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Information technology — City data model —

Part 3: Service level concepts for transport

Technologies de l'information — Modèle de données urbaines —

Partie 3: Concepts de niveau de service dans le domaine des transports

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*, in collaboration with Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

A list of all parts in the ISO/IEC 5087 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The intended audience for this document includes municipal information systems departments, municipal software designers and developers, and organizations that design and develop software for municipalities.

Cities today face a challenge of how to integrate data from multiple, unrelated sources where the semantics of the data are imprecise, ambiguous and overlapping. This is especially true in a world where more and more data of interest are being openly published by various organizations. A morass of data is increasingly becoming available to support city planning and operations activities. In order to be used effectively, it is necessary for the data to be unambiguously understood so that it can be correctly combined, avoiding data silos. Early successes in data “mash-ups” relied upon an independence assumption, where unrelated data sources were linked based solely on geospatial location, or a unique identifier for a person or organization. More sophisticated analytics projects that require the combination of datasets with overlapping semantics entail a significantly greater effort to transform data into something useable. It has become increasingly clear that integrating separate datasets for this sort of analysis requires an attention to the semantics of the underlying attributes and their values.

A common data model enables city software applications to share information, plan, coordinate and execute city tasks, and support decision making within and across city services, by providing a precise, unambiguous representation of information and knowledge commonly shared across city services. This requires a clear understanding of the terms used in defining the data, as well as how they relate to one another. This requirement goes beyond syntactic integration (e.g. common data types and protocols), it requires semantic integration: a consistent, shared understanding of the meaning of information.

To motivate the need for a standard city data model, consider the evolution of cities. Cities deliver physical and social services that traditionally have operated as silos. In other words, data are generated, processed and used by systems that are nominally under the control of one or more parties with similar interest, and are thus handled in such a way as to facilitate the business processes of those parties. Parties with other interests and business needs develop their own data, often with different requirements and data sharing among the different groups is limited.

If during the process of becoming smarter, transportation, social services, utilities, etc. were to develop their own data models, the result would be smarter silos. To create truly smart cities, data need to be shared across these silos. This can only be accomplished through the use of a common data model. For example, “Household” is a category of data that is commonly used by city services. Members of Households are the source of transportation, housing, education, and recreation demand. This category represents who occupies a home, their age, their occupations, where they work, their abilities, etc. Though each city service can potentially gather and/or use different aspects of a Household, much of the data need to be shared.

Supporting this interoperability among city datasets is particularly challenging due to the diversity of the domain and the heterogeneity of its data sources. The purpose of this document is to support the precise and unambiguous specification of city data using the technology of ontologies[1],[2] as implemented in the Semantic Web.[3] By doing so it will:

— enable the computer representation of precise definitions thereby reducing the ambiguity of interpretation;

— remove the independence assumption, thereby allowing the world of Big Data, open-source software, mobile apps, etc., to be applied for more sophisticated analysis;

— achieve semantic interoperability, namely the ability to access, understand, merge and use data available from datasets spread across the Semantic Web;

— enable the publishing of city data using Semantic Web and ontology standards;

— enable the automated detection of city data inconsistency, and the root causes of variations, and

— support semantic interoperability of city data in SMART transformation and smart governance.

With a clear semantics for the terminology, it is possible to perform consistency analysis and thereby validate the correct use of the standard.

Figure 1 identifies the three levels of the ISO/IEC 5087 series. The lowest level, defined in ISO/IEC 5087-1, provides the classes, properties and logical, computational definitions for representing the concepts that are foundational to representing any data. The middle level, defined in ISO/IEC 5087-2, provides the classes, properties and logical, computational definitions for representing urban-specific concepts common to all city services but not specific to any service. The top level provides the classes, properties, and logical, computational definitions for representing service-specific concepts that are used by other services across the city. For example, ISO/TS 5087-3 (this document) defines the transport concepts. In the future, additional parts will be added to the ISO/IEC 5087 series covering services such as education, water, sanitation, energy, etc.

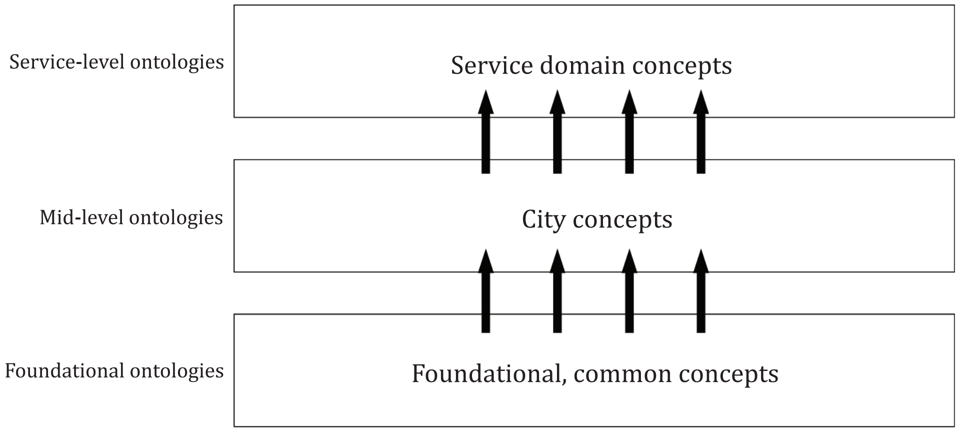

Figure 1 — Stratification of city data model

Figure 2 depicts example concepts for the three levels.

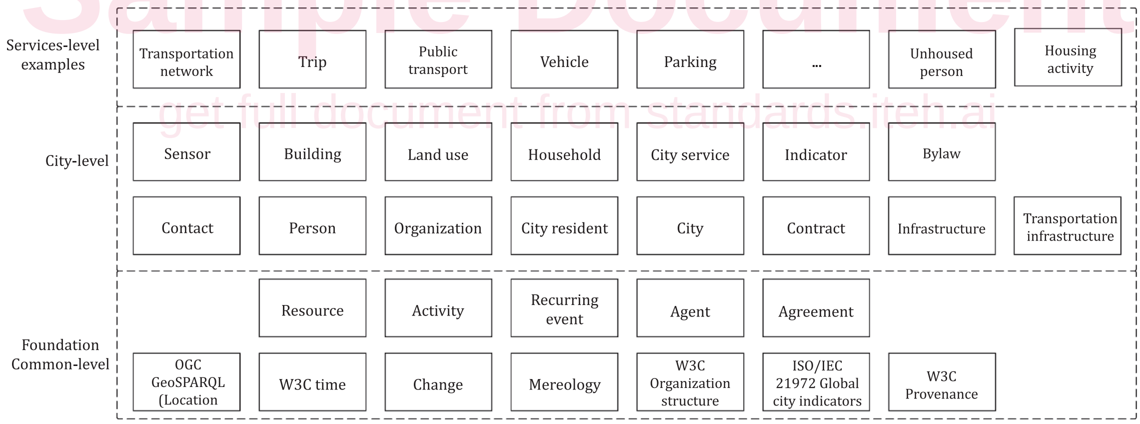

Figure 2 — Example concepts for each level

Information technology — City data model —

Part 3: Service level concepts for transport

1 Scope

This document defines an ontology for service level concepts defined for the transport domain using terms specified in ISO/IEC 5087-1 and ISO/IEC 5087-2. The values for service-level concepts defined in this document are intended to be managed by the transport domain but accessible by multiple city services and stakeholders.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 5087-1, *Information technology — City data model — Part 1: Foundation level concepts*

ISO/IEC 5087-2, *Information technology — City data model — Part 2: City level concepts*

ISO/IEC/IEEE 24765, *Systems and software engineering — Vocabulary*

ISO/TS 14812, *Intelligent transport systems — Vocabulary*

Manchester Syntax, W3C Editor's Draft 28 November2008, https://www.w3.org/2007/OWL/draft/ED-owl2-manchester-syntax-20081128/

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC/IEEE 24765, ISO/TS 14812, ISO/IEC 5087-1 and ISO/IEC 5087-2 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Abbreviated terms and namespace prefixes

DL	description logic
OWL	ontology web language
RDF	resource description framework
RDFS	resource description framework schema
IRI	international resource identifier

The following namespace prefixes are used in this document:

— cdm1: https://w3id.org/citydata/part1/v1/

— cdm2: https://w3id.org/citydata/part2/v1/

— geo: http://www.opengis.net/ont/geosparql#

— rdfs: https://www.w3.org/2000/01/rdf-schema#

— time: https://www.w3.org/2006/time#

— xsd: https://www.w3.org/2001/XMLSchema#

5 Conventions

5.1 Documentation format

The formalization of the classes in this document is specified using the table format shown in Table 1, which is a simplification of description logic (DL) where the first column identifies the class name, the second column identifies its properties, the third column indicates the multiplicity of the property (i.e. how many instances of the property can occur for each instance of the class), and the fourth column identifies each property's value restriction. It shall be read as: "The <Class> is a conjunction of the associated <property> with their specified <multiplicity> and <value restriction>". Value restrictions are specified according to Manchester syntax as defined by the W3C. For example, Table 1 specifies that Agent is a subclass of the intersection of (Person or Organization) and can be an org_s:memberOf of zero or more Organizations. Value restrictions are interpreted as follows:

— "only Organization" is interpreted as the value of the property is restricted to being instances of the class Organization or of one of its subclasses. In the UML diagrams, this is depicted as an «only» restriction.

— "min 1 Organization" is interpreted as the value of the property is restricted to having at least one value that is an instance of the class Organization or of one of its subclasses. In UML diagrams, this is depicted as an «min 1» restriction.

— "max 2 Organization" is interpreted as the value of the property is restricted to having at most two values that are instances of the class Organization or of its subclasses. In UML diagrams, this is depicted as an «max 2» restriction.

Table 1 — Example formalization of the Agent class

Class	Property	Mult.	Value restriction
Agent	rdfs:subClassOf		Person or org_s:Organization
	org_s:memberOf	0..*	only Organization
	individual		{joe, frank}

CamelCase is used for specifying classes, properties and instances. For example, "legalName" instead of "legal_name". The first letter of a class name is capitalized. The first letter of a property and instance name are not capitalized.

An instance of a class shall satisfy the class's definition. The instance's properties and values shall satisfy the multiplicity and value restrictions of the class it is an instance of.

The formalization of properties in this document is achieved similarly to the formalization of classes, using the table format shown in Table 2, which allows for the identification of properties and their sub-properties, inverse properties

or other characteristics. It shall be read as: "The <property> is <characteristic> of <value>", or simply "the <property> is <characteristic>" if no value is applicable. For example, in Table 2 hasPrivilege is a sub-property of the agentInvolvedIn property. Characteristics are specified using the Manchester syntax.

Table 2 — Example property formalization

Property	Characteristic	Value (if applicable)
hasPrivilege	rdfs:subPropertyOf	agentInvolvedIn
	Irreflexive	

In the case of DL definitions of classes where the simplified table representation is insufficient, the DL specification will be supplied as an addition to the content in the table.

The table-based definitions are supplemented by informative UML diagrams according to the conventions defined in Annex A.

The patterns defined in this document are formally defined at https://w3id.org/citydata/part3/v1/ as open-source material. This document recognizes release 0.0 of that open-source ontology (https://w3id.org/citydata/part3/v1/5087-3/r0.0/) as forming part of an ISO standard. However, the latest v1 release should always be considered.

NOTE Ontology version and release numbers follow the logic of semantic versioning, but the major version is kept with the ontology IRI as the "v" number while the minor version and patch number only appear in the version IRI as the "r" number. This allows for stable IRIs for updates that are backwards compatible. The ontology files are maintained based on user demand while the ISO standards capture snapshots of these ontologies at distinct points in time. By comparison, the edition number on an ISO standard is a sequential integer and unrelated to the semantic version of the ontology.

5.2 Datatypes

The datatypes assigned to data properties use XML schema datatypes in conformance with widely accepted data practices within the web ontology language and city data model communities. The datatypes provided are intended to describe the range of values intended for the data property but are not intended to constrain the representation to XML.

5.3 Unique identifiers

All classes, properties and instances of classes have a unique identifier that conforms to Linked Data/Semantic Web standards. The unique identifier is an IRI. When using this document in an application, a class is identified by the IRI for the pattern of which it is a member, followed by the class name. In the Agent example in 5.1, the unique identifier for the Agent class, which is formally defined in ISO/IEC 5087-1 would be:

https://w3id.org/citydata/part1/v1/Agent

Breaking the IRI down:

— "https://w3id.org/citydata/part1/v1/" identifies the ontology IRI

— "Agent" identifies the Agent class within the ontology.

The IRI can be shortened using the prefix defined in Clause 4:

cdm1:Agent

where cdm1: is the prefix for the Agent Pattern.

Properties are identified in the same manner. The IRIs of individuals created by an application of ISO/IEC 5087-2 would have IRIs unique to the application.

5.4 Official URLs

The official ontologies referenced by this document can be found at the locations indicated by the IRI and making the request for the "application/rdf" file, which is typical of ontology tools. When using a web browser, the IRIs can default to a webpage instead, which then provides the link to the ontology file. The official ontology for the content of this document can be found at https://w3id.org/citydata/part3/v1/5087-3.owl/r0.0.

6 Service-level ontologies for transport

6.1 General

The service-level documents of the ISO/IEC 5087 series provide representations for concepts that are used by services that operate in the city context. The following concepts can be used (consumed) by multiple different city services and stakeholders but are typically only generated by the city service area identified in the part name (i.e. in the case of this document, the data are typically only generated by transport services).

The patterns defined in the service-level documents of the ISO/IEC 5087 series conform to the foundational and city-level concepts defined in ISO/IEC 5087-1 and ISO/IEC 5087-2, respectively. Specific references to content defined in ISO/IEC 5087-1 and ISO/IEC 5087-2 are identified in text descriptions of pattern imports, as well as through the explicit identification of terms from ISO/IEC 5087-1 and ISO/IEC 5087-2.

6.2 Transport network pattern

6.2.1 Overview

The Transport network pattern models the core concepts involved in describing a transport network. This includes an identification of both physical and administrative characteristics. The most general class is that of the NetworkElement, which can be further classified as one of several types of NetworkElements.

A key feature of this pattern is the formalization of the hasProperPart relationship from a NetworkElement to another NetworkElement. This allows for a representation of networks at multiple levels of detail. For example, at one level, a motorway interchange can be modelled as a single node. But that node is a NetworkElement that can be defined to consist of an entire TransportNetwork that has a node for each junction within the interchange.

6.2.2 Key classes and properties

6.2.2.1 Network element

A NetworkElement represents any element of a transport network. It can be a part of another NetworkElement and can be decomposed into smaller NetworkElements. Each NetworkElement is characterized with a unique identifier. A NetworkElement can be characterized by its status. Figure 3 provides an overview of a NetworkElement.

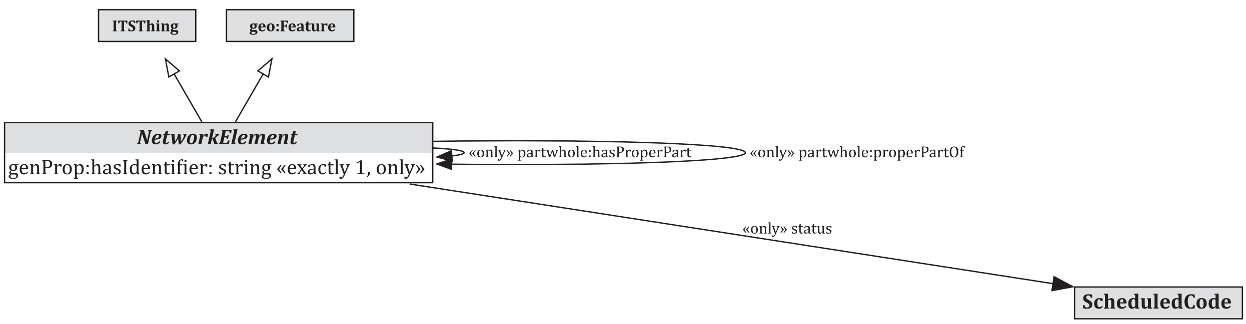

Figure 3 — Network element model

6.2.2.2 Transport network

A TransportNetwork is a NetworkElement that is a collection of other network elements that jointly represent a network of paths along which entities (e.g. vehicles, pedestrians) of a specified mode can operate. Figure 4 provides an overview of a TransportNetwork.

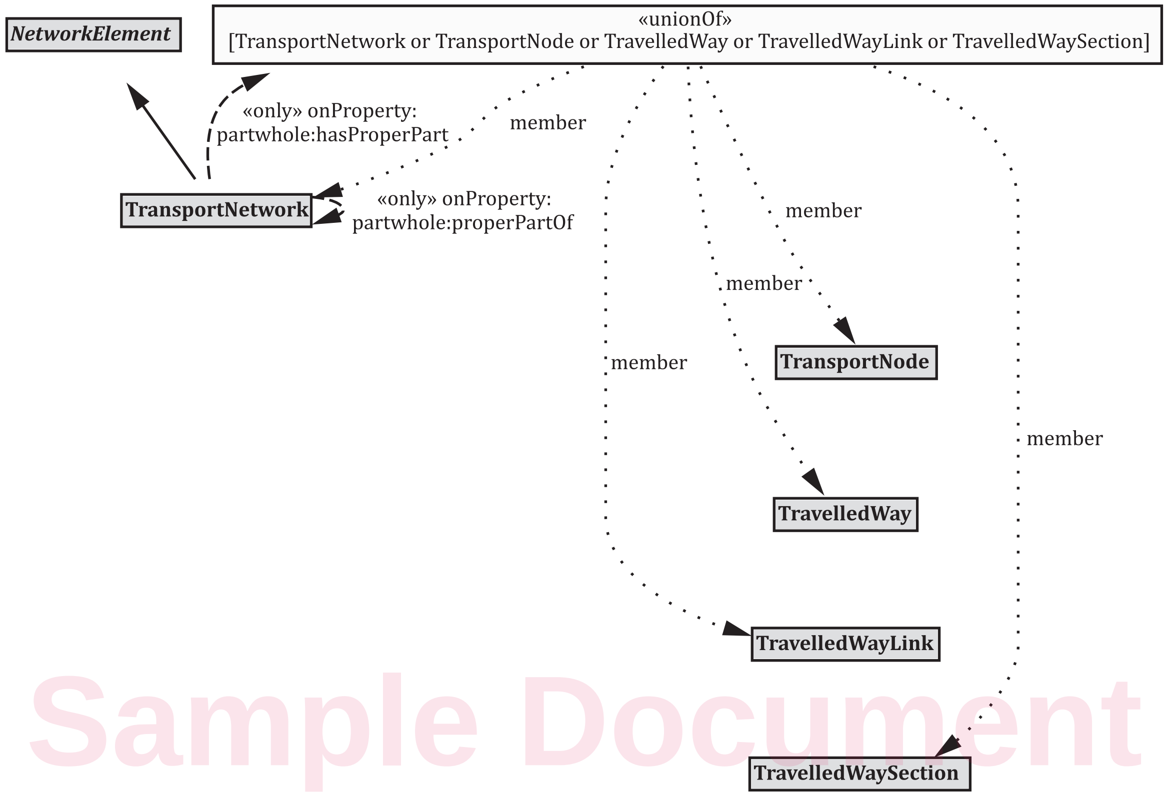

Figure 4 — Transport network model

6.2.2.3 Transport node

A TransportNode is a NetworkElement that represents a node on the transport network that can be used to designate an end to a link or to join links. Each TransportNode is a part of at least one TransportNetwork. A TransportNode is characterized by ingress and egress TravelledWayLinks. The ingress and egress link can be the same link if it is bi-directional (e.g. a cul-de-sac). Figure 5 provides an overview of a TransportNode.

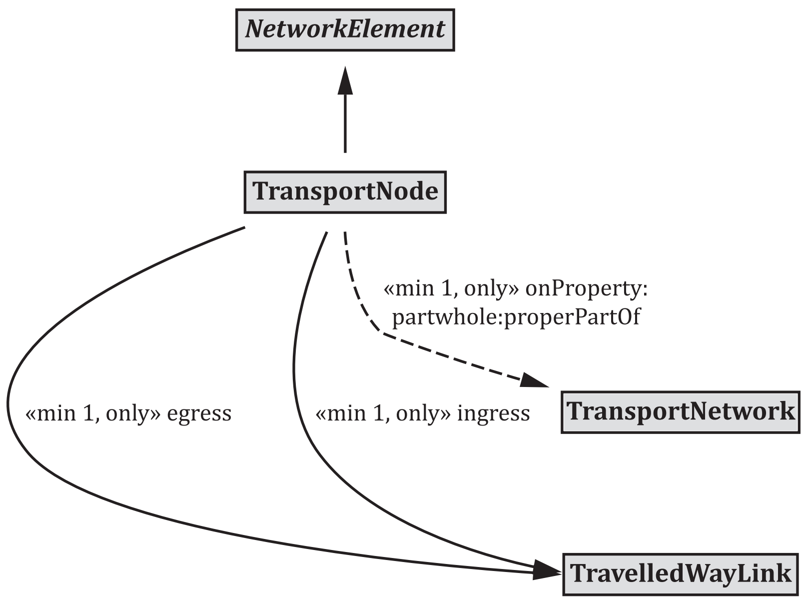

Figure 5 — Transport node model

6.2.2.4 Junction

A Junction is a TransportNode that allows a traveller to connect from one TravelledWayLink to another.

6.2.2.5 Travelled way

A TravelledWay is a type of NetworkElement and transinfras:TravelledWay that represents the curvilinear length of a transport route that is identified by a specific designator. It is a generalized class that can be specialized into mode-specific terms (e.g. for a road or for a rail corridor).

Each TravelledWay is defined as being a part of at least one TransportNetwork and can be decomposed into TravelledWayLinks. TravelledWays are identified with a unique designator. Figure 6 provides an overview of a TravelledWay.

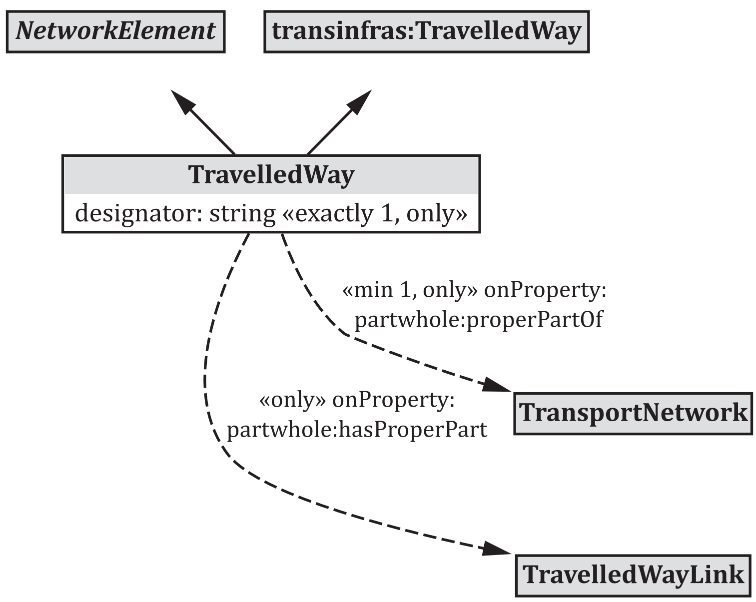

Figure 6 — Travelled way model

6.2.2.6 Travelled way link

A TravelledWayLink is a type of NetworkElement and transinfras:TravelledWayLink. It represents a contiguous length of a TravelledWay between two TransportNodes of operational or managerial significance. Each TravelledWayLink is a part of at least one TransportNetwork and can form a part of TravelledWays and TravelledWaySections. A TravelledWayLink can be composed of only TravelledWaySegments. A TravelledWayLink starts from one TransportNode and connects to a second TransportNode. A TravelledWayLink can be characterized by its allowed directions of travel (e.g. forward from the first node to the second node, reverse from the second node to the first, bi-directional, closed).

For example, a TravelledWayLink can be defined from one signalized intersection to the next or from one bus stop to the next. Figure 7 provides an overview of a TravelledWayLink.

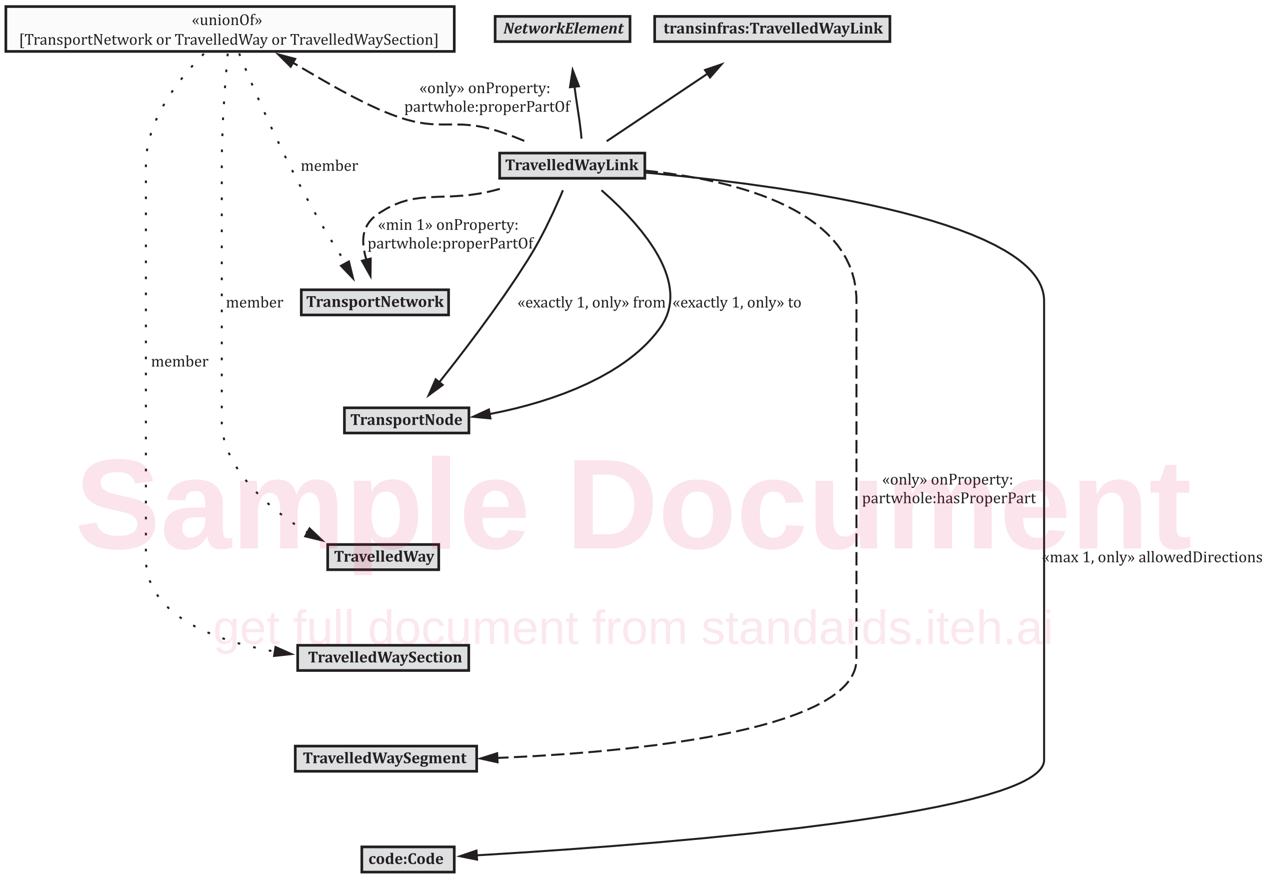

Figure 7 — Travelled way link model

6.2.2.7 Travelled way section

A TravelledWaySection is a type of NetworkElement that represents an aggregation of TravelledWayLinks and TravelledWaySegments that jointly represent a contiguous length of a path that shares the same management and operational strategies (within the scope of interest of the implementation). Each TravelledWaySection is part of at least one TransportNetwork. It can only be parts of TransportNetworks and TravelledWays. A TravelledWaySection consists of only TravelledWayLinks.

For example, a TravelledWaySection can be used to represent the portion of a TravelledWay that uses the same traffic signal coordination strategy. It can also be used to represent a bus line or subway line. Figure 8 provides an overview of a TravelledWaySection.

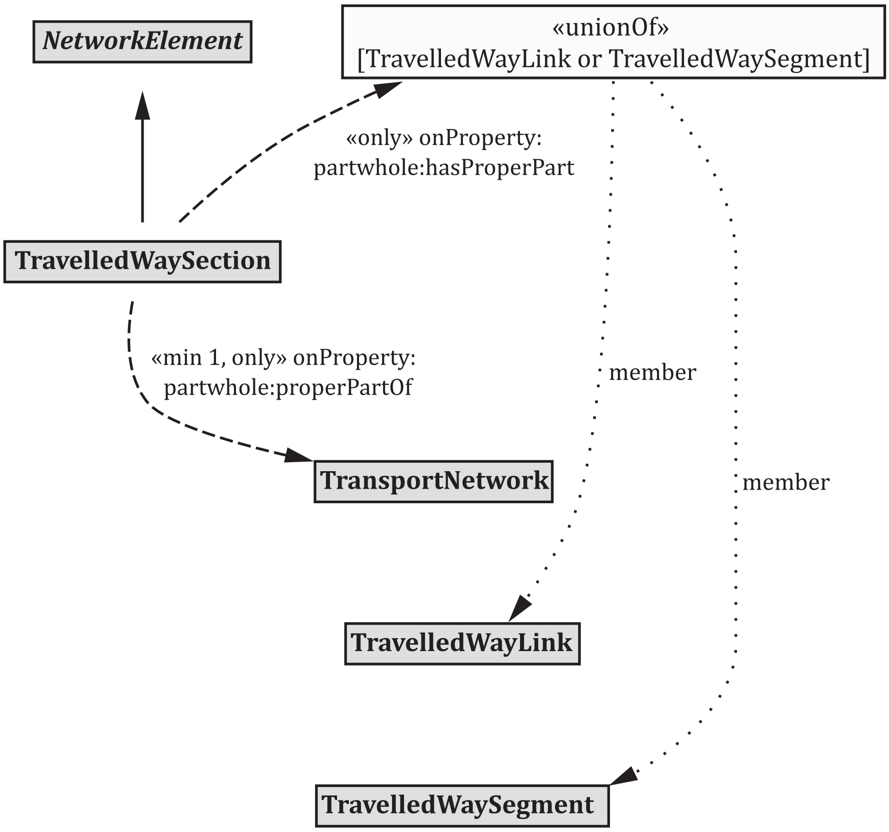

Figure 8 — Travelled way section model

6.2.2.8 Travelled way segment

A TravelledWaySegment is a type of a transinfras:TravelledWaySegment and NetworkElement that represents a contiguous length of a TravelledWayLink characterized by the same physical characteristics. Each TravelledWaySegment is a part of at least one TravelledWayLink and can be a part of a TravelledWaySection (e.g. if the section does not end at a TransportNode). A TravelledWaySegment consists of one or more TravelledWayLanes.

For example, a TravelledWayLink can be defined to connect two TransportNodes. If the number of lanes changes in the middle of the TravelledWayLink, the unique physical characteristics of each component part of the TravelledWayLink can be defined by defining separate TravelledWaySegments.

Any TravelledWaySegment can be defined to be a part of a TravelCorridorSegment. Figure 9 provides an overview of a TravelledWaySegment.

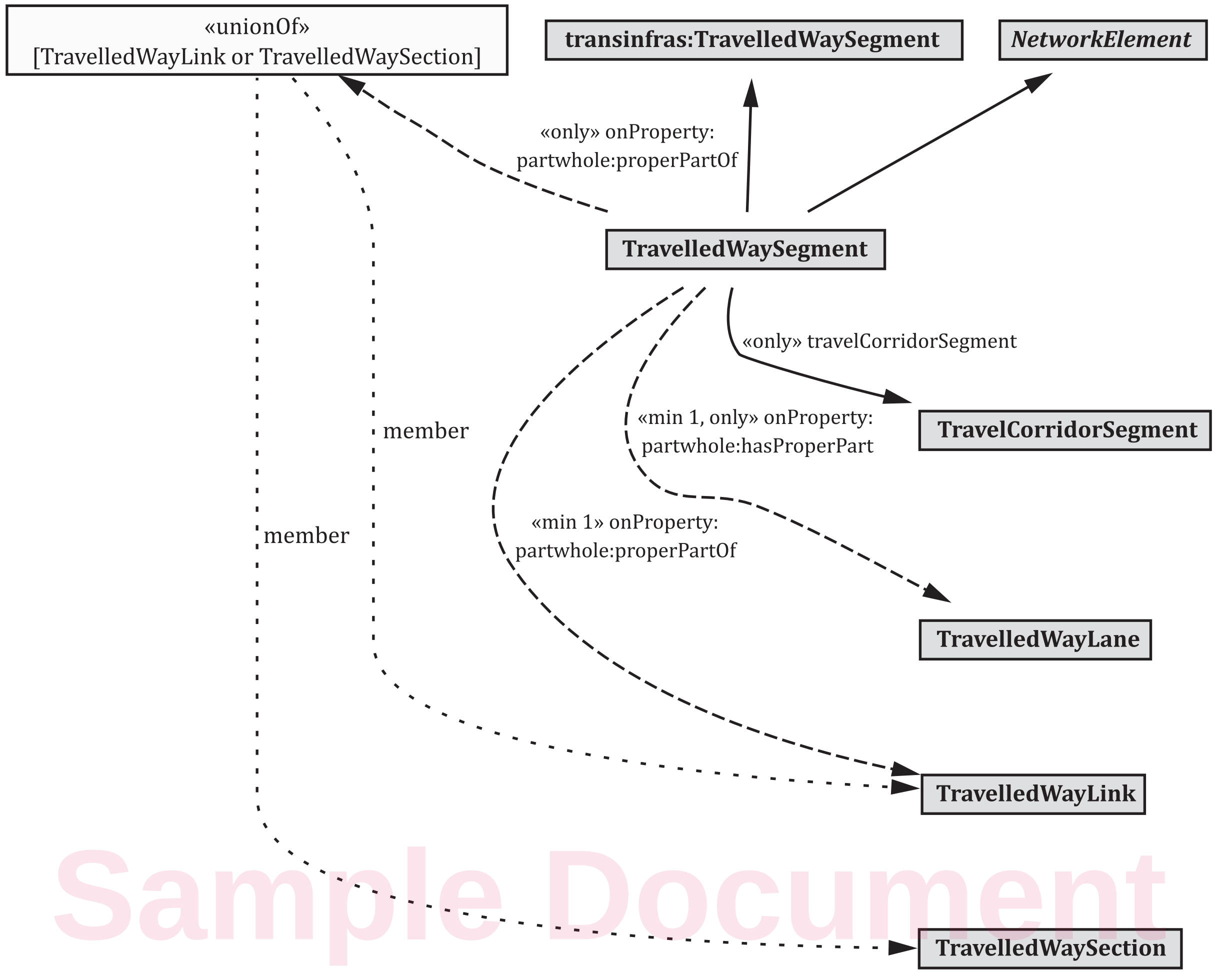

Figure 9 — Travelled way segment model

6.2.2.9 Travelled way lane

A TravelledWayLane is a NetworkElement that is a portion of TravelledWaySegment intended to accommodate a single line of moving material entities (e.g. vehicles) along its length. Figure 10 provides an overview of a TravelledWayLane.

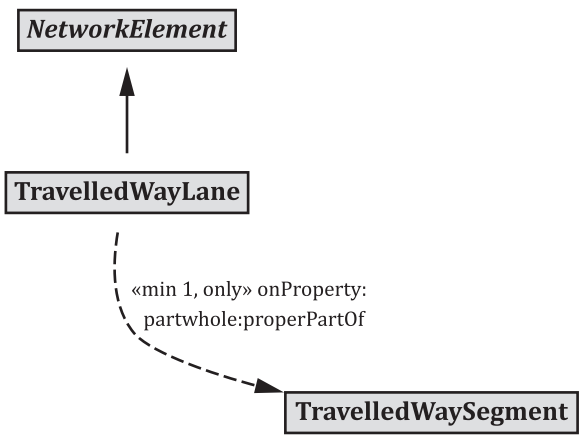

Figure 10 — Travelled way lane model