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Intelligent transport systems — Shareable geospatial databases for ITS applications —

Part 1: Framework

Systèmes intelligents de transport — Base de données géospatiales partageables pour applications ITS —

Partie 1: Architecture

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Foreword

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

A list of all parts in the ISO 19297 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 advancement of telecommunication and database technologies has helped the introduction of new types of services such as indoor navigation and multimodal navigation deployed on rapidly proliferating mobile devices such as smartphones. These newly emerging services may require geospatial databases that contain diverse and detailed content beyond the map databases used in current car navigations systems. A new database service framework that enables the usage and sharing of geospatial databases can facilitate emerging ITS applications and services.

This document addresses a database service framework and the components of the framework based on a federated database architecture commonly adopted to resolve heterogeneousness between databases. The purpose of the ISO 19297 series of standards is to promote the interoperability of geospatial databases for both suppliers and user environments, to enable the usage and sharing of geospatial databases and to facilitate ITS applications that satisfy market needs.

The ISO 19297 series of standards is a two-part standard. The following is a brief description of the parts.

— Part 1: Framework

ISO 19297-1 describes the concept, architecture and characteristics of the shareable geospatial database framework and use cases. It provides an introduction to the standard series and identifies key components of the framework, which will be developed as separate standards.

— Part 4: Common data structure

ISO 19297-4[1)] explains a common data structure for data delivery. A common data structure transports query results to information mediators or user applications. Thus, data sources coming from heterogeneous geospatial databases become homogenous to information mediators or user applications.

1) To be published. Current stage: 20.00.

Intelligent transport systems — Shareable geospatial databases for ITS applications —

Part 1:
Framework

1 Scope

This document defines a shareable geospatial database service framework and provides an overview of the ISO 19297 series of standards. This is intended to enhance user accessibility and interoperability of databases. It does not cover ITS applications or service specific issues.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

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

3.1
data warehouse
special kind of database system built upon existing operational databases that plays a key role in building a decision support system for an organization or an enterprise

3.2
federated database
collection of co-operating database systems that are autonomous and heterogeneous

3.3
feature catalogue
catalogue containing definitions and descriptions of the feature types, feature attributes and feature relationships occurring in one or more sets of geographic data, together with any feature operations that can be applied

[SOURCE: ISO 19101-1:2014, 4.1.13]

3.4
geospatial database
database that is optimized to store and query data that represents objects defined in a geometric space

3.5
indoor navigation
application of monitoring and controlling the movement of people or vehicles from one place to another within a building

3.6
information mediator
software module that exploits encoded knowledge about certain sets or subsets of data to create information for a higher layer of applications

3.7
interoperability
capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units

[SOURCE: ISO/IEC 2382:2015, 2121317, modified — <fundamental terms> at the beginning of the definition has been deleted. Notes 1 and 2 to entry have been deleted.]

3.8
multimodal navigation
application that provides information on a trip from an origin to a destination using alternative modes of transportation or a combination of transport modes for one trip

3.9
volunteered geographic information
harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals

3.10
wrapper
software component that establishes the communication and the data flow between *information mediators* (3.6) and data sources

4 Symbols and abbreviated terms

DB	Database
GDF	Geographic Data File
ITS	Intelligent Transport Systems
LDM	Local Dynamic Map
LDO	Logical Data Organization
OLAP	Online Analytical Processing
POI	Point of Interest
PSF	Physical Storage Format
W3C	World Wide Web Consortium

5 Shareable geospatial database framework

5.1 Concept

A shareable geospatial database framework should allow diverse ITS applications to access, query, process, and download various types of geospatial data content stored in separated databases in a simple and unified way. The framework originates from a wrapper and information mediator-based architecture where a pool of participating geospatial databases operated by individual organizations or enterprises form a virtually integrated database, and the architecture makes these coupled databases easily accessible over the internet.

5.2 Architecture of the shareable geospatial database framework

5.2.1 Tier 1

The shareable geospatial database framework consists of four tiers (Figure 1). Tier 1 represents a pool of service centres operated by map providers, mobile network operators, private companies, central or local governments, and even commercial buildings (e.g. department stores) participating in the federated database architecture. These service centres have full autonomy in their operations and great diversity of geospatial data content.

5.2.2 Tier 2

Tier 2 denotes wrappers. A wrapper is a software component that establishes the communication and the data flow between information mediators and data sources. Access and querying of databases by users is transparent regardless of the database type due to the standardized interfaces of wrappers. Wrappers are usually closely coupled with the service centre databases.

5.2.3 Tier 3

Tier 3, information mediators, exist between wrappers and user application tiers. An information mediator is a software module that exploits encoded knowledge about certain sets or subsets of data to create information for a higher layer of applications[6]. An information mediator offers two important functions: information reconciliation and information brokerage. Information reconciliation refers to the actions of translation, distribution, and dispatching user requests to acquire proper query results. The information brokerage function covers a series of processes so that user applications are able to get information about services, feature catalogues, and metadata.

The mediator-wrapper architecture effectively resolves database heterogeneity and greatly lessens the burdens of building a huge integrated centralized geospatial data store.

5.2.4 Tier 4

Tier 4 in the architecture comprises a group of ITS user applications running on various types of platforms including mobile phones, car navigation systems (i.e. ITS stations), tablets, and ordinary personal computing devices.

All the tiers in the architecture are interconnected with a standard networking methodology (i.e. internet/intranet). Internet, common protocols, and standard web environment provide a very convenient and interoperable environment between the constituents of all four layers.

A conceptual model of the shareable geospatial database framework is shown in Figure 1. In addition to the four tiers, there is another indispensable constituent of this architectural framework; a common data structure that helps to transport geospatially-related data content from wrappers to user applications via information mediators.

Data flows between the database tier and the application tier is bidirectional. Applications should be able to query and fetch geospatial data from the one or more servers through the information mediators and wrappers. Database servers may also be able to get user data within this framework. Applications that need data uploading from the users such as volunteered geographic information applications, will be one of the examples.

Due to the diverse and heterogeneous environments of service centres and user applications, service specific issues such as billing, traffic management, security, physical service architectures, and transaction handling are not covered in this architectural framework.

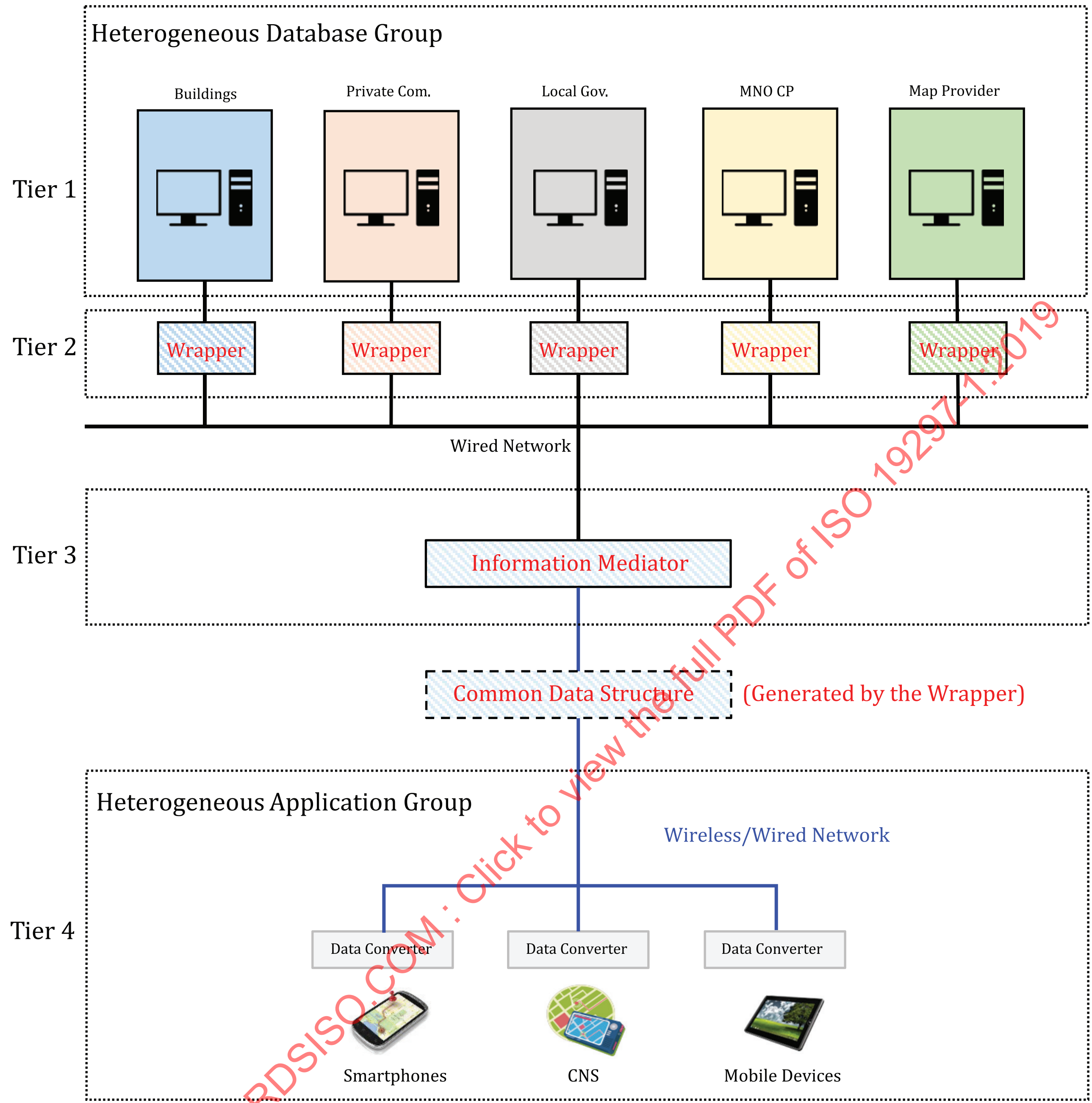


Figure 1 — Conceptual model of the shareable geospatial database framework

5.3 Characteristics and capabilities of the framework

5.3.1 Scalable architecture

The shareable geospatial database framework shall be scalable enough to ensure the addition of source databases, i.e. participation of service centres into the framework, in an easy and cost-effective manner. Addition of new geospatial databases will increase accessible data content for user applications.

5.3.2 Operational levels

The framework shall be applicable to all organizations (local, regional, national, and international) regardless of size. Because interconnections between the components in the framework are conveniently implementable over the Internet, the framework can be implemented globally. Moreover, this framework supports several ways of combining many different organization levels by connecting information mediators and wrappers.

5.3.3 Geospatial data model types

This shareable geospatial database framework shall be able to utilize all the ITS related service centres or institutions that maintain various kinds of geospatial databases. Vector-based geospatial data content such as road networks will dominate the volume of data handling within the databases, however image-based geospatial data content such as satellite imagery may be transferable to user applications.

5.3.4 Real time data handling ITS applications support

The shareable database framework shall be able to handle real time data transferring between databases servers and user applications with the aid of the framework components, i.e. wrappers, information mediators, and a common data structure. For example, this capability is necessary for some ITS applications such as multimodal transportation routing applications that need real time data coming from several databases simultaneously.

Annex A
(informative)

Geospatial data sharing

A.1 General

Geospatial data sharing commonly refers to a series of processes for exchanging or transferring data between systems or organizations. This geospatial data sharing concept is sometimes extended to the geospatial database interoperability according to the levels of sharing. At an enterprise or an infrastructure level, geospatial data sharing means not only a way of interchanging data, but also making geospatial database accessible or available to users.

Contemporary geospatial information systems own a geospatial database as the most important component and primarily focused on providing a variety of geospatial information services for either business or public service purposes. Geospatial data sharing thus spans a wide spectrum of concepts from data exchanging to database interoperability in current geospatial information technology environment.

A.2 Benefits of geospatial database sharing

Sharing geospatial databases offers many benefits to all stakeholders. Following is a list of major benefits.

— Reducing the cost of collecting or converting geospatial data when setting up new services.

— Accelerating application or service development and deployment.

— Helping geospatial data maintenance and enhancing the quality of geospatial data.

— Minimizing redevelopment of geospatial database access programs.

— Removing the entry barriers to new comers in business.

— Easily integrating various geospatial data sets.

A.3 Database sharing approaches

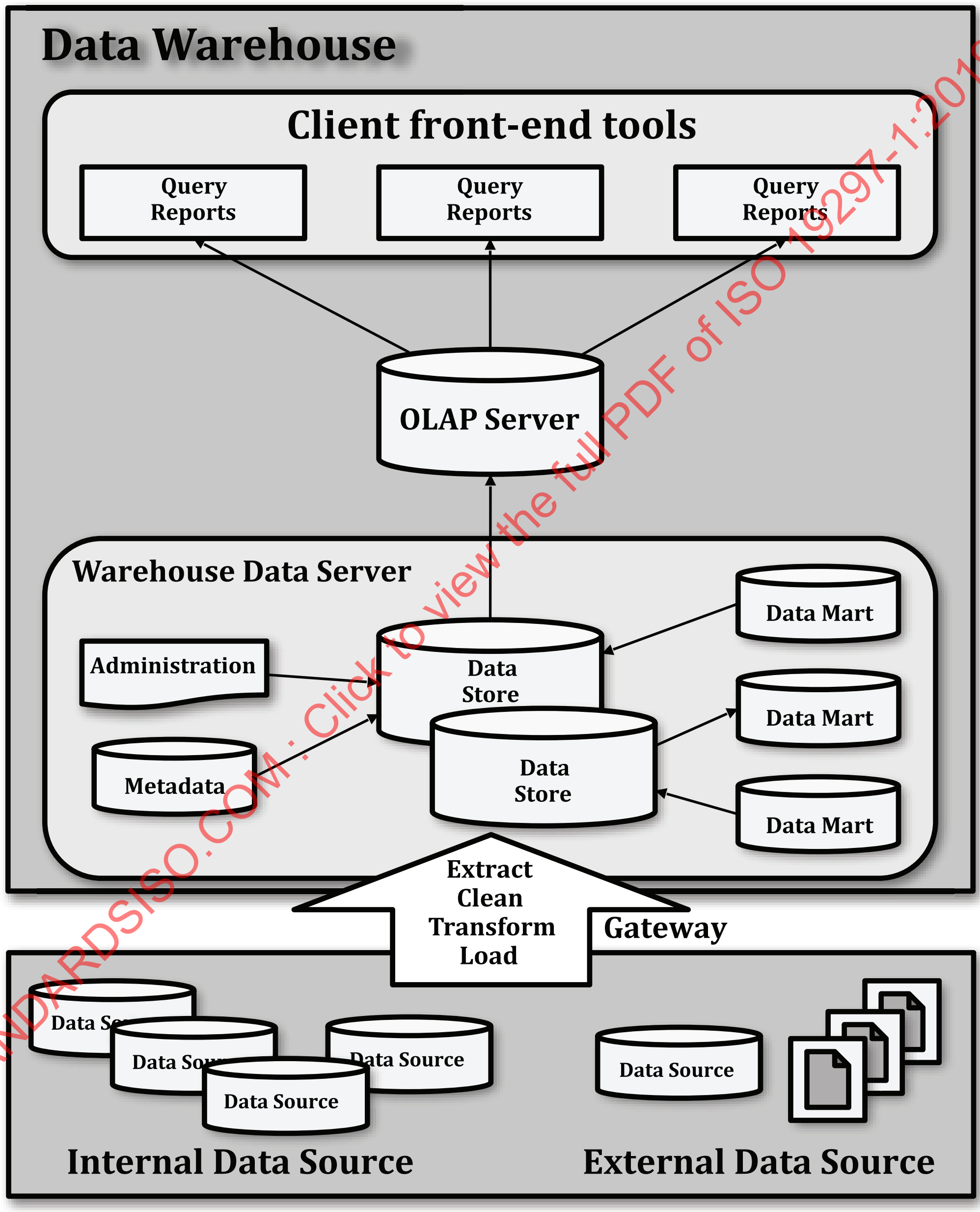
A.3.1 General

There are two different approaches available when sharing databases. The first approach, data warehousing, aims to physically integrate data sets in the centralized store so that this approach can make the database a unified data source. A federated database approach is the second approach applicable for sharing databases in the database environment. Compared to the data warehousing, a number of physically distributed databases form a virtually unified database so that users can easily access multiple databases simultaneously without knowing the details of database locations.

A.3.2 Data warehousing approach

A data warehouse is a special kind of database system built upon existing operational databases and plays a key role in building a decision support system for an organization or an enterprise. Since data content from the separated operational database systems are centrally stored within the data warehouse, users are able to access, process, and analyze the whole spectrum of organization/enterprise data content very effectively and efficiently. According to Inmon:2005[3], a data warehouse has four characteristics in subject oriented, integrated, non-volatile, and time variant collection of data. In the viewpoint of data sharing, the integrated data storage approach is the most attractive point among the four characteristics.

Figure A.1 shows a typical architecture of an enterprise wide data warehouse. The warehouse data server has one or more integrated central data stores that contain data content extracted, cleaned, and transformed from both internal and external data sources. The warehouse server also maintains the metadata of data content to keep information about data sources. Client tools or applications conduct various types of analyses in conjunction with the OLAP server.



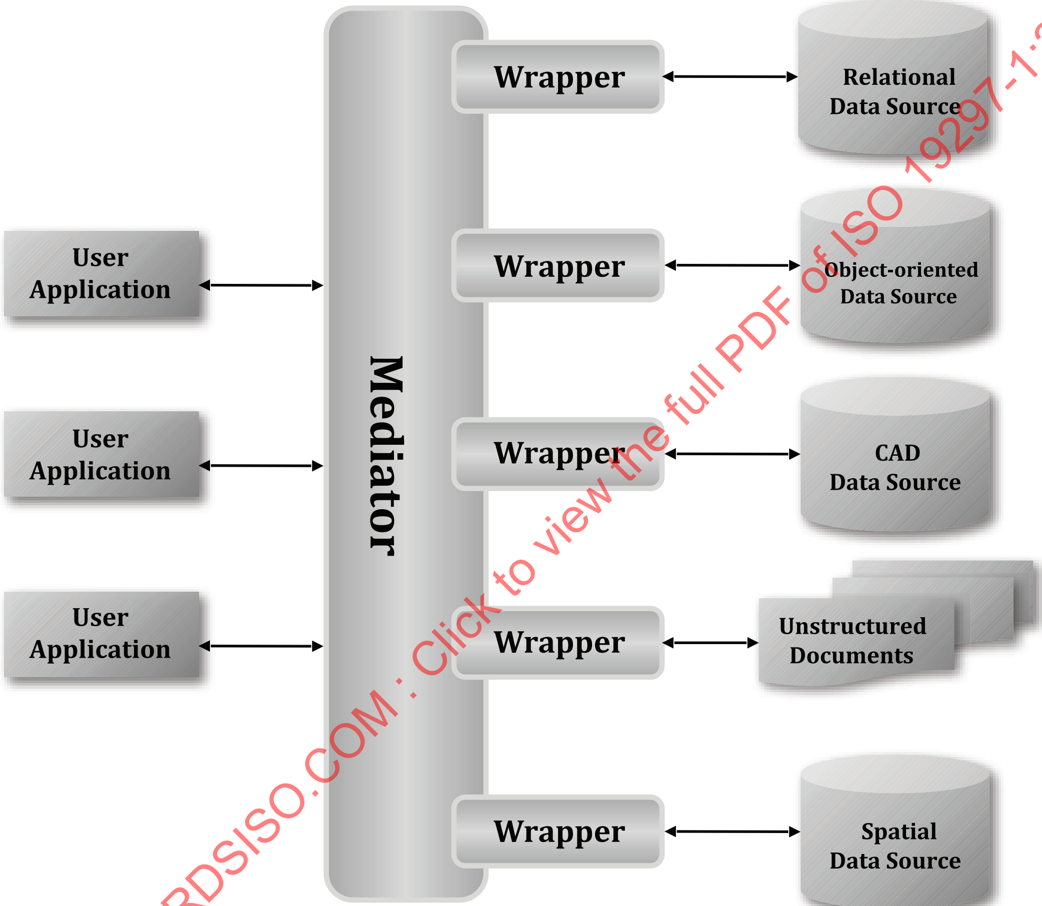
SOURCE: Yeung, A. K. W. and G. B. Hall, *Spatial Database Systems – Design, Implementation and Project Management*, Springer, 2007[5]

Figure A.1 — Architecture of an enterprise wide data warehouse

Implementation of a spatial data warehouse is one good strategy to share spatial data content and enhance the organization/enterprise's decision support capabilities. Currently available spatial database environments provide solutions for spatial data warehousing by combing spatial analysis tools with their spatial database systems.

A.3.3 Federated database approach

A federated database can be defined as a collection of co-operating database systems that are autonomous and heterogeneous (Sheth, A. P. and J. A. Larson:1992)[4]. A federated database allows database users transparent access to all of the data content through wrappers and information mediators. A wrapper and information mediator-based architecture is one that practically resolves database heterogeneity and supports a unified database handling for user applications. Figure A.2 shows the concept of wrapper and information mediator tier architecture.



SOURCE: Yeung, A. K. W. and G. B. Hall, *Spatial Database Systems – Design, Implementation and Project Management*, Springer, 2007[5]

Figure A.2 — Wrapper and mediator-based architecture

A wrapper and information mediator-based federated database system bonds source databases together and treats them as a single database in order to provide a homogeneous environment for user applications. A mediator located between wrappers and user applications is a series of software handling queries providing information about data (i.e. metadata). Through the information mediator, user applications are able to access the data content that is needed. The other important component of this architecture is a wrapper that makes heterogeneous data sources homogeneous to the information mediator and/or user applications. A single wrapper is a standardized database interface specially designed to a corresponding source database. Adopting standardized wrappers guarantees a consistent and seamless access to the databases. The scalability of a federated database is also supported with the mediator-wrapper architecture due to the flexibility of adding source databases.

Compared to the data warehousing approach, a wrapper and information mediator-based federated database framework has several advantages in geospatial data accessing and sharing. First, adding new data content into the federated database is much easier and efficient. Secondly, data exchanging between service centres will be greatly enhanced. Finally, launching various kinds of new ITS services into the market will be feasible within a short period of time.

Annex B
(informative)

Possible services with the shareable geospatial database framework

B.1 General

The shareable geospatial database framework may be applicable to both traditional ITS and cooperative ITS application fields. The next sub clauses explain some services feasible with the framework.

B.2 Information provisioning

Many ITS applications need a variety of traffic related information for supporting safe driving, road condition notification, disaster warning, routing, and information services. This information, e.g. POIs, traffic status, hazardous locations, road work zones, disaster alerts, weather information, and transportation facilities, are usually coming from the service centres of institutions, governments, map providers, or commercial centres operated independently. All of the data content is not maintained by a single organization and one single application cannot currently access these service centres simultaneously. Furthermore, users of the applications need the latest information content in real time due to the nature of these services. Using the shareable geospatial database framework, users are able to get the latest information from the participating service centres in a comprehensive manner.

B.3 Multimodal and cross navigation services

Contemporary ITS applications often require more than one kind of spatial information. Calculation of navigable space and information browsing when moving one space to another may demand several different geospatial databases. Outdoor and indoor navigation, personal navigation including sub-surface, parking assisted service, 2- and 3-dimensional map services, and multimodal navigation are some examples.

Multimodal navigation routing requires route information of various transportation modes. Besides basic road networks, complete route information about buses, subways, railways, ferries, and airplanes should be included in the calculations. Public transportation route information is usually produced, maintained, and distributed by the agencies in charge. Sharing such routing information allows users to access the detailed and latest information for many purposes.

B.4 Transportation data content update

Transportation network updating is still one of the most expensive operations in ITS services. Because obtaining updated transportation networks costs time and effort, if other alternative data sources are available that are easily shareable within the framework, transportation network updating can be performed cost effectively. In addition to transportation networks, updates of timetables, fares, and road networks, are able to be distributed by using the framework.

B.5 Geospatial content mashups

A pool of federated geospatial databases can provide a very good environment for gathering geospatial data content and representing these contents to existing applications. Combining geospatial content with maps, i.e. mashups, especially in a mobile environment provides a very effective way of representing geospatial information to users. Public and commercial service for local and regional

