TECHNICAL REPORT

ISO/TR 24529

First edition
2008-04-15

Intelligent transport systems — Systems architecture — Use of unified modelling language (UML) in ITS International Standards and deliverables

Systèmes intelligents de transport — Architecture de systèmes — Emploi du langage de modélisation unifié (UML) dans les Normes internationales ITS et produits livrables

Reference number
ISO/TR 24529:2008(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 24529 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Introduction

The objective of this Technical Report is to provide guidance on the use of the “Unified Modeling Language” [UML] in the development of standards for “Intelligent Transport Systems” [ITS].

The advantages of applying UML to the development of ITS include the following:

— UML provides an Internationally Standardized form of system model that should be readily interpreted anywhere world-wide;

— UML enables cohesive description from multiple user views;

— There is available extensive training and tool support for UML;

— UML is capable of manipulation by a metadata registry for ITS;

— UML tools enable conversion directly to computer coding;

— UML is very widely used in the architecture, design and development of software-intensive systems.

The disadvantages of using UML include the following:

— UML is not understood by many stakeholders who are not also software developers;

— UML uses a larger amount of unfamiliar language and jargon which, while it may be necessary for precision, is daunting and off-putting to the non specialist and lay reader;

— UML is not yet developed enough to support the full scope of systems engineering;

— UML is still under active development and therefore the compatibility of UML models may be an issue.

There are therefore some risks in using UML but nevertheless the benefits are widely judged as exceeding the disadvantages. This document is intended to provide guidance to stakeholders who are considering the use of UML for ITS.

Intelligent transport systems — Systems architecture — Use of unified modelling language (UML) in ITS International Standards and deliverables

1 Scope

The scope of this Technical Report is the use of UML within International Standards Technical Specifications and Technical Reports and related documents.

This Technical Report discusses the application of the "Unified Modelling Language" [UML] to the development of standards within the context of "Intelligent Transport Systems" [ITS].

2 Normative references

ISO 14813 (all parts), *Transport information and control systems — Reference model architecture(s) for the TICS sector (Parts 1 to 6)*

ISO 14817, *Transport information and control systems — Requirements for an ITS/TICS central Data Registry and ITS/TICS Data Dictionaries*

ISO/TR 17452, *Intelligent transport systems — Using UML for defining and documenting ITS/TICS interfaces*

ISO/IEC 19501, *Information technology — Open Distributed Processing — Unified Modeling Language (UML) Version 1.4.2*

ISO/TR 25102, *Intelligent transport systems — System architecture — 'Use Case' pro-forma template*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
actor
coherent set of roles that users of an entity can play when interacting with the entity.

NOTE An actor may be considered to play a separate role with regard to each use case with which it communicates.

In the metamodel, 'Actor' is a subclass of 'Classifier'. An 'Actor' has a 'Name' and may communicate with a set of 'UseCases', and, at realization level, with 'Classifiers' taking part in the realization of these 'UseCases'. An 'Actor' may also have a set of 'Interfaces', each describing how other elements may communicate with the 'Actor'.

An 'Actor' may have generalization relationships to other 'Actors'. This means that the child Actor will be able to play the same roles as the parent 'Actor', that is, communicate with the same set of 'UseCases', as the parent 'Actor'.

3.2
architecture
⟨ITS⟩ set of concepts and rules for an intelligent transport system describing the inter-relationship between entities in the entire system, independent of the hardware and software environment

NOTE Architecture is described through a series of viewpoints that may be at varying levels of generality/specificity, abstraction/concretion, totality/component and so on. See also communications architecture, logical architecture, organizational architecture, physical architecture, reference architecture and system architecture definitions below.

3.3
communications architecture
framework that tells designers how elements of hardware and software are to operate in harmony using common protocols and air interface techniques (where applicable)

3.4
logical architecture
definition of the processes (the activities and functions) that are required to provide the required 'User Services'

3.5
model
representation of an entity from which the important elements have been abstracted by removing unimportant detail while at the same time retaining the interrelationship between the key elements of the whole

NOTE A model may be made more or less abstract by the successive suppression of detail such that the concepts and relationships come into enhanced focus and become more readily understood. However the process can be taken too far when the simplification has exceeded the threshold where a necessary understanding may be achieved. Thus the process of modelling is one of going only far enough to achieve the optimum understanding and insight — and no further.

NOTE A model is a way of representing something, other than in its natural state. (See 'Models of ITS' documents at http://www.frame-online.net/library.htm).

3.6
organizational architecture
framework into which business processes are deployed and ensures that the organization's core qualities are realised across the business processes deployed within the organization

NOTE In this way organizations aim to consistently realise their core qualities across the services they offer to their clients.

3.7
physical architecture
high-level structure around the processes and data flows in the logical architecture

NOTE The physical architecture defines the physical entities (subsystems and terminators) that make up a system.

3.8
reference architecture
list of functions and some indication of their interfaces (or APIs) and interactions with each other and with functions located outside of the scope of the reference architecture

3.9
relation
relationship
nature of how two entities affect each other including dependencies

3.10
requirement
statement of user need, typically expressed in a single-sentence form to assist with later verification of compliance

3.11
scenario
sequence of steps that are taken to change the state from that before the scenario to that immediately after the scenario

3.12
system architecture
system architecture is a framework for ITS deployments; it is a single, high-level description of the major elements or objects and the interconnections among them

NOTE System architecture provides the framework around which the interfaces, specifications and detailed system designs can be defined. An architecture is not a product design, nor a detailed specification for physical deployment. [Mil4]

3.13
template
framework that may be used repeatedly to meet requirements that are similar to some extent

3.14
use case
representation of a series of interactions between an outside entity and the system, which ends by providing business value

NOTE A use case is a sequence of actions that an actor (usually a person, but perhaps an external entity, such as another system) performs within a system to achieve a particular goal [Rosenberg].

4 Abbreviated terms

ITS
intelligent transport system

KAREN
keystone architecture required for European networks

MDD
model driven developments

OMG
object management group

POM
process oriented methodology

SEI
software engineering institute

TICS
transport information and control systems

TR
technical report

UML
unified modelling language

5 Background

5.1 TC 204 working group 1 (WG 1)

This Technical Report arose from work by WG 1 on the elaboration of ITS architecture in the ISO 14813 series of International Standards and Technical Reports. It had become apparent that there was concerted opposition from some sources to the uniform use of UML for ITS architecture. While WG 1 has never mandated the sole use of UML above other architecture methodologies, and the 14813 series focuses on consistency and interoperability rather than preferring any one modelling technique, UML is seen as an increasingly useful tool in a developing and changing sector because of its ability to change and adapt without abandoning previous work and having to start again. Additionally, the ability to present a cohesive model from different perspectives (views) is seen by many to be useful in many situations. Finally, UML is an ISO International Standard and therefore one of the modelling techniques that should be supported. WG 1 therefore agreed the need for a Technical Report [TR] to discuss the applicability, strengths and weaknesses and recommended best practice for the use of UML in ITS standards.

5.2 UML as a standard

UML is very widely used as a specification and modelling language for software-intensive systems. This wide use of UML is recognised in the publication of the ISO/IEC standard 19501 that addresses UML.

The development of UML is continuing and has now reached version 2.0 with added features and the prospect of increasing support for model-based development (also known as model-driven development or MDD). This progress towards greater automation, particularly with the development of web services, is important for ITS standards.

5.3 Modelling for ITS architecture

The need for multiple viewpoints in architecture models has been widely recognised The similar need for a layered architecture reflecting differing levels of abstraction and encapsulation is also widely agreed. What is not agreed yet is the preferred manner in which these complementary model artefacts should be expressed.

The heterogeneous result is a proliferation of ITS architectural models expressed in a mixture of notations and formats. This has been considered acceptable for human comprehension — up to the point where complexity, confusion and misinterpretation can arise. However this approach is acceptable when only manual modelling and interpretation is involved. In the future this work will be of such complexity that it will be desirable to employ automation in various forms.

At that time the existence of multiple formats and inconsistently applied rules in manual approaches will not support automation, and hence standardization is needed.

These needs are recognised by ISO/TC 204 in their Technical Report/Draft International Standard ISO, by the ISO 14813 series of International Standards and Technical Reports determining the domains, service groups and services of the ITS sector, providing example elaborations and reference models and tutorials and specifying standardized data definition to enhance interoperability, and by the International Standard ISO 14817, *Transport information and control systems — Requirements for an ITS/TICS central Data Registry and ITS/TICS Data Dictionaries*.

UML is not the only available solution on offer. Other computerised architecture modelling techniques exist and are recognised to also have advantages and disadvantages compared with UML. Generally, while most computerised architecture modelling systems provide advantage over manual techniques, the disadvantage of most computer driven modelling schemes is their inflexibility in the event of change. The ITS sector is still young and is evolving and developing, often in unforeseen directions, at a rapid pace. UML provides flexibility and is well adapted to this environment. (Proponents of other methodologies will quite rightly claim their differences and, in some circumstances, advantages over UML, and it is not the objective of this Technical Report to claim preference for UML, simply to say that it is a suitable technique and to consider the ways of using it most effectively.)

UML is likely to provide the basis for much architecture based standardization because it is already so widely used and supported and is codified as the International Standard ISO/IEC 19501. At the end of the day ITS system design finishes up to a large extent as computer coding, and the closer an architecture model can get to the coding level, the easier and quicker the implementation, and the greater the probability that the final system will reflect the system conception and design. As UML is increasingly taught to new generations of systems designers and developers, any alternative approach that does not approach or reach the coding level, and have an ability to adapt and change, will face increasing difficulties once implementation phases arrive. To adopt an idiosyncratic approach for the single domain of ITS, the choice of some, ignores the fact that ITS is a field that is still very small by comparison with many other domains, particularly IT focussed domains, and sector idiosyncratic approaches increasingly seem improbable, and systems are most likely to be designed either using UML or the traditional engineering based process oriented decomposition model.

The need for interoperability between ITS systems, particularly at the base communication and data exchange levels has been recognised in the adoption by ISO/TC 204 of ASN.1 for interoperable machine-readable specification of data concepts in its Technical Report/Draft International Standard ISO/TR 14813-6 (Use of ASN.1 in ITS Standards). A similar need will arise for the many other aspects of rich architectural models if they are to be amenable to meta-modelling and manipulation. Thus there is benefit in thinking ahead to when ITS architecture specifications and standards will be used in a semi-automated fashion, perhaps through use of a data registry as is currently being piloted by the Highways Agency in the UK.

This does not preclude use of other notation — such as entity-relationship diagrams, data-flow diagrams, Markov chains, state-transition diagrams or Petri nets — but this proliferation will only make automation more difficult later.

6 Discussion

6.1 Scope of the discussion

"Intelligent Transport Systems" (ITS) generally comprise a distinguished form of a large-scale, distributed information system deployed in some form of tangible or virtual network.

NOTE Those forms of ITS which are not monitored, controlled or managed in a networked fashion are not considered further in this Technical Report. They are generally special-purpose devices that are used in an autonomous role rather than systems in the broad sense. However, discrete ITS will generally be subject to increasing levels of integration over time.

This Technical Report addresses the specific needs for systems architecture of heterogeneous, distributed, networked systems that are designed, developed and deployed in ITS applications and which may interface to a wide range of existing systems — both ITS and non-ITS used in an ITS context (for example cellular telephony, Bluetooth, etc.). For this development process to be undertaken effectively, it is customary to define requirements, undertake analysis and then to develop an architectural design, before moving into detailed design and implementation.

6.2 What is systems architecture?

Systems architecture in its most fundamental form is the description of an intended complex system that includes the major features and interfaces together with sufficient detail for the interfaces between sub-systems and to other external entities. The architectural entities and interfaces must be described or specified sufficiently for their intended behaviour to be understood sufficiently by stakeholders to support their approval to proceed with implementation.

Systems architecture identifies the major actors, interfaces and components and provide a basis to understand all their inter-relationships and interactions

Systems architecture for ITS has frequently been described as comprising several major viewpoints, such as:

— Reference architecture;

— Logical (sometimes called functional) architecture;

— Physical architecture;

— Communications architecture;

— Organizational architecture.

This Technical Report asserts that in general practice there may be several other viewpoints needed to fully comprehend an architectural model and the three forms (see Clause 3) of architecture specified for ITS is an unnecessary, and possibly unhelpful, restriction. What matters most is that the composite description satisfies all user and interface requirements, all non functional requirements and provides a rigorous basis not only for the initial design, but also for the ongoing development of the system as it evolves and as it interacts in new ways with its environment.

> 'Software architecture involves the descriptions of elements from which systems are built, interactions among those elements, patterns that guide their composition, and constraints on those patterns.' (Shaw 1996).

