

Transmodel

Fare Management

EN12896 – 5

The fare management data model aims at a generic description of the data objects and elements needed to support functions such as defining of the tariff structures, fare products and their parameters; operating sales, validating the consumption and charging customers. Tariff structures and products can be complex and there are differences in how these functions and their underlying data structures are handled in different European countries, and even between the public transport operators within one country - it is notable that historically there have been little attempt to standards fares across all modes.

Faced by such a degree of complexity and diversity in the concepts to be taken into account, in order to define a single fare management data model capable of covering as many existing solutions and practices as possible, a careful separation of concerns is required, together with some novel modelling abstractions. The resulting fare management data model concentrates on the abstract, generic concepts that form the core of any fare system, independently of how these abstract concepts are implemented by a set of concrete fare products (e.g. tickets or passes) offered for sale to the public.

The starting point for the description of these fundamental concepts is the definition of theoretical *access rights*, based on use of network and temporal elements. These can be combined to form immaterial fare products, which are linked to travel documents in order to form sales packages to be sold to passengers. Controls may be applied to these travel documents to validate the utilisation of the public transport system. Price components are linked to the access rights, fare products and sales packages: they are used to calculate the price to be paid by a customer for a specific consumption (e.g. sale on a vending machine, debiting a value card, post-payment).

This paper presents in brief the following topics discussed in detail in EN12896-5:

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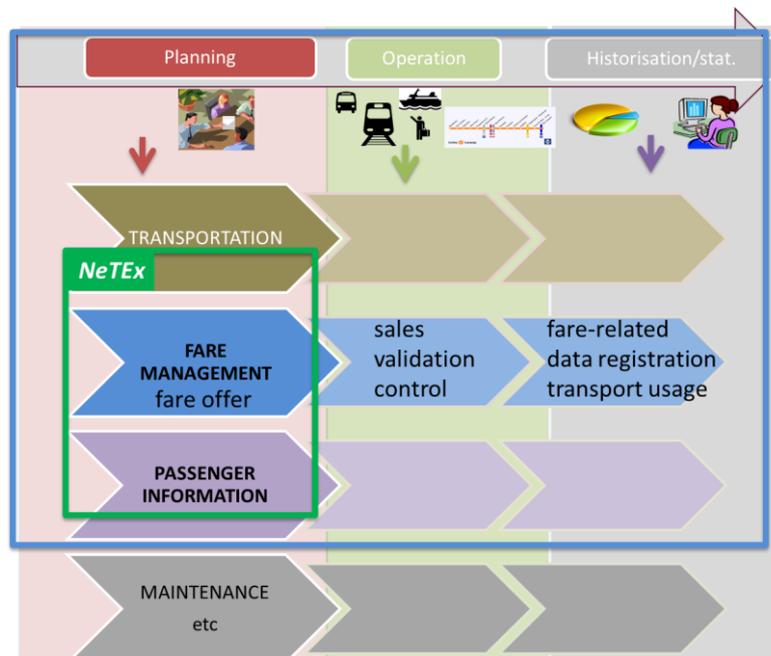
1 Overview

1.1 Fare model in the overall context of transportation

The Fare Management model covers mainly the planning and operational stages of use:

- definition of the fare offers, information on fares and prices in the planning stage
- operational processes, such as sales, control and validation of access rights.

Transport usage information through the registration of fare-related data is also modelled.



However, not all the functional aspects of the planning and operational stage are taken into account in the reference model. Data requirements for the following domains are only partly covered:

Sales organisation:

- Management of the sales network (not covered, some basic retail and distribution elements relevant for passenger information are included).
- Sales operations, including fulfilment (partly covered).
- Management of customers (partly covered).
- Collecting funds or accounting (not covered).

Pricing:

- Pricing parameters specification (partly covered).
- Exact price calculation (not covered).

Consumption control:

- Access right validation & control (covered).
- Fraud management and revenue protection measures (partly covered).
- Collection and aggregation of consumption data (partly covered).

The implementation of Transmodel as an XML schema within the Technical Specification NeTEx (TS 16614-3) covers the planned fares offer including information on fare offers and prices, i.e. concerns the planning stage.

1.2 What data domains are part of the Fares Model?

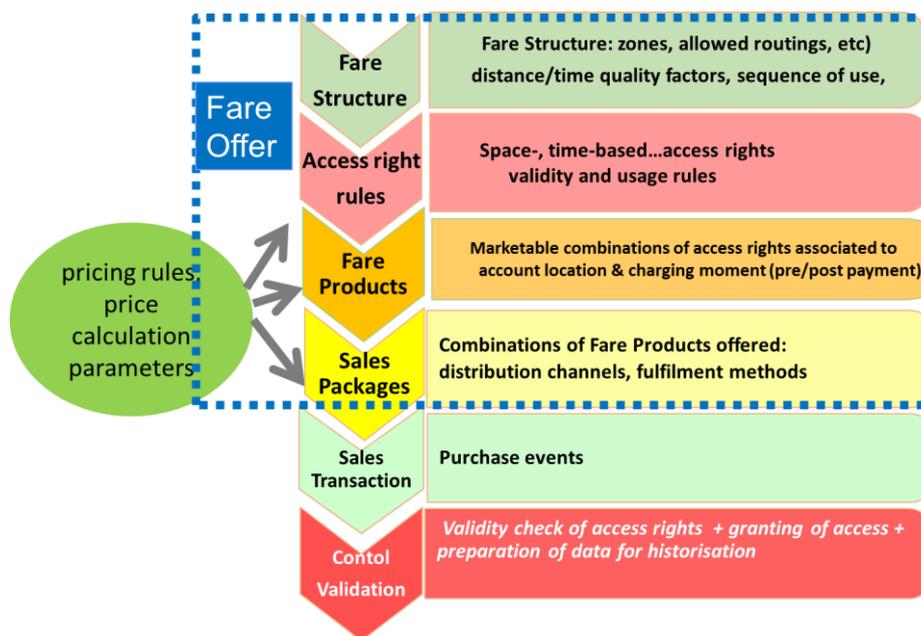
The data model for the Fare Management domain incorporates the following data packages:

- Fare Structure Description
- Access Rights Description
- Pricing
- Sales Description
- Customer & Sales Transaction
- Fare Roles
- Validation and Control
- Explicit Frames

As in all other domains the model represents the data needed for the different processes; in this case, it is concerned with functional domains such as sales, distribution, retail, traveller information on available fare products, control of access rights and validation.

In other words, the modelling addresses **what** information elements are needed and **not how** the information is processed.

The fare offer data domain splits further into sub-domains corresponding to well identified data packages as described above: Fare Structure Description, Access Rights Description (Access Rights Rules & Fare Products), Pricing and Sales Offer Description.



1.3 General nature of the approach, through an example

Often there is a simple one-to-one correspondence between the network, the fare structure, the access rights, and the products offered. For example, a product giving use of a zone or zones in a zonal system, or to go between an origin and destination in a point-to-point tariff system. Such fare structures are relatively trivial to describe. Here we consider a slightly more complex example that serves to illustrate the distinctions between network elements, access rights and products.

The following example considers a number of different **access rights** to use different elements of Public Transport that could be combined within one or more fare products:

1. The operator of a Public Transport system offers travel on public transport services within a zonal fare system covering a city. The same set of tariff zones apply to both bus and metro but there are slightly different constraints on travelling by each separate mode:

- The bus trip allows travel between any bus stop within the named zones, with unlimited transfers between different bus lines during a specified time interval.
- The metro trip allows travel through a specified number of zones.
- A bus trip may be followed by a metro trip (in that order only).

2. Parking stakeholders (with their own fare structure) may define an access right:

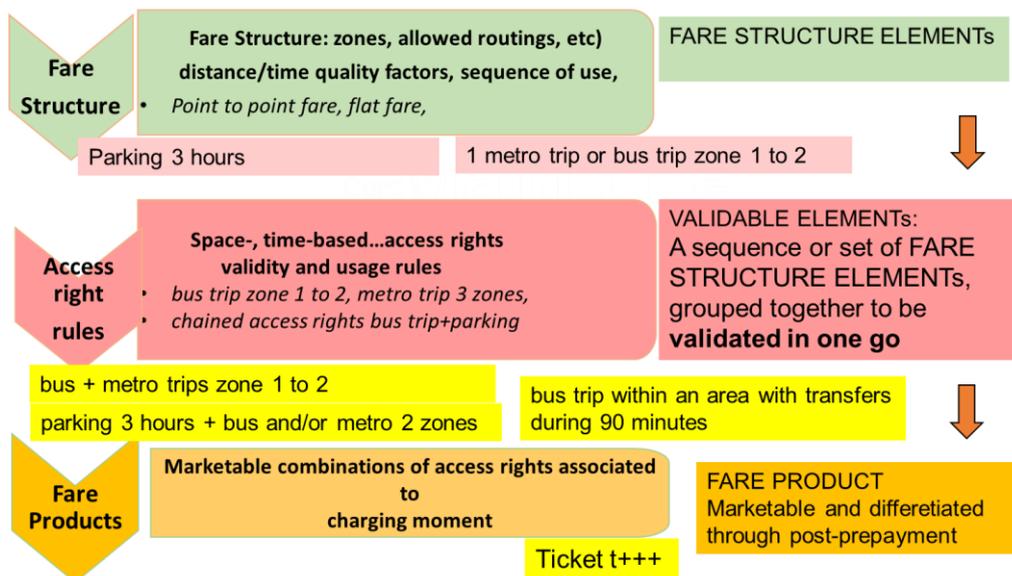
- parking for up to 3 hours.

3. A joint Public Transport + Parking product might offer the following access rights:

- parking up to 3 hours followed by a bus/metro 2-zones trip.

This requires the product definition to impose a *sequence of use of the access rights* and furthermore, to place usage limitations on this sequence (that is, a passenger must use the access rights in a particular order and may not be allowed to use certain rights without previously having consuming another).

A **fare product**, called in this example **Ticket t+++**, could combine the right to use all the above access rights.



For this example, we assume that Ticket t+++ is prepaid before use. However, the same access rights may be used in several FARE PRODUCTS, e.g. pre-paid (materialised on a paper ticket and paid before use), post-paid (materialised on a smartcard) and post-paid using a debit card or bank credit card and charged to account).

A FARE PRODUCT is defined in Transmodel as an immaterial marketable element (access rights, discount rights, etc.), *specific to a CHARGING MOMENT*, which provides a classification of FARE PRODUCTS according to the payment method and the account location (and thus having different contractual terms for the passenger as to obligations and financial risk). For example, pre-payment with cancellation (throw-away), pre-payment with debit on a value card, pre-payment without consumption registration (pass), post-payment etc.

1.4 Travel documents

A distinction is also made in Transmodel between

- the access right to a service,
- the corresponding products offered to the public (e.g. pre-paid or post-paid fare products) and
- the materialisation of a fare product *on a medium* when sold to the public.

A SALE OFFER PACKAGE is used to describe **the materialisation** of one or more FARE PRODUCT(s) on a specific media or TYPE OF TRAVEL DOCUMENT.

The same product may be used in different offers with differentiated pricing for different media and distribution channels. Thus our prepaid Ticket t+++ described in the example above, might be offered both as a paper ticket "*Ticket t+++ classic*" and as an app "*Ticket t+++ mobile*" and on a smartcard "*eTicket t+++*".

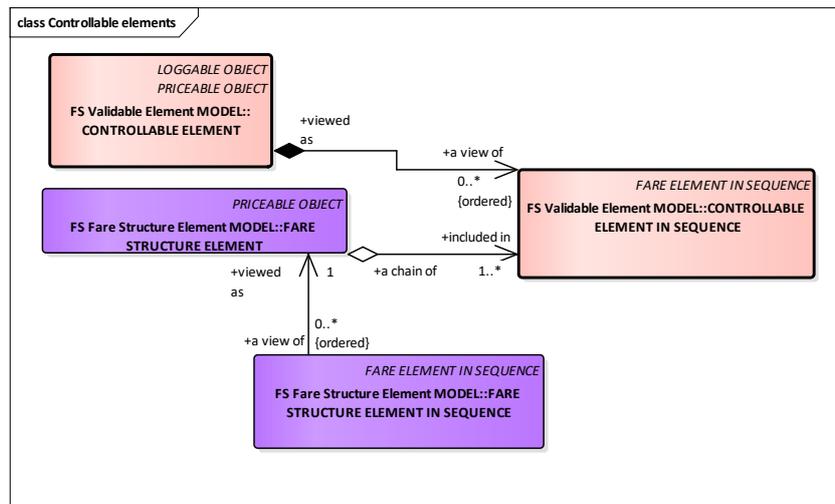
2.2 Access rights and fare structure

In terms of data model concepts, the description of access rights is organised in a hierarchy of three levels:

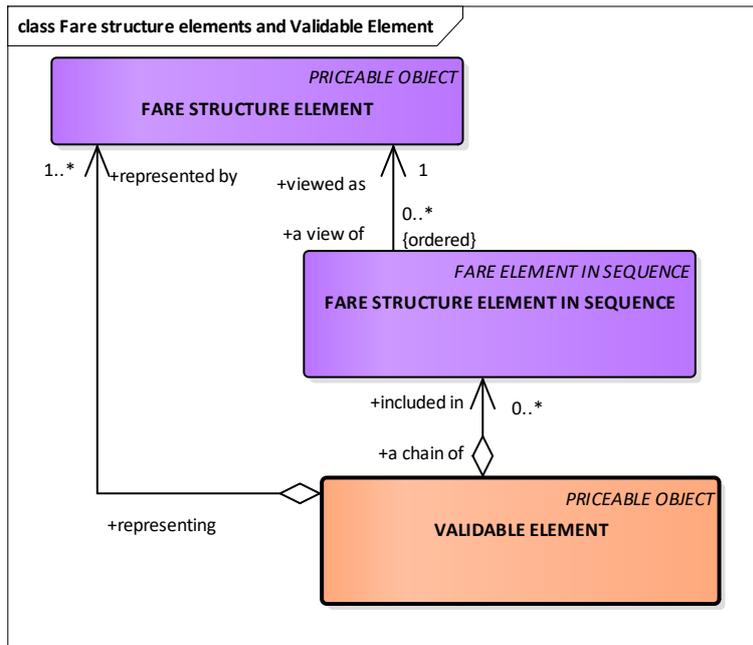
- CONTROLLABLE ELEMENTs,
- FARE STRUCTURE ELEMENTs (corresponding to one or more CONTROLLABLE ELEMENT).
- VALIDABLE ELEMENTs (corresponding to one or more FARE STRUCTURE ELEMENT).

The basic component of a fare structure (FARE STRUCTURE ELEMENT) is defined as a sequence or set of CONTROLLABLE ELEMENTs to which rules for limitation of access rights and calculation of prices (fare structure) are applied.

A CONTROLLABLE ELEMENT is the smallest controllable element of public transport consumption throughout which any particular VALIDITY PARAMETER ASSIGNMENT remains valid.

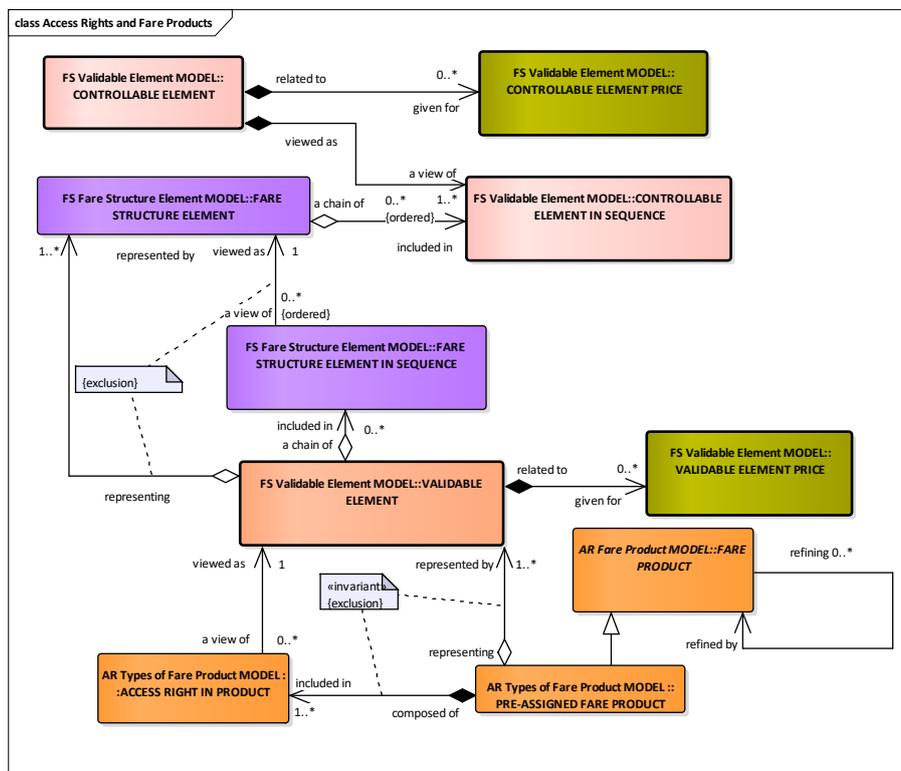


Examples (see § 1.3) show the usefulness to 'chain' access rights related to different fare structures, as in a multimodal, multi-service environment combined (joint) fare products granting access to services to which access rules are determined by several organisational entities are often proposed to the public.. For example, a fare product may include the access to a car park, followed by the access to a museum, or a discount for travellers using a car park and then public transport. If the fare structure of these two components is different (e.g. flat fares for public transport and price based on duration of stay for car parking), they will be described by two different FARE STRUCTURE ELEMENTs. The discount is granted only when the validation process recognises that both have been consumed in sequence.



A sequence or set of FARE STRUCTURE ELEMENTs, grouped together to be validated in one go is called a VALIDABLE ELEMENT (A FARE STRUCTURE ELEMENT, dedicated to being consumed as such, is identical to a VALIDABLE ELEMENT).

A VALIDABLE ELEMENT may, for example, indicate the consumption rights of a PREASSIGNED FARE PRODUCT (specifying a particular trip).



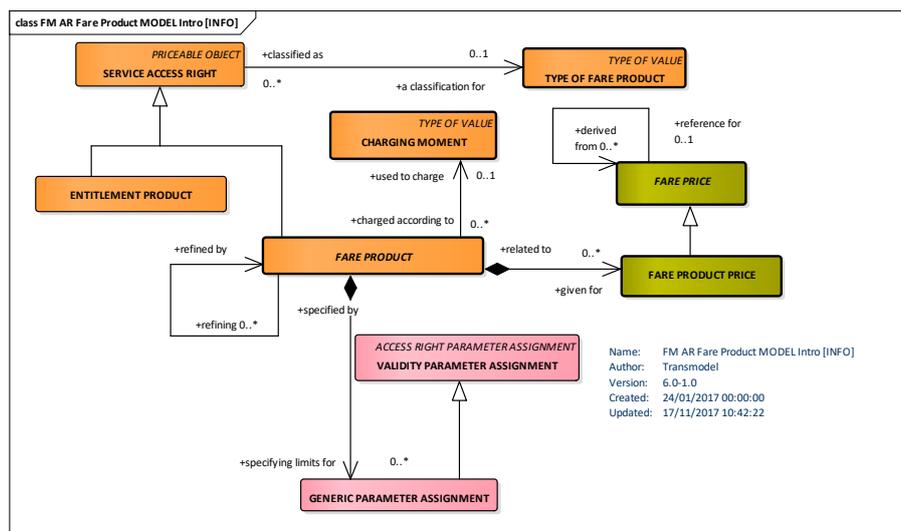
A key point to grasp is that a VALIDABLE ELEMENT in effect represents the allowed set of choices (conform to the access right rules within a particular fare structure) from which a user may select for a particular step in the journey, rather than one particular single combination of such choices. Thus, continuing with our example, if the access rights are for zone A, or zone B, or a combination of the two (A+B), each with a different price, then the VALIDABLE ELEMENT may be specified using FARE STRUCTURE ELEMENTs that specify the various zone combinations which may be selected. This selection may be multidimensional – for example for a season pass there might both be a selection of zones, and a selection of time periods associated with a given VALIDABLE ELEMENT through the appropriate FARE STRUCTURE ELEMENTs. When a user comes to purchase a product (see later) a selection is made in each required dimension of the tariff structure.

2.3 Fare products

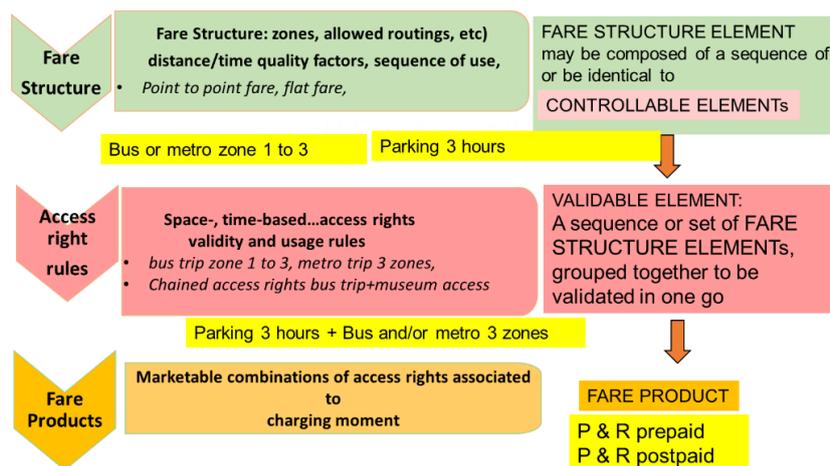
As already mentioned in §1.3 above, a FARE PRODUCT is an immaterial marketable element (access rights, discount rights, etc.), specific to a CHARGING MOMENT (i.e. the payment method and the account location: pre-payment with cancellation (throw-away), pre-payment with debit on a value card, pre-payment without consumption registration (pass), post-payment etc).

So, the CHARGING MOMENT is a classification of FARE PRODUCTs according to the payment method and the account location. This means that to the "access right to the metro network" may correspond to three separate FARE PRODUCTS:

- a pre-paid one: materialised e.g. by a throw-away ticket
- a pre-paid one with a debit on a value card
- a post-paid one: amount debited on a bank card.



Continuing with the example from earlier, the access right '3 hours parking followed by a trip on the bus or metro within 1 to 3 zones' is an example of a sequence of 2 access rights originating from 2 different fare structures, used in a certain order (parking followed by public transport trip) and required to be validated together.



This access right may be pre-paid or post-paid, i.e. may correspond to 2 different FARE PRODUCTS. To be noted, that the different access right elements are related to their PRICE determined through pricing algorithms (see also §6.4 below).

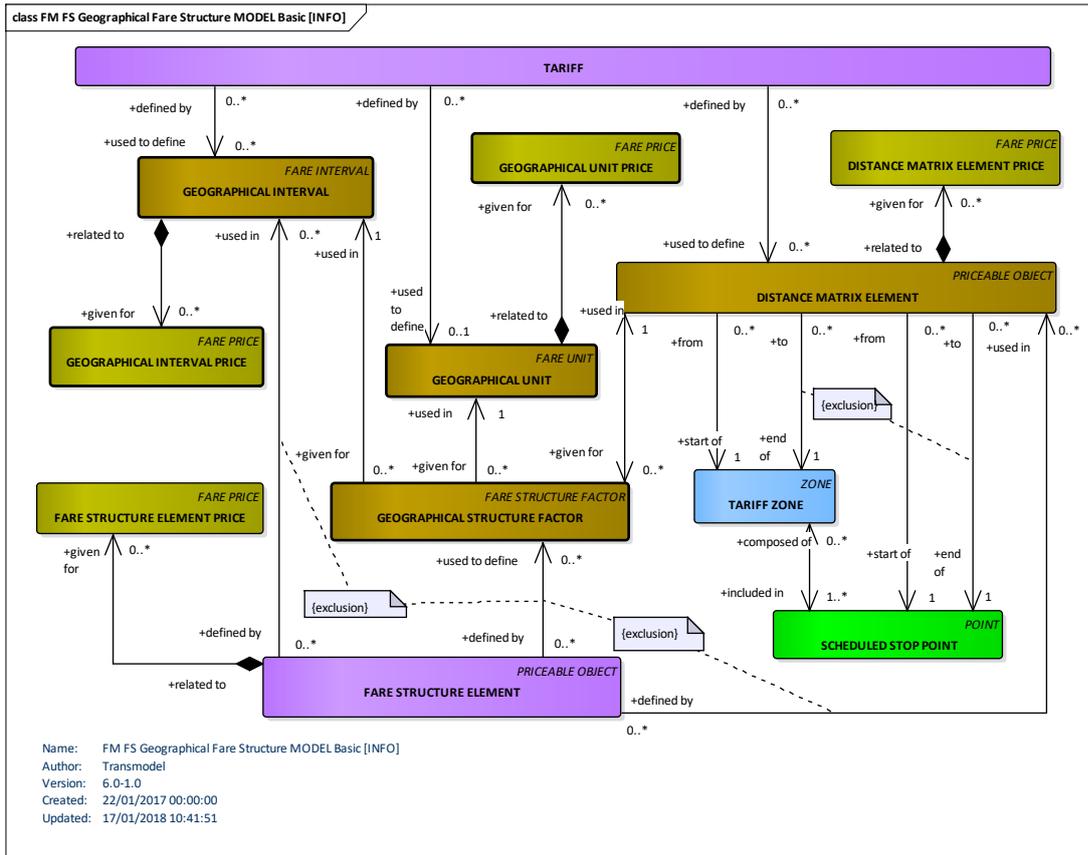
A FARE PRODUCT may need another FARE PRODUCT to be used, for instance an ENTITLEMENT PRODUCT, defined as a precondition to access a service or to purchase a FARE PRODUCT issued by an organisation that may not be a PT operator (e.g. military card).

3 Distance-based fare structure

The most common fare structure rules are space-based, or more precisely, distance-based. The three main types are respectively:

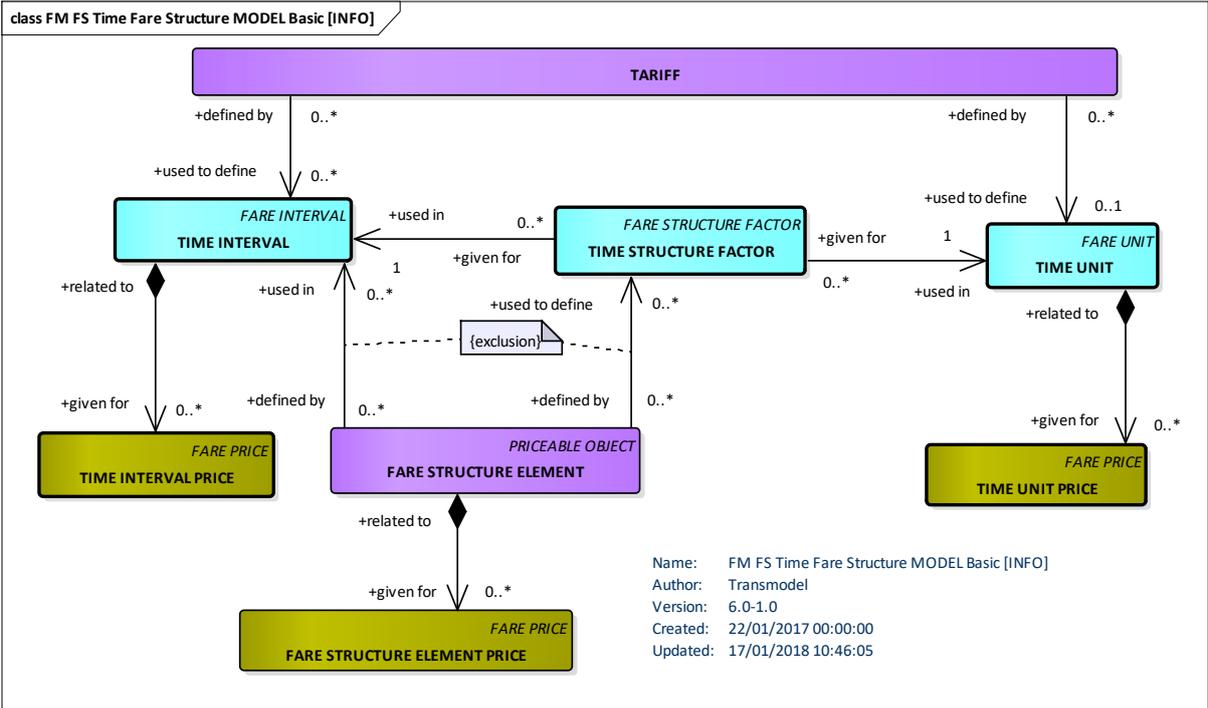
- progressive (based on intervals), a GEOGRAPHICAL INTERVAL specifying access rights within the range of this interval: 0-5 km, 4-6 zones etc.;
- graduated depending on a distance covered during the trip; the distance is computed using a certain unit, the most classical being the distance in kilometres, the number of fare sections (or zones) or the number of stop points. Such a graduation unit is described by the entity GEOGRAPHICAL UNIT;
- using zones or sections; a TARIFF ZONE is a view of a ZONE, specifically defined for fare calculation; a FARE SECTION is another type of fare structure parameter: it is a subdivision of a JOURNEY PATTERN, consisting of consecutive SCHEDULED STOP POINTs in that JOURNEY PATTERN;

Some of these types may be combined together. The entity GEOGRAPHICAL STRUCTURE FACTOR makes it possible to combine two simple structures into a complex factor. It is identified by a GEOGRAPHICAL UNIT, describing the used graduation unit, and by either a GEOGRAPHICAL INTERVAL (specifying access rights for the FARE STRUCTURE ELEMENTs within the range of this interval: 0-5 km, 4-6 zones etc) or a DISTANCE MATRIX ELEMENT (a cell of an origin-destination matrix for TARIFF ZONEs or SCHEDULED STOP POINTs, expressing a fare distance for the corresponding trip: value in km, number of fare units etc.).



4 Main components of a time-based tariff structure

The time-based fare structures are described in a similar way to the space-based structures. The entity TIME INTERVAL describes intervals of time (0-1 hour, 1-3 hours, etc.) during which a certain fare is applied to FARE STRUCTURE ELEMENTs. A graduated time-based structure will be defined using a specified TIME UNIT (e.g. days, hours or minutes).



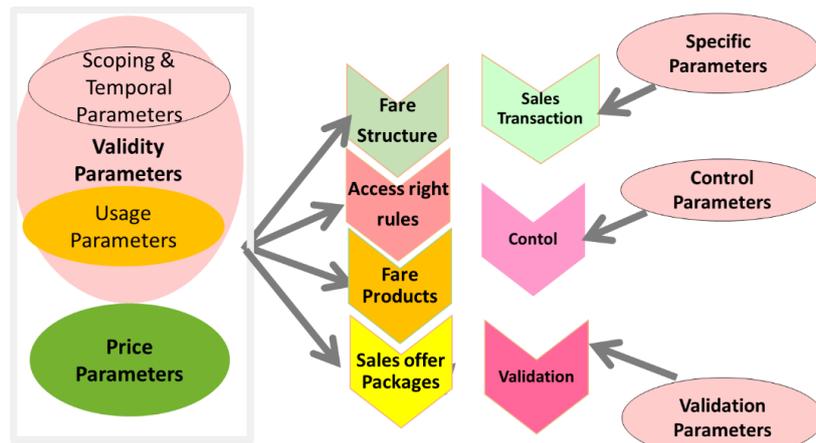
Both types of structures may be combined into TIME STRUCTURE FACTORS. This allows for instance to specify a fare per hour spent, which varies depending on the range of days spent.

5 Modelling access right rules

To model a 'fare', Transmodel uses the concept of an 'access right' to a service rather than 'pricing' or 'tarification' rules. Transmodel distinguishes between:

- 'access rights' to a service which are represented by a set of rules (determined by a range of parameters) and related to the fare structure and
- 'prices' which are applied to the 'access rights'.

This approach allows the combination of different rules and a flexible assignment of different **parameters**.



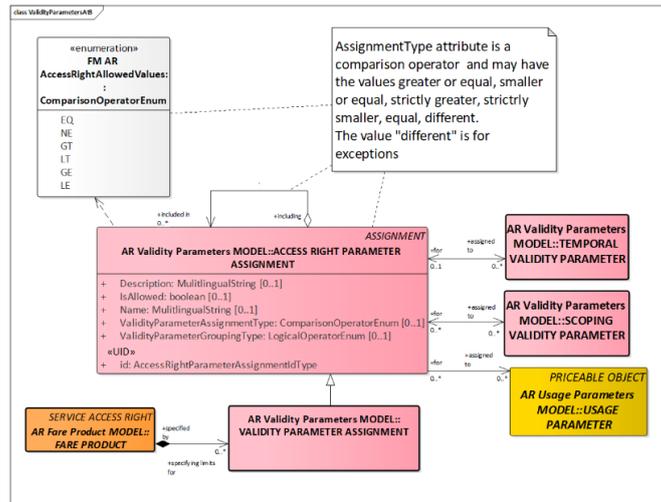
It is possible, for example to express the following rules (using the different types of parameters):

- the access right is valid on all bus network LINES except for LINE 278 and LINE 66' or
- the access right to zone 4 is not valid between 2 a.m. – 4 a.m.

5.1 Assigning and combining rights

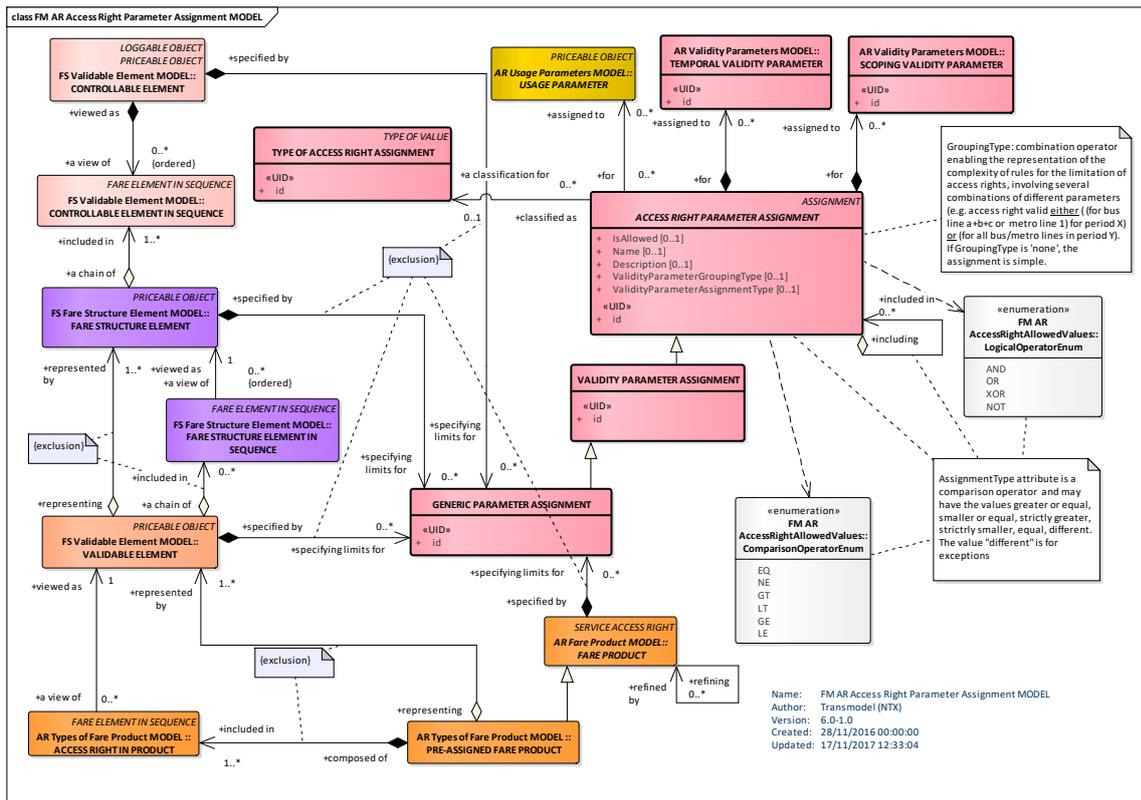
Access rights are specified using an ACCESS RIGHT PARAMETER ASSIGNMENT, which allows specific access rights *to be associated with fare structure components using a variety of 'validity parameters'*, each specifying which access rights may be consumed.

Access right limitation rules may be complex and involve *several combinations of parameters and conditions*. These rules may be expressed as *logical propositions with logical operators (and, or, exclusive or)*. This means that different types of combinations of groups of parameters have to be taken into account and that the ACCESS RIGHT PARAMETER ASSIGNMENT is a *multiple (or composite) assignment*.



5.2 Different characteristics of access rights

Access right rules may concern different components of a fare structure (e.g. FARE STRUCTURE ELEMENT, DISTANCE MATRIX ELEMENT, GROUP OF DISTANCE MATRIX ELEMENTS), products (e.g. FARE PRODUCT, SALES OFFER PACKAGE) or other elements (e.g. VALIDABLE ELEMENT, or CONTROLLABLE ELEMENT) in order to specify the specific rights that are granted or need to be validated.



The *validity parameters* that may be assigned with an ACCESS RIGHT PARAMETER ASSIGNMENT can be considered as being of two main categories:

- TEMPORAL VALIDITY PARAMETERs reflecting temporal limitations, for example: DAY TYPE or OPERATING DAY on which the assignment applies, the TIMEBANDs during which the

assignment applies, the VALIDITY CONDITION or AVAILABILITY CONDITION restricting the assignment.

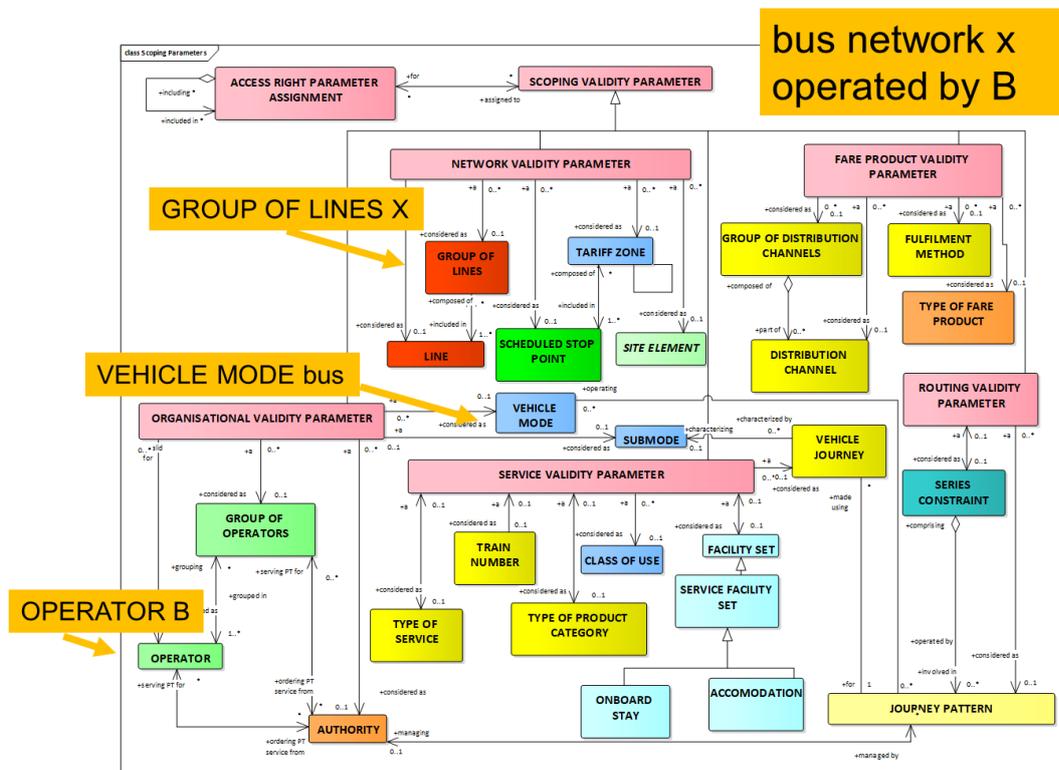
- SCOPING VALIDITY PARAMETERS, reflecting mainly spatial limitations, for example: which OPERATORS or GROUPS of OPERATORS, which VEHICLE MODES and submodes, which LINES, GROUPS OF LINES or NETWORKS, which TARIFF ZONES, FARE SECTIONS, which SCHEDULED STOP POINTS may be used, etc.

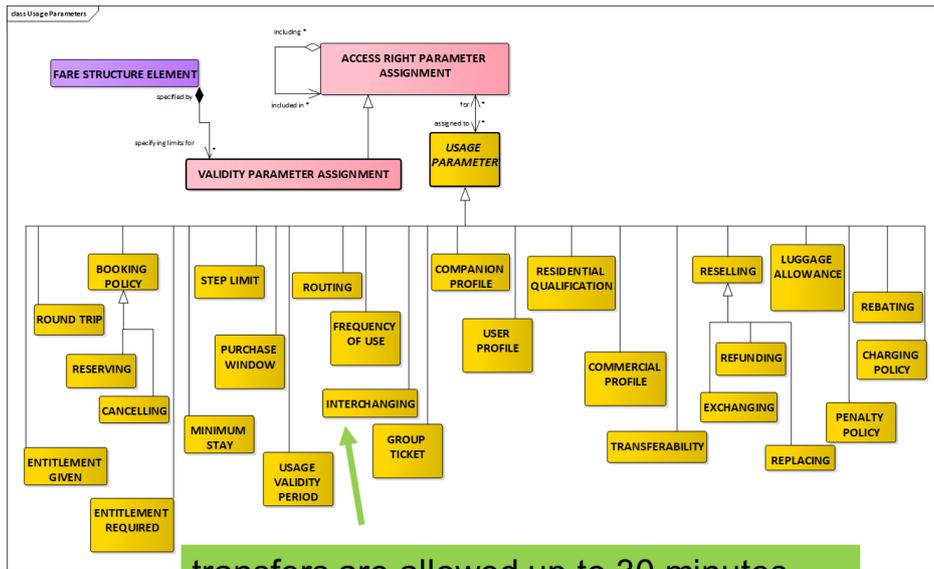
5.3 Further conditions on fare products

Fare products may also be subject to conditions as to eligibility (who may purchase a fare, adult child, senior, etc) or commercial terms (can it be exchanged, refunded, replaced etc) and other considerations,

A USAGE PARAMETER is another type of parameter linked to the actual usage of the access rights (e.g. particular user profiles, luggage allowance, booking possibility, necessary to provide a particular entitlement, etc.).

The figures below show how some of the parameters are instantiated, taking an example of the access right : 'valid on 1 to 3 zones, for bus network x operated by B, with different price according to whether the user is an adult, child or a student, transfers are allowed up to 30 minutes'



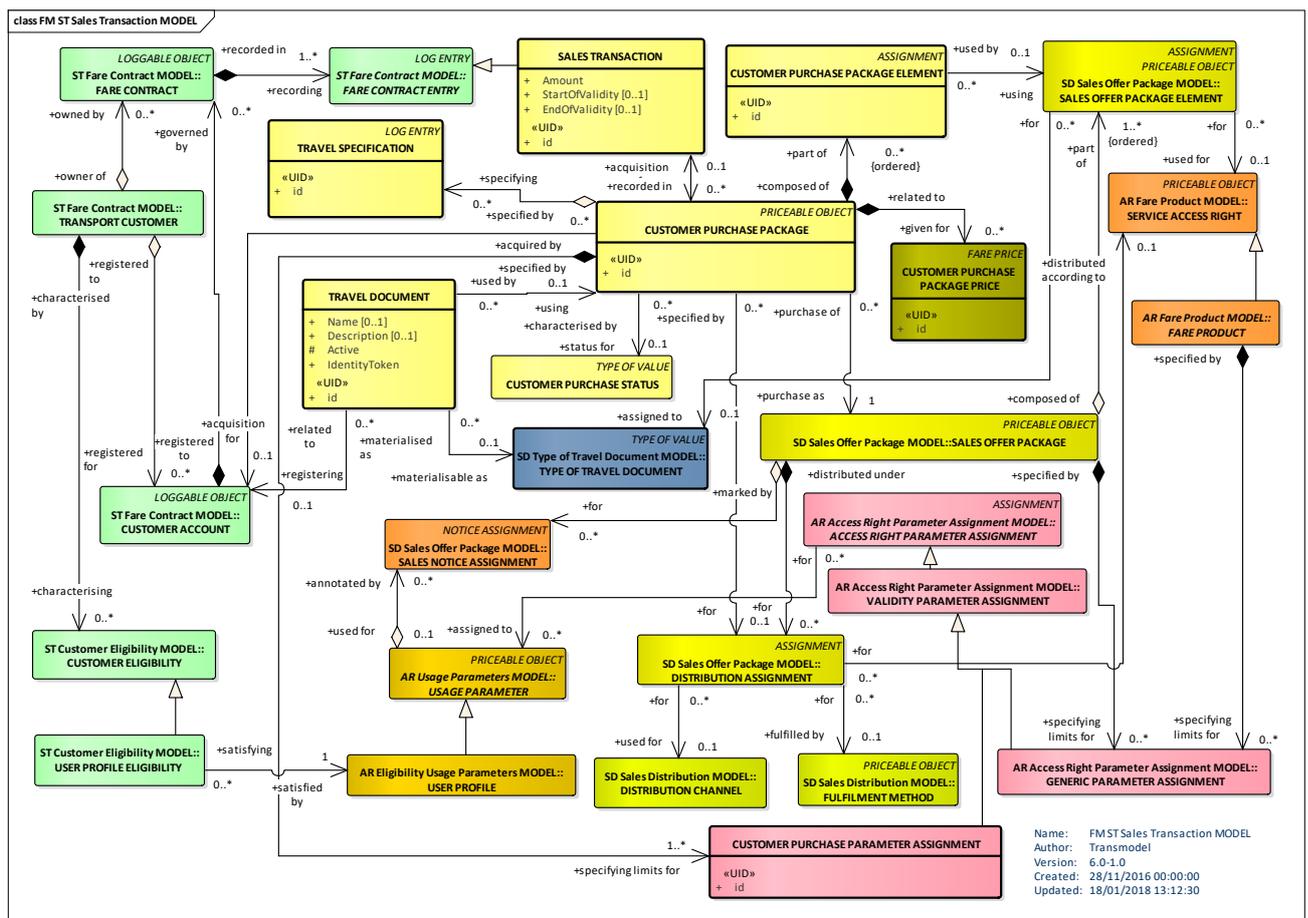


6.2 What information is needed to describe the sales transactions?

The Sales Transaction model is modularised into a number of sub-models:

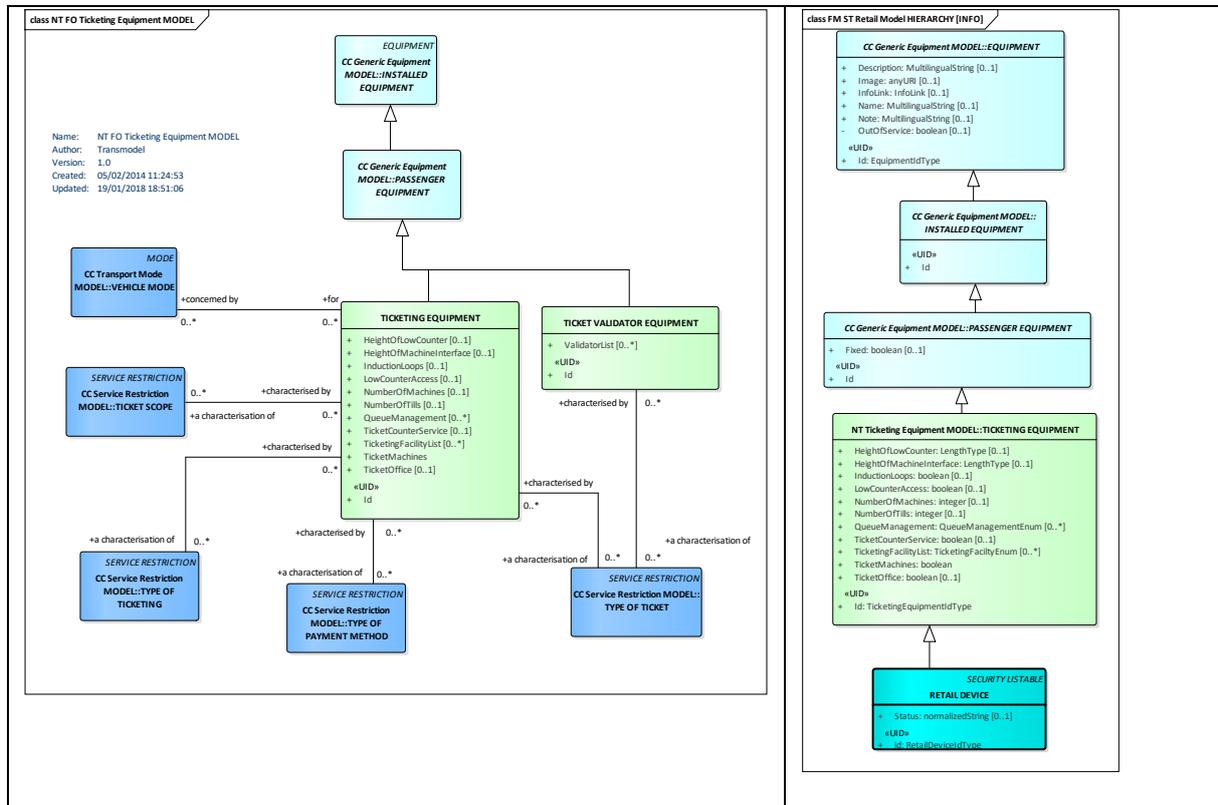
- The Fare Contract MODEL describes identified CUSTOMERs and their CUSTOMER ACCOUNTs and FARE CONTRACTs. The Customer Payment Means MODEL and the Customer Eligibility MODEL describe additional aspects of CUSTOMER ACCOUNTs.
- The Retail MODEL identifies RETAIL CONSORTIUMs, ORGANISATIONs that sell products, and RETAIL DEVICEs used to sell products.
- The Sales Transaction MODEL records sales of SALES OFFER PACKAGEs. TRAVEL SPECIFICATION ENTRYs describe each specific selection of theoretical fare elements for an individual SALES TRANSACTION.
- The Sales Debit MODEL describes the different types of debit which may occur during the purchase and after sales of fare products (e.g. refund, exchange).
- The SALES TRANSACTION FRAME model describes the elements used to group sales data for exchange, such as SALES TRANSACTIONs, CUSTOMER PURCHASE PACKAGEs, TRAVEL DOCUMENTs, etc.

An overview is presented below:



7 Ticketing equipment

TICKETING EQUIPMENT (introduced in EN12896-2) is a specialization of PASSENGER EQUIPMENT for ticketing.



A RETAIL DEVICE is a specialisation of the TICKETING EQUIPMENT used to sell FARE PRODUCTS. Its identity can be used to record fulfilment and support security processes.

A RETAIL DEVICE is also SECURITY LISTABLE, i.e. an entity capable of being placed on a SECURITY LIST.

	Action Name	Paper based	Media Centric	ABT	Note
Customer Account	CUSTOMER REGISTER EVENT	Applicable	Applicable	Applicable	Classical may register for season pass
	CUSTOMER DEREGISTER EVENT	Applicable	Applicable	Applicable	ditto
	CUSTOMER MODIFY PROFILE EVENT	Applicable	Applicable	Applicable	ditto
	CUSTOMER REGISTER MEDIA EVENT	n/a	Applicable	Applicable	
	RESTORE CUSTOMER ACCOUNT EVENT	n/a	Applicable	Applicable	
Retail	CUSTOMER PURCHASE EVENT	Applicable	Applicable	Applicable	
	CUSTOMER EXCHANGE EVENT	Applicable	Applicable	Applicable	
	CUSTOMER REFUND EVENT	Applicable	Applicable	Applicable	
	CUSTOMER CHANGE BOOKING EVENT	Applicable	Applicable	Applicable	
Fulfilment	CUSTOMER COLLECT EVENT	Applicable	Applicable	Applicable	
	CUSTOMER MEDIA INSTALL EVENT	n/a	Applicable	n/a	
	CUSTOMER PRODUCT ACTIVATION EVENT	n/a	Applicable	Applicable	Account may have media
	CUSTOMER MEDIA RESTORE EVENT	n/a	Applicable	Applicable	ditto
	CUSTOMER MEDIA APPLICATION RESTORE EVENT	n/a	Applicable	Applicable	ditto
Travel	PASSENGER CHECK IN EVENT	n/a	Applicable	Applicable	
	PASSENGER CHECK OUT EVENT	n/a	Applicable	Applicable	Post payment only
	PASSENGER WAY POINT EVENT	n/a	Applicable	Applicable	Post payment only
	PASSENGER VALIDATE TRAVEL DOCUMENT ACTION EVENT	Applicable	Applicable	Applicable	
Account	ACCOUNT DETECT TRIP EVENT	n/a	Applicable	Applicable	
	ACCOUNT DETECT NO CHECK IN EVENT	n/a	Applicable	Applicable	
	ACCOUNT DETECT NO CHECK OUT EVENT	n/a	Applicable	Applicable	
	ACCOUNT DETECT REENTRY EVENT	n/a	Applicable	Applicable	Depends on Policy
	ACCOUNT SUSPICIOUS BEHAVIOUR EVENT	n/a	Applicable	Applicable	

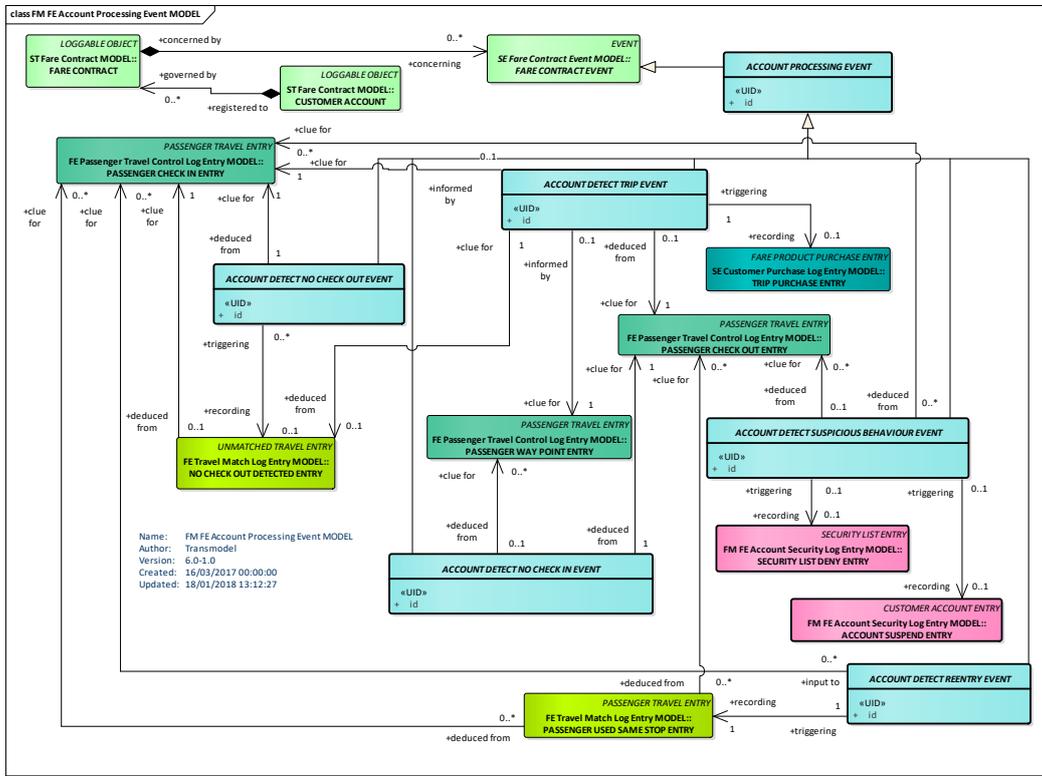
9.3 Fare Management LOG ENTRIES

LOG ENTRIES record EVENTS as different actors interact with the system. Different LOG ENTRIES are relevant to different ticketing technologies, as summarised below.

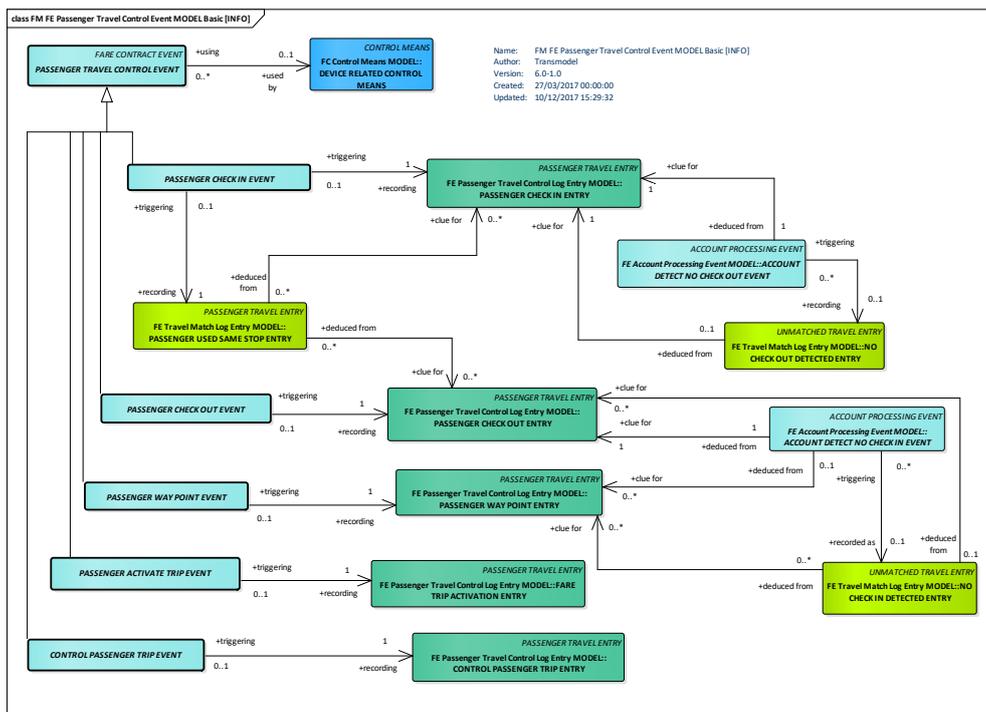
	Action Name	Classical	Media Centric	ABT	Note
Customer Account	CUSTOMER REGISTRATION ENTRY	Applicable	Applicable	Applicable	Classical may register for season pass
	CUSTOMER DEREGISTRATION ENTRY	Applicable	Applicable	Applicable	
	CUSTOMER PROFILE MODIFICATION ENTRY	Applicable	Applicable	Applicable	
	CUSTOMER MEDIA REGISTRATION ENTRY	n/a	Applicable	Applicable	
	RESTORE CUSTOMER ACCOUNT ENTRY	n/a	Applicable	Applicable	
Customer Purchase & After Sales	FARE PRODUCT PURCHASE ENTRY	Applicable	Applicable	Applicable	
	TRIP PURCHASE ENTRY	Applicable	Applicable	Applicable	
	FARE PRODUCT RENEWAL ENTRY	Applicable	Applicable	Applicable	
	MEDIA RECHARGE PURCHASE ENTRY	n/a	Applicable	Applicable	
	FARE PRODUCT REFUND EVENT	Applicable	Applicable	Applicable	
	FARE PRODUCT EXCHANGE ENTRY	Applicable	Applicable	Applicable	
	TRAVEL COMPENSATION ENTRY	Applicable	Applicable	Applicable	
	CUSTOMER BOOKING ENTRY	Applicable	Applicable	Applicable	
	CUSTOMER BOOKING CANCELLATION ENTRY	Applicable	Applicable	Applicable	
Account Auto Sales	ACCOUNT AUTO RENEWAL ENTRY	n/a	Applicable	Applicable	
	ACCOUNT AUTO TOP UP ENTRY	n/a	Applicable	Applicable	
	ACCOUNT AWARD REFUND ENTRY	n/a	n/a	Applicable	
Fulfilment	TRAVEL DOCUMENT COLLECTION ENTRY	Applicable	Applicable	Applicable	
	PURCHASE FULFILMENT ENTRY	n/a	Applicable	Applicable	
	MEDIA PRODUCT INSTALLATION ENTRY	n/a	Applicable	Applicable	Account may have media
	MEDIA PRODUCT ACTIVATION ENTRY	n/a	Applicable	Applicable	ditto
	MEDIA PRODUCT DEACTIVATION ENTRY	n/a	Applicable	Applicable	to
	MEDIA RESTORE ENTRY	n/a	Applicable	Applicable	to

9.4 Fare Events and Log Entries: Account Processing Event Model

As shown in the Event Model, EVENTS trigger LOG ENTRIES, for instance, as shown in the Account Processing Event Model below.



Similar models describing in detail the link between the different fare management events and log entries are presented in EN12896-5. The diagram below describes the PASSENGER TRAVEL CONTROL EVENT and the associated LOG ENTRIES.

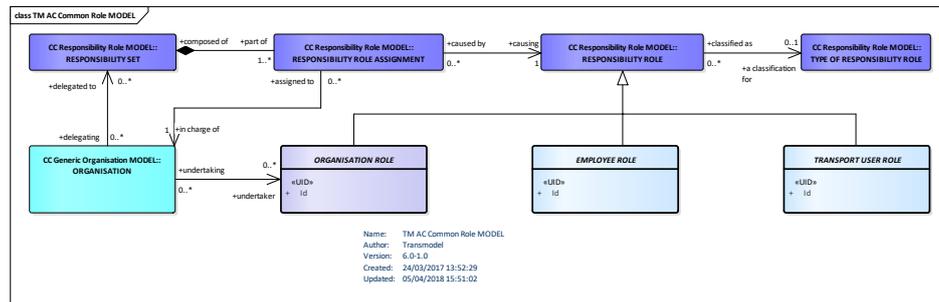


10 Different roles of actors linked to the fare processes

To describe a fare process, a number of different roles are identified that may be associated with a given organisation. Some of these are relevant for services other than fares and ticketing, such as ACCOUNT PROVIDER ROLE, IDENTITY PROVIDER ROLE, MEDIA PROVIDER ROLE, MEDIUM APPLICATION OWNER ROLE, MEDIUM APPLICATION PROVIDER ROLE, PAYMENT PROVIDER ROLE, CUSTOMER SERVICE PROVIDER ROLE

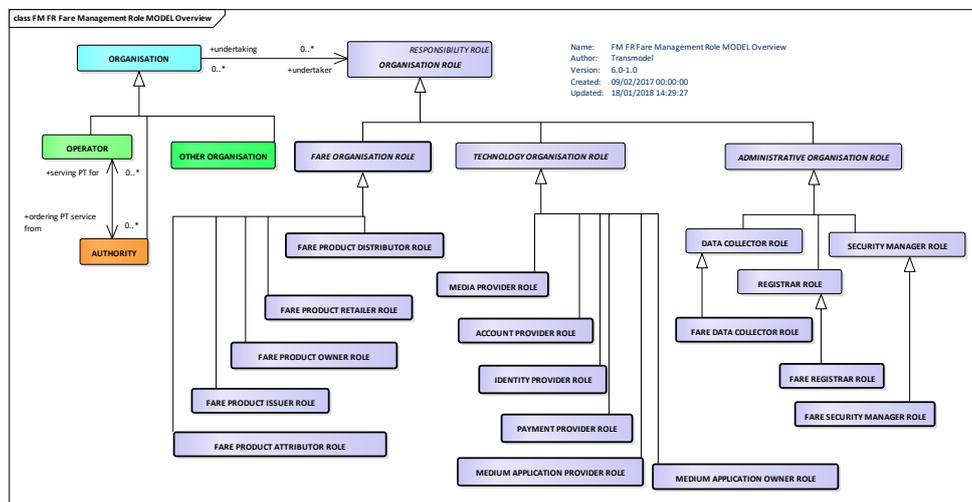
Others are specific to fares, such as FARE PRODUCT OWNER ROLE, FARE PRODUCT RETAILER ROLE, FARE PRODUCT DISTRIBUTOR ROLE, etc. Extended distribution for rail may also involve FARE PRODUCT ISSUER and FARE PRODUCT ATTRIBUTOR ROLES.

The ROLES can be considered as specialisations of the general roles shown in the diagram below (EN12896-5, Annex B).



The generic model representing the assignment of responsibilities to an ORGANISATION or an ORGANISATION PART is presented in EN12896-1.

An overview of the *Management Roles* of an ORGANISATION is presented below.

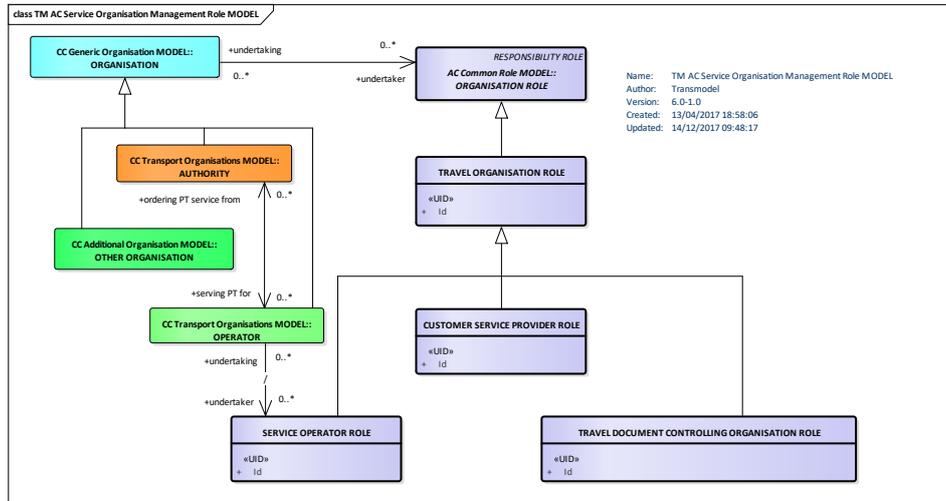


The abstract class ORGANISATION ROLE, defined as a generic corporate role to provide or manage transport services, splits into concrete roles, among which into a range of roles related to fare management, as shown in the diagram below.

Most of these roles have extensively been described by ISO 24014-1 (Integrated Fare Management) and by the Full Service Model (cf. EN12896-5, Bibliography). Transmodel takes over the semantics of these roles, although, in some cases uses own terminology (role names).

Specific FARE ORGANISATION ROLES are also defined *and related to the relevant concepts of the Fare Model*.

An ORGANISATION may have the responsibility to provide any kind of travel related service, i.e. fulfil the TRAVEL ORGANISATION ROLE.



The responsibility for the fare control process is shared between the SERVICE OPERATOR ROLE providing any automated barriers and other control equipment, and the TRAVEL DOCUMENT CONTROLLING ORGANISATION ROLE which undertakes control activities; the execution of inspection and other duties may be allocated to individual EMPLOYEES performing a TRAVEL DOCUMENT CONTROLLER ROLE. The diagram below shows the link of these roles with the related data structures.

