CEN/TS 16614-3:2014.*

## OTHER NeTEx WHITE PAPERS

[W1]　NeTEx *Introduction* - White Paper
[W2]　NeTEx *Getting Started* - White Paper
[W3]　NeTEx *Design Methodology* - White Paper
[W4]　NeTEx *Reusable Components* - White Paper
[W5]　NeTEx *Network* - White Paper
[W6]　NeTEx *Flexible Networks and Multimodality* - White Paper
[W7]　NeTEx *Accessibility* - White Paper
[W8]　NeTEx *Timetables* - White Paper
[W9]　NeTEx *Fares* - White Paper

## FURTHER INFORMATION

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