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# Intelligent transport systems — Systems architecture, taxonomy and terminology — Using CORBA (Common Object Request Broker Architecture) in ITS standards, data registries and data dictionaries

*Systèmes intelligents de transport — Architecture, taxinomie et terminologie des systèmes — Emploi de CORBA (Common Object Request Broker Architecture) dans les normes, registres de données et dictionnaires de données ITS*

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# Introduction

CORBA is one of many software technologies involved in distributed systems and system integration. There is a significant number of existing CORBA deployments in ITS, and discussions on best practice and standardization have naturally emerged, and discussion can often lead to comparisons between different technologies and confusion, even apparent “competition” between different software technologies.

The objective of this Technical Report is to identify the role of and provide guidelines for the use of CORBA in ITS.

# Intelligent transport systems — Systems architecture, taxonomy and terminology — Using CORBA (Common Object Request Broker Architecture) in ITS standards, data registries and data dictionaries

## 1 Scope

This Technical Report clarifies the purpose of CORBA and its role in ITS. It provides some broad guidance on usage, and prepares the way for further ISO deliverables on the use of CORBA in ITS.

## 2 Terms and definitions

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

**2.1**
**General Inter ORB Protocol**
inter ORB protocol that defines the message formats between ORBs in a distributed environment

**2.2**
**Interface Definition Language**
language for defining interfaces to CORBA objects which is independent of platform, operating system and programming language

**2.3**
**Internet Inter ORB Protocol**
inter ORB protocol that allows ORBs to use the Internet as a communications bus by mapping inter ORB messages onto TCP/IP

NOTE This is an implementation of GIOP.

**2.4**
**Model-Driven Architecture**
method of writing specifications and developing applications, based on a platform-independent model (PIM)

NOTE A complete MDA specification consists of a definitive platform-independent base UML model, plus one or more platform-specific models (PSM) and interface definition sets, each describing how the base model is implemented on a different middleware platform.

**2.5**
**Object Request Broker**
function within the CORBA architecture that acts as a broker in fulfilling client requests for services from objects in a distributed environment

**2.6**
**Platform-Independent Model**
model of a software system that is independent of the specific technological platform used to implement it

**2.7**
**Platform-Specific Model**
model of a software system that is linked specifically to a technological platform

**2.8**
**Secure Sockets Layer**
protocol for transmitting private information via the Internet by using public and private keys to encrypt data

**2.9**
**Travel Information Highway**
open and independent association of information publishers and receivers who have an interest in exchanging travel information using an agreed set of principles

## 3 Abbreviated terms

| | |
|---|---|
| C2C | Centre to Centre |
| CORBA | Common Object Request Broker Architecture |
| GIOP | General Inter ORB Protocol |
| IDL | Interface Definition Language |
| IIOP | Internet Inter ORB Protocol |
| IOR | Interoperable Object Reference |
| ITS | Intelligent Transport Systems |
| MATTISSE | Midlands Advanced Transport Telematics Information Services and Strategies in Europe |
| MDA | Model-Driven Architecture |
| NTCIP | National Transportation Communications for ITS Protocol |
| OMG | Object Management Group |
| ORB | Object Request Broker |
| PIM | Platform-Independent Model |
| PSM | Platform-Specific Model |
| QMISS | Quantified Motorway Information Supply System |
| SSL | Secure Sockets Layer |
| TCP | Transmission Control Protocol |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TIH | Travel Information Highway |
| UML | Unified Modelling Language |

# 4 Requirements

## 4.1 CORBA Background

CORBA is a vendor-independent architecture and infrastructure that computer applications use to work together over networks. Using the standard protocol IIOP, a CORBA-based program from any vendor, on almost any computer, operating system, programming language or network can interoperate with a CORBA-based program from the same or another vendor, on almost any other computer, operating system, programming language and network.

CORBA applies object-oriented principles to distributed programming. A “CORBA object” offers services through well-defined interfaces specified using the OMG/ISO IDL. Clients use an object’s services by issuing requests to the object. The implementation details are kept hidden from clients. Language mappings from IDL to various programming languages make CORBA constructs available to invoke in programs.

This Technical Report does not attempt to provide a full explanation of CORBA. Key parts of CORBA are already International Standards, including ISO/IEC 14750 and ISO/IEC 19500-2.

CORBA is created and developed at the Object Management Group (OMG), a not-for-profit industry consortium. The best reference for further CORBA background is www.omg.org/corba.

## 4.2 When CORBA is appropriate

CORBA is a direct and productive way of implementing systems with distributed behaviour. Due to the wide range of language and operating system bindings available, CORBA is often a suitable choice when integrating existing systems. CORBA can provide a richer range of services than those available in many other middleware technologies.

## 4.3 Applying CORBA in ITS

For the purpose of this Technical Report, usage of CORBA will be split into distinct paradigms: “objects with behaviour” and “data/message transfer”. Both are legitimate usage paradigms for ITS.

### 4.3.1 Objects with behaviour

Distributed ITS systems have traditionally relied on messaging, but CORBA offers a richer programming model than just messaging. In this model, objects communicate and collaborate with one another to achieve the purpose of an overall system. Designers, rather than thinking about what data will be exchanged, consider what services will be offered by each component. The components are given CORBA interfaces with operations that denote some real behaviour.

Compared to messaging, this approach is more tightly coupled. Although asynchronous messaging is well supported in CORBA, the classic mode of use is for clients to make synchronous invocations of the operations of the service-providing CORBA objects. In many applications, this tight coupling is likely to be the best approach. Where the desired behaviour of components is known, creation of corresponding object interfaces is considered to be the most direct and productive way of designing and programming. The objects will tend to be domain-specific. A good example context in ITS would be integration of control systems, where components must interact to achieve overall system behaviour.

### 4.3.2 Data/message transfer[1)]

In a limited set of application contexts, data transfer is the best model. The reasons are partly non-technical, but nonetheless valid. Data owners, such as transportation authorities or operators, may have an idea that

[1)] While it is also possible to implement object invocations through messaging, this subclause describes message transfer in the sense widely used in ITS, where the messages are considered to be data.

their data is valuable, and that it could be used to provide further services, but they may not yet know exactly what services could be provided. Rather than waiting to define services, the data owner may actually achieve quicker uptake by making their data available, to encourage service providers to participate.

In travel information applications, both information service providers and network operators need to know the current state of the travel network. Because significant travel incidents are irregular and yet require timely response and information dissemination, there is often a requirement for asynchronous event-based data exchange. There is also a requirement for discovery of current state on initialization of a client application. These two distinct requirements are the key forces on the design of CORBA interfaces for travel information systems. While OMG has already standardized particular CORBA interfaces for common computing patterns ("CORBA Services"), none of the current OMG set provides a complete solution. For example, the OMG Notification Service has been used in ITS, but with an additional layer added to handle client initialization.

CORBA interfaces for data distribution will tend to be general, with operations phrased in terms of general software and data concepts rather than ITS-specific concepts. The ITS-specific content will be passed as parameters. An interesting design issue is whether specific ITS data models should be encoded into the IDL (e.g. as ITS-specific structs or value types) or whether the IDL should use general mechanisms (such as IDL "Any" type or IDL unions of possible basic types). Specific types have slightly better performance when marshalling. General types avoid recompilation of IDL after data model changes. While the great majority of applications would require re-coding anyway to reflect data model changes, general types are very useful to those few applications (typically graphical user interfaces or protocol bridges) that can adapt to new models at runtime using metadata.

Message transfer can be a useful technique where loose coupling is desired, perhaps to match underlying legacy system behaviour. In this case, existing OMG services such as the Notification Service can be employed.

### 4.3.3 Specialized CORBA versions

For embedded or other low-footprint systems, "Embedded CORBA" or "Minimum CORBA" shall be used. For hard real-time systems "Realtime CORBA" shall be used.

### 4.3.4 CORBA Security

Like any distributed technology, CORBA has points at which security threats should be considered. For each threat-point there are countermeasures, and many countermeasures have been standardized in OMG security specifications. Possibly the most widely implemented aspect of CORBA security is the use of the IIOP protocol over the secure SSL protocol. However, any deployment of CORBA (or indeed any information technology) should consider the threats, define a security policy, and (in the case of CORBA) investigate available countermeasures in CORBA security specifications and implementations.

### 4.3.5 CORBA Access Through Firewalls

CORBA has acquired a reputation for being awkward to use through firewalls. This is due to a combination of non-technical factors, which can be overcome.

A fundamental firewall function is to prevent any outgoing access except to specific ports with specific protocols, for example a firewall may explicitly allow the web protocol HTTP to pass through the well-known TCP port 80. CORBA IIOP also has established well-known ports (one for regular IIOP and one for IIOP over SSL). However, firewall administrators have been reluctant to open up ports other than the well-known HTTP ports. The argument is sometimes given that since HTTP is the protocol for retrieving static HTML information, while IIOP could be used to invoke any arbitrary behaviour, then the latter is less secure. However, this argument is refuted by the ability to "tunnel" — to layer virtually any protocol on top of an HTTP request and defeat the firewall. Even CORBA IIOP can be tunnelled using HTTP, and commercial products exist to implement this. This is clearly a ridiculous situation, since the act of layering IIOP on HTTP does not make it any more secure. It would be more secure to allow IIOP to pass but to impose further security restrictions. Unfortunately, firewall vendors have been slow to implement IIOP-aware firewalls that can interpret the details of IIOP requests and block any unauthorized invocations. However, there would have to be an existing security breach for an incoming unauthorized CORBA invocation to successfully find a target. The recommended strategy is therefore to allow IIOP access on the well-known port, as part of a carefully considered security implementation.

Firewalls also typically prevent connections being opened in the protected enclave. For this reason, CORBA supports a bi-directional mode of IIOP, in which callbacks are made on the same TCP/IP connection used for the initial outgoing communication. Bi-directional IIOP is currently supported by most ORBs, but if the feature is not supported, then the callback pattern can be avoided.

Firewalls also complicate addressing (true for all protocols) since the connections are made with firewalls before the ultimate endpoint. The recommended strategy for dealing with this (in the case of common TCP firewalls) is that the server ORB is configured to know about the inbound firewall, and uses the firewall address in the IOR that is supplied as an endpoint for clients to use. There is also a tag that can be added to IORs to declare inbound firewall details, but to take advantage of this feature, a GIOP-aware firewall is needed, and not all firewalls have implemented this feature.

It should be noted that firewalls are only one part of implementing an overall security policy, and CORBA security offers additional mechanisms.

## 4.4 Relationship of CORBA to other relevant technology

### 4.4.1 UML, CORBA and MDA

In all cases, it is good practice to start with a UML model. In the objects-with-behaviour paradigm, the objects and their interactions are modelled in UML, then the appropriate parts are realized as CORBA interfaces. However, when deciding on remote services, the designer needs to keep in mind performance issues of CORBA, and must choose a practical level of granularity. Theoretical “location transparency” does not mean that complexities and performance issues of distributed systems can be ignored at the design stage.

The use of a UML model that is independent of middleware implementation is one of the key principles of the MDA approach. A PIM contains no references to specific implementation technology such as CORBA, and is therefore usable as a basis for a range of implementations. In the MDA approach, a more detailed PSM is then created to specify the software that would be created using a particular middleware approach. For example, the same PIM could be mapped to both a CORBA PSM and an Enterprise Java Beans PSM. In many cases, the PSM is a UML model enriched with details so that it is a precise specification. In other cases, the PSM will consist of artefacts associated with the implementation technology. For example, with CORBA, IDL can be viewed as a form of PSM. However, IDL is less semantically rich than UML and the UML-based PSM is recommended. When creating CORBA PSMs, the OMG specification “UML profile for CORBA” should be used. If the pattern used in the software is a very standard one, then generators in MDA tools can automatically generate a PSM and code from a PIM.

For pure data distribution, the information model should be created in UML. This kind of model should be made precise, and stakeholders in systems should agree mappings from precise UML models to physical implementations. From such a precise UML information model, a developer will (with an understanding of the general delivery mechanism of the server and with reference to the agreed mapping) be able to develop an operational client application.

### 4.4.2 Links to OMG

OMG controls the evolution of the CORBA, UML and MDA specifications, and there is therefore a wealth of expertise on those technologies at OMG. OMG committees are divided into “Platform” (general software platforms) and “Domain” (industry-specific) groups. “Domain groups” include the “Transportation domain task force”. Any CORBA-related specification is likely to benefit from the OMG adoption process, through exposure to OMG expertise.

For the data transfer paradigm, the precise UML models described above can be registered. The introduction of CORBA as the delivery mechanism makes no difference to the way that the underlying UML models are registered. A full discussion of the compatibility of UML with ISO14817 is beyond the scope of this Technical Report.

The precise UML models and/or IDL representing CORBA interfaces and their behaviour could be registered using a similar process to that described in ISO14817, but with a different structure.

### 4.4.3 XML and CORBA

CORBA and XML are not direct alternatives, although they are sometimes cast that way.

CORBA and XML are both suitable choices of technology for ITS applications. CORBA and XML fulfil different purposes and can sometimes be used together. From a neutral UML viewpoint, CORBA offers a way to implement a UML model with behaviour, whereas XML offers a layout for data in the model. XML does not offer a network protocol. XML data types, even full XML documents, can be used as parameters in CORBA methods, either as strings or by the CORBA "XML/value" data type, introduced in CORBA 2.3.

CORBA and XML also work together in web services implementations, where CORBA is often used in the implementation of a service while XML is used at the web-facing public interface.

## 4.5 Examples

The following examples are taken from the United Kingdom's TIH and can be used to illustrate the "data transfer paradigm". The TIH is conceived as a way of exchanging travel information on the basis of common standards and best practice. It allows those organizations with information (for example, service and network operators) to make it available to those wanting information (for example, organizations offering travel-related information services). In the United Kingdom today, flagship transport initiatives such as the "National Traffic Control Centre (NTCC) project and "Urban Traffic Management and Control" (UTMC) support the use of the TIH. CORBA is the principal protocol used on the TIH backbone. Operational TIH CORBA services at the time of writing include "QMISS", which provides English motorway data, "MATTISSE", which provides urban data from a wide area in the Midlands of England, and the "COURIER DATEX-TIH Provider", which provides data from England, Wales and France through a unified CORBA interface. For further details, see http://www.travelinformationhighway.co.uk.

There is a perception that CORBA requires more skill to implement and deploy than (for example) XML over HTTP. Some consumers requested access to QMISS data via an XML interface. These needs have been met through a freely available "QMISS XML toolkit" application that uses the CORBA interface to acquire data, then outputs that data as XML. An instance of this application is also deployed centrally to populate XML pages accessible through a web server. A QMISS consumer can therefore choose any of the following strategies: a) use the CORBA interface directly, where expertise is available; b) use the XML toolkit locally, giving efficient CORBA over the wire, but with a local XML interface; c) use HTTP to retrieve the XML from the centrally deployed instance. The toolkit is highly configurable and performs an automatic IDL-to-XML Schema transformation so that it can accept new kinds of data without further development.

The NTCIP C2C standards program in the United States illustrates both the data transfer and objects-with-behaviour paradigms. The standards will allow one traffic management centre not just to obtain data from another centre but also to request control of devices. This is an ongoing programme that is informed by several CORBA deployments. In draft standards, domain objects such as signs appear as CORBA interfaces, with operations for suggesting new legends, etc. In parallel, updates to data are distributed via a notification protocol based on the OMG Notification Service. For further details see http://www.ntcip.org.

There are also proprietary CORBA ITS deployments for which it is not possible to provide details. (For example, CORBA is at the heart of the world's largest operational floating vehicle data system; see http://www.itisholdings.com.)

### 4.5.1 Benefits provided by CORBA in existing ITS deployments

In these ITS deployments, CORBA has been found to provide a number of benefits:

- Programming language and operating system independence has been extremely useful. For example, on the TIH, the choice of CORBA encourages information providers and service providers to participate because they can continue to use their familiar development platforms while maintaining interoperability.

It has also provided flexibility to ITS suppliers who quote instances of changing development language to suit available skill resources, with minimal cost.

- Vendor-neutral interoperability has on the TIH enabled multiple ITS suppliers to build integrated systems, yet through independent development and using different ORBs.

- Productivity through availability of a rich set of services, such as the “Notification service”, used in several existing ITS deployments, provides a sophisticated messaging system.

- Productivity through the directness of implementation of distributed object-oriented programming (in the objects-with-behaviour paradigm), is achieved for example in the ITIS Floating Vehicle Data System.

- Both the objects-with-behaviour and data transfer paradigms can be efficiently implemented in a single technology platform.

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