Service Architecture and Metadata
(PAM)

Deliverable PAM-6

Personal Navigation Service Architecture: Survey of Background and Standards

Version 2.0

PAM Project Group
Editor: Juha Törönen, VTT

17.1.2003

Version history

Version	Date	Author(s)	Reviewer	Description
0.1-0,3	27.5.2002-31.5.2002	Project Group		Internal drafts
1.0	31.5.2002	Project Group		Version 1.0
2 Drafts 0.1-0.4	29.11.2002-412.2002	Project Group		Internal drafts
2 Draft 0.5	5.12.2002	Project Group	Steering Group	Version 2, draft 5
2 Drafts 0.6-0.8	17.12.2002-31.12.2002	Project Group		Internal drafts
2 RC	3.1.2003	Project Group	NAVI network	Version 2, release candidate
2.0	17.1.2003	Project Group		Final version

Authors

Jari Ahola
VTT Information Technology
P.O.Box 1206
FIN- 33101 Tampere
Finland
E-mail: jari.ahola@vtt.fi

Atte Kortekangas
VTT Information Technology
P.O.Box 12041
FIN-02044 VTT
Finland
E-mail: atte.kortekangas@vtt.fi

Juuso Kummala
VTT Building and Transport
P.O.Box 1800
FIN-02044 VTT
Finland
E-mail: juuso.kummala@vtt.fi

Markku Kylänpää
VTT Information Technology
P.O.Box 1203
FIN-02044 VTT
Finland
E-mail: markku.kylanpaa@vtt.fi

Timo Laakko
VTT Information Technology
P.O.Box 1203
FIN-02044 VTT
Finland
E-mail: timo.laakko@vtt.fi

Lassi Lehto
Finnish Geodetic Institute
P.O. Box 15
FIN-02431 Masala
Finland
E-mail: lassi.lehto@fgi.fi

Mikko Lehtonen
VTT Building and Transport
P.O.Box 1800
FIN-02044 VTT
Finland
E-mail: mikko.j.lehtonen@vtt.fi

Timo Leppinen
Finnish Communications Regulatory Authority
P.O. Box 313
FIN-00181 Helsinki
Finland
E-mail: timo.leppinen@ficora.fi

Juha Leppänen
VTT Information Technology
P.O.Box 1203
FIN-02044 VTT
Finland
E-mail: juha.leppanen@vtt.fi

Jaakko Lähteenmäki
VTT Information Technology
P.O.Box 1202
FIN-02044 VTT
Finland
E-mail: jaakko.lahteenmaki@vtt.fi

Reijo Martamo
VTT Building and Transport
P.O.Box 1800
FIN-02044 VTT
Finland
E-mail: reijo.martamo@vtt.fi

Reino Ruotsalainen
National Land Survey of Finland
Development Centre
P.O.Box 84
FIN-00521 Helsinki
Finland
E-mail: reino.ruotsalainen@nls.fi

Petri Rönnholm
Helsinki University of Technology
Institute of Photogrammetry and Remote Sensing
P.O.Box 1200
FIN-02015 TKK
Finland
E-mail: petri.ronnholm@hut.fi

Santtu Toivonen
VTT Information Technology
P.O.Box 1203
FIN-02044 VTT
Finland
E-mail: santtu.toivonen@vtt.fi

Juha Törönen
VTT Information Technology
P.O.Box 1203
FIN-02044 VTT
Finland
E-mail: juha.toronen@vtt.fi

Martin Vermeer
Helsinki University of Technology
Institute of Geodesy
P.O.Box 1200
FIN-02015 TKK
Finland
E-mail: martin.vermeer@hut.fi

Editor

Juha Törönen
VTT Information Technology
P.O.Box 1203
FIN-02044 VTT
Finland
E-mail: juha.toronen@vtt.fi

Abstract

This is a review of backgrounds and standards associated with personal navigation, especially its service architecture. The basic concepts - geographic and location information, including co-ordinate systems, spatial data and geographic identifiers, location methods and information transfer, and location based services, are introduced. The concept and interpretation of metadata is described. Intelligent transport systems and the associated information services are reviewed. Finally, standards and other sets of definitions and practices affecting any of the various aspects of personal navigation and its service architecture, i.e., 3GPP, Bluetooth, CEN, Cell Broadcast Forum, ETSI, IETF, ISO/TC211, OMA, Open GIS, and W3C are reported, with a review of international transport telematics standardisation. This document is mainly a collection of available technologies and definitions. Service architecture is introduced in document *Core Service Architecture For Personal Navigation* (PAM Deliverable 7).

Tiivistelmä

Tämä raportti on katsaus henkilökohtaisen navigoinnin taustateknologioihin ja standardointiin. Käsittely alkaa perusteista ja yleisistä asioista, pyrkien etenemään yksityiskohtiin myöhemmissä luvuissa. Tätä linjaa tosin ei kaikilta osin, asioiden moninaisuuden takia, voida kovin tarkasti noudattaa.

Lähtökohdiksi on otettu maantieteellinen ja paikannustieto, joita esitellään luvussa 2, alkaen koordinaattijärjestelmistä. Samassa yhteydessä pohditaan langattomien päätelaitteiden paikannustiedon esittämiselle asettamia haasteita ja paikkariippuvan palvelutapahtuman perusrakennetta sekä kuvataan maantieteellisten tunnisteiden käyttöä koskevia periaatteita. On ennakoitavissa, että joissakin tapauksissa maantieteellisten käsitteiden tulkinta saattaa tuottaa rajatapausongelmia niihin vahvasti nojaavissa sovelluksissa, kuten sellaisissa, joissa käyttäjä joutuu itse tätä tietoa tulkitsemaan.

Luku 3 on katsaus henkilökohtaisen navigoinnin kannalta kiinnostaviin paikannusmenetelmiin sekä paikannustiedon välitykseen ja paikannettuihin palveluihin. Eri teknologioihin perustuvia paikannusmenetelmiä esitellään lyhyesti. Paikannettuja palveluja on määritelty ISO:n ja OCG:n piirissä, mutta palvelujen tulo käyttöön luonnollisesti edellyttää tarvittavien perustekniikoiden olemassaoloa. Paikannusmenetelmien kehittymisellä voi olla voimakas vaikutus paikannettujen palvelujen yleistymiseen. Erityisesti sisätilapaikannuksessa olisi tarvetta kustannustehokkaan menetelmän yleistymiselle.

Metatiedon käsite ja tulkinta vaihtelevat paljonkin sen mukaan, millaiseen tarkoitukseen ja millaisista lähtökohdista metadataa halutaan käyttää. Tämän aihepiirin kannalta metadataa käsitellään luvussa 4. Semanttisen sisällön tulo mukaan verkotettuihin palveluihin antaa uusia mahdollisuuksia myös henkilökohtaisten navigointipalvelujen kehittämiselle. Myös ISO ja OGC ovat laatineet tämän aihepiirin kannalta kiinnostavia määrittelyjä metatiedolle.

Liikenteen telematiikalla ja älykkäillä liikennejärjestelmillä (luku 5) on keskeinen rooli sekä liikkumiseen liittyvänä infrastruktuurina että sovellusmahdollisuuksien potentiaalisena käyttäjänä. EU ja Yhdysvallat ovat laatineet omat määrittelynsä älykkäille kuljetusjärjestelmille (ITS). Lähestymistavat ovat hieman erilaiset, mutta perimmäisenä tarkoituksena on parantaa liikenteen tehokkuutta, turvallisuutta ja ympäristövaikutuksia teknologian avulla. Näitä suuntaviivoja noudattaen kehitetään myös eri liikennemuotojen yhteistoimintaa, joiden avulla kuljetuksia voitaisiin tarkastella yhtenäisen ketjun tyyppisinä palveluina erillistapahtumien asemesta.

Dokumentin luvussa 6 käydään läpi henkilökohtaisen navigoinnin kannalta tärkeitä standardeja ja muita standardinomaisia määrityksiä ja ohjeita. Katsaukseen sisältyvät henkilökohtaiseen navigointiin liittyviltä osin 3GPP, Bluetooth, CEN, Cell Broadcast Forum, ETSI, IETF, ISO/TC211, OMA, Open GIS ja W3C, ja mukana on myös katsaus kansainväliseen liikennetelematiikan standardointiin edellä mainituissa ja muissakin elimissä. Aihepiirin standardoinnin käytännön järjestelyissä on tätä kirjoitettaessa käynnissä muutoksia, lähinnä OMA:n piirissä, ja siitä syystä OMA-dokumenttien ja -viitteiden ajantasaisuus on epävarmaa.

Tämän katsauksen sisältö on siinä määrin vaihtelevaa, että sen yhtenäistä kuvausta ei ole helposti muodostettavissa. Materiaalia voitaneen pitää käsikirjanomaisena hakemistona tai arkkitehtuurityön tukimateriaalina. Joitakin yleishavaintoja voidaan silti tehdä.

Viime aikoina jotkin henkilökohtaista navigointia koskevat teknologiat ovat saavuttaneet merkittävän laajan hyväksynnän, vaikkei kyse useimmiten olekaan esimerkiksi viranomaismääräyksen

tasoisista määrittelyistä. Käytännön sovelluksia ei näilläkään usein ole vielä kovin runsaasti. Esimerkkejä tällaisesta ovat LIF-määrittelyt (nyttemmin OMA:n alaisuudessa) ja OGC:n OpenLS.

Henkilökohtaisen navigoinnin hyvä palvelutaso vaatii vielä uusiakin teknologiaratkaisuja. Eräs tällainen tarve on lyhyen kantaman paikannus, paljolti sisätiloissa käytettäväksi. Useita ratkaisuehdokkaita on tarjolla ja kehitteillä, ja jotkut niistä tavoittelevat suoraan massamarkkinoitakin. Ratkaisun läpimurto näillä alueilla saattaa tuoda uusia liiketoimintamahdollisuuksia nopeastikin. Eräs mahdollinen sovellusalue saattaisi löytyä tällä hetkellä useasti esille tulevia virtuaaliyhteisöjä mahdollistavista teknisistä palveluista. Näissähän myös henkilökohtaisella navigoinnilla on paikkansa palvelukomponenttina.

Varsinaisia palvelujen arkkitehtuurikysymyksiä käsitellään raportissa *Core Service Architetcure For Personal Navigation* (PAM Deliverable 7).

Contents

1 Introduction ... 1
1.1 Document structure ... 1
2 Geographic Information ... 3
2.1 Co-ordinates ... 3
2.1.1 Geocentric co-ordinates ... 3
2.1.2 Plane co-ordinates ... 4
2.1.3 Handling existing co-ordinates and heights ... 5
2.1.4 Bodies of geolocated information ... 6
2.1.5 Co-ordinate quality ... 6
2.1.6 Motion ... 7
2.1.7 Distance metrics ... 7
2.1.8 Useful links ... 7
2.2 Spatial Data Services ... 8
2.2.1 General ... 8
2.2.2 Technical Architecture ... 9
2.3 Spatial Referencing by Geographic Identifiers ... 10
2.3.1 Scope ... 10
2.3.2 Spatial referencing using geographic identifiers ... 11
2.3.3 Spatial reference systems using geographic identifiers ... 12
2.3.4 Gazetteers ... 12
2.3.5 Examples of gazetteer data ... 12
3 Location Information Services ... 14
3.1 Mobile location methods ... 14
3.1.1 Cellular network location methods ... 14
3.1.2 Satellite location methods ... 15
3.1.3 Local networked location methods ... 16
3.1.4 Local non-networked location methods ... 16
3.1.5 Image positioning-based location method ... 17
3.2 Location information transfer ... 20
3.3 Location Based Services ... 22
3.3.1 OGC/ Location based services ... 22
3.3.2 ISO TC211/ Location based services ... 23
Location based services - possible standards ... 23
Location based services - tracking and navigation ... 23
Multimodal location based services for routing and navigation ... 23
4 Metadata ... 25
4.1 The Semantic Web ... 25
4.1.1 Semantic Web Technologies and Geographic Information ... 26

4.2 Web Services ... 27
4.2.1 UDDI ... 28
4.2.2 WSDL ... 28
4.2.3 SOAP ... 28
4.2.4 WSMF ... 28
4.2.5 Web Service Technologies and Geographic Information ... 30
4.3 Metadata of datasets ... 30
4.3.1 Scope ... 31
4.3.2 Core metadata for geographic datasets ... 31
4.3.3 Metadata - Implementation specification ... 32
4.4 Initiatives of Open GIS Consortium ... 32
4.4.1 GetCapabilities ... 32
4.4.2 Web Registry Service ... 33
5 Intelligent transport system (ITS) ... 34
5.1 Introduction ... 34
5.2 ITS System Architectures in the World ... 34
5.2.1 The U.S. National ITS Architecture ... 34
5.2.2 The European ITS Framework Architecture ... 36
5.2.3 The Finnish National ITS Framework architecture ... 40
5.3 Multimodal information services ... 42
5.3.1 Background ... 42
5.3.2 Travel planning ... 42
5.3.3 Information and guidance ... 43
5.3.4 Incident management ... 44
5.3.5 Communication channels ... 44
5.3.6 Merging information systems ... 44
5.3.7 Co-operation between transport modes ... 45
5.3.8 Co-operation between the public and private sectors ... 45
5.4 The Finnish Multimodal Traffic Data Dictionary ... 46
6 Standardisation ... 48
6.1 Bluetooth SIG ... 48
6.1.1 SIG activities in local positioning ... 48
6.2 3GPP ... 49
6.3 Cell Broadcast Forum ... 51
6.4 IETF ... 51
6.5 CEN/TC287 ... 52
6.6 ISO/TC 211 Geographic Information / Geomatics ... 53
6.6.1 Source documents (under preparation) ... 53
6.6.2 Characteristics / description ... 54
6.7 Open Mobile Alliance (OMA) ... 55
6.7.1 Location Interoperability Forum (LIF) ... 56
6.7.2 WAP Forum ... 57
6.7.3 SyncML ... 59
6.7.4 Wireless Village ... 59

6.8 Open GIS Consortium 60
6.8.1 Introduction 60
6.8.2 Standardised interfaces 61
6.8.3 Encoding of Geographic Information 62
6.8.4 Data Service Interfaces 63
OpenGIS Web Map Service 63
Web Feature Service 64
Web Coverage Server 66
6.8.5 Data Encoding Specifications 66
6.9 W3C 68
6.9.1 Semantic Web Activity 69
6.9.2 XML Protocol Activity 70
6.9.3 Device Independence Activity 70
6.9.4 SVG 70
6.9.5 Extensible Stylesheet Language (XSL) 71
6.9.6 XML Schema 71
6.9.7 Web services Activity 71
6.9.8 Annotea Project 71
6.9.9 Some other XML languages 72
6.9.10 Workshop 72
6.10 International Transport telematics' standardisation 72
6.10.1 CEN TC 278 Road Transport and Traffic Telematics 72
6.10.2 CEN TC 224 Machine readable cards, related device interfaces and operations 73
6.10.3 CEN TC 226 Road Equipment 73
6.10.4 ISO/TC 204 Transport Information and Control Systems 74
6.10.5 GDF 74
What is GDF ? 74
(Mis)Understanding GDF 74
GDF Structure 75
7 Summary 76

1 Introduction

This document is Deliverable 6 (version 2) of the *Service Architecture and Metadata* project (PAM, or *Palveluarkkitehtuuri ja metatieto* in Finnish), a part of the Finnish national *Personal Navigation programme* (NAVI).

The motivation of the PAM project follows from the large number of parties and technologies of mutually independent origins and purposes in personal navigation business chains. Compatibility between those is very desirable, and one way to help to achieve this is a commonly recognised and applicable service architecture. The goal of the PAM project is to increase the knowledge of service architecture issues within the NAVI network by collecting information on the subject, processing and re-distributing it to the members and projects of the NAVI research programme.

This document describes the basic concepts and the state of the art, at the time of writing, of the basic concepts, technologies and standards behind personal navigation services and architectures. Its role is to be an all-round collection of basics and concepts of personal navigation, with the intention to help in building the service architectures. The architecture modelling and modelling tools are described in other documents.

The starting point is in basic and general concepts, and the approach gets more technical and detailed towards the later chapters - even though this rule is not kept very strictly.

The contacts given for some titles refer to the persons in the PAM project mainly responsible for the corresponding chapters or sub-chapters in this document.

1.1 Document structure

The document begins with the introduction of the very basic elements of navigation (co-ordinates and maps, their handling, and geographic identifiers), followed by information services and location information transfer in networks.

Our starting point is in **geographical information**, starting from co-ordinate systems, then carrying on with introduction of spatial data concepts (Chapter 2).

In Chapter 3, **location information services** are introduced, including a short review of location methods and descriptions of location information transfer and location based services.

Interpretation of the **metadata** concept varies considerably with the frame of reference in which it is used. To be actually useful, the correct point of view should of course be taken in each case - and this also applies in our case. Metadata is discussed in Chapter 4.

Transport systems and services are at central for personal navigation as infrastructure, but potentially also as users of the personal navigation services. Intelligent transport system architectures and multimodal information services are introduced in Chapter 5.

Standards and other commonly accepted definitions and practices in the enabling technologies for personal navigation must be taken into account when establishing a service architecture. A number of organisations, of varying legal and technological status, have impact in personal navigation solutions. The ones introduced in this document are:

- Bluetooth Special Interest Group,
- Cell Broadcast Forum (CBF),
- European Committee for Standardization (CEN)/TC287,
- Internet Engineering Task Force (IETF),
- International Organization for Standardization/Technical Committee 211: Geographic information/Geomatics (ISO/TC211),
- Open GIS Consortium, Inc. (OGC),
- Open Mobile Alliance (OMA), including the former Location Interoperability Forum (LIF), WAP Forum, Wireless Village, and SyncML,
- Third Generation Partnership Project (3GPP),
- WorldWideWeb Consortium (W3C).

The standards and their implications are described in Chapter 6.

2 Geographic Information

2.1 Co-ordinates[1]

2.1.1 Geocentric co-ordinates

For these new technologies, it appears wise to use the co-ordinate system that also the GPS system already employs, and transform, according to need, legacy co-ordinate data into this system. The focus here is slightly different from that within traditional geodesy, and one should directly adopt standards compatible with the latest technology.

This means that co-ordinates are defined in the local realisation of WGS84; In Europe that means a realisation of ETRS89, a co-ordinate system that co-moves with the Eurasian plate. Its original realisation covering most of Europe is called EUREF-89 and is internally consistent to within a few cm. In Finland, a newer realisation exists called EUREF-FIN, produced by the work of the Finnish Geodetic Institute. It agrees on the Finnish territory to within a few cm with EUREF-89.

As stated earlier, the background for using geocentric co-ordinates is that this is what the pervasive GPS technology produces. These can be rectangular (XYZ), or ellipsoidal (ϕ, λ, h) for visualisation. "Geocentric" means the following things:

1) The origin is in, or very close to (few cm), the centre of mass of the Earth. This again means that different realisations of geocentric systems are interconsistent on this level too.

2) The Z axis is very close to the Earth's rotation axis. As this axis isn't in a fixed position on the surface of the Earth but moves over several tens of metres (polar motion), one has conventionally agreed that the Z axis should coincide with the mean pole position over the year 1903, the so-called CIO (Conventional International Origin).

3) The reference ellipsoid used for ellipsoidal co-ordinates will be GRS80 (Geodetic Reference System 1980), which differs from currently used reference ellipsoids in national co-ordinate systems, e.g. the Hayford 1924 (International) ellipsoid used as the basis for the Finnish kkj system.

4) One distinguishes between international reference frames, e.g. ITRF93, and continental e.g. European reference frames, e.g., ETRF93. The latter co-move with the continental plate, and are defined to be co-incident with the corresponding ITRF at an agreed epoch. E.g. ITRF93 and ETRF93 co-ordinates are identical at epoch 1989.0, but diverge after that.

On the dm level, all geocentric co-ordinate systems and their realisations are identical and compatible with direct positioning use of the GPS technique --with or without using nearby reference stations in known locations. It is however advisable to determine the

[1] Contact:
Martin Vermeer, Helsinki University of Technology

locations of reference stations to be used in the local realisation of EUREF using best available means, to avoid error propagation from this source.

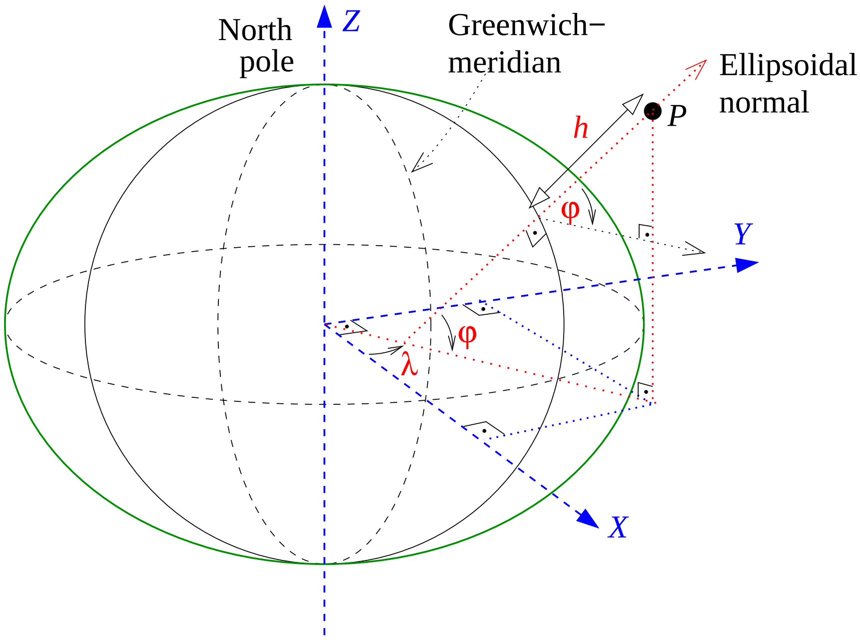


Figure 2-1. Geocentric co-ordinates, both rectangular (X,Y,Z) and ellipsoidal (ϕ,λ, h)

2.1.2 Plane co-ordinates

For practical reasons the three-dimensional co-ordinates can be presented as two dimensional map projection co-ordinates. In Finland, UTM with a central meridian 27° E was recommended by the Finnish Working Group on Co-ordinate Systems Reform as the official plane co-ordinate system to be adopted. Therefore this may become the new standard. However, the current system of Gauss-Kueger co-ordinates in several zones, with central meridians at 21°, 24°, 27° and 30° will also remain in use in parallel, for engineering applications, but re-computed using EUREF co-ordinates on the new GRS80 ellipsoid.

In Finland, the matter of the possible transition from the existing kkj system to a new, ETRS89 based system -- as well as the associated matter of a transition to a new, possibly common Nordic or European, height system -- was discussed in a working group convened on the initiative of the Finnish Geodetic Institute in 1999. The commission, which contained representatives from public authorities, defence, municipalities, academia, defence and the mapping industry, reported on its findings that same year, recommending a gradual transition to ETRS89 (EUREF-FIN), and to the UTM map projection where appropriate for small-scale maps -- but a postponement of the decision on the height system.

The text of the report is in

http://www.fgi.fi/kirjasto/julkaisut/pdf/koord5b.pdf .

The matter is under active discussion in Finnish society; it was the theme of the 2001 Annual Seminar of the Finnish Society of Surveying Sciences: "Co-ordinate Systems in a Time of Change".

In Finland, two leading mapping institutions resort under the Ministry of Agriculture and Forestry: The National Land Survey and the Finnish Geodetic Institute. Currently a cautiously positive attitude can be detected in the Ministry, which seems to indicate that a gradual transition to EUREF-FIN will take place in the years ahead.

2.1.3 Handling existing co-ordinates and heights

Ways to handle legacy co-ordinate systems (non-geocentric; in Finland especially kkj, local systems) must be provided. Methods for doing so vary according to need and situation; a simple plane Helmert (similarity) transformation will often be sufficient. At the ±1 m accuracy level, a single national co-ordinate transformation formula would be sufficient almost everywhere, and already exists.

Height handling, as needed; for location, one would recommend as standard the use of ellipsoidal heights, as these are directly provided by GPS.

However, it is important to understand that for practical use, heights are needed that directly connect to the geopotential (energy) level within the 1-g gravity regime on the Earth's surface ("heights above sea level"). Connection with these traditional heights has to be made using a geoid model (i.e. a mathematical description of mean sea level model also valid in-land) of accuracy matching co-ordinate accuracy considered.

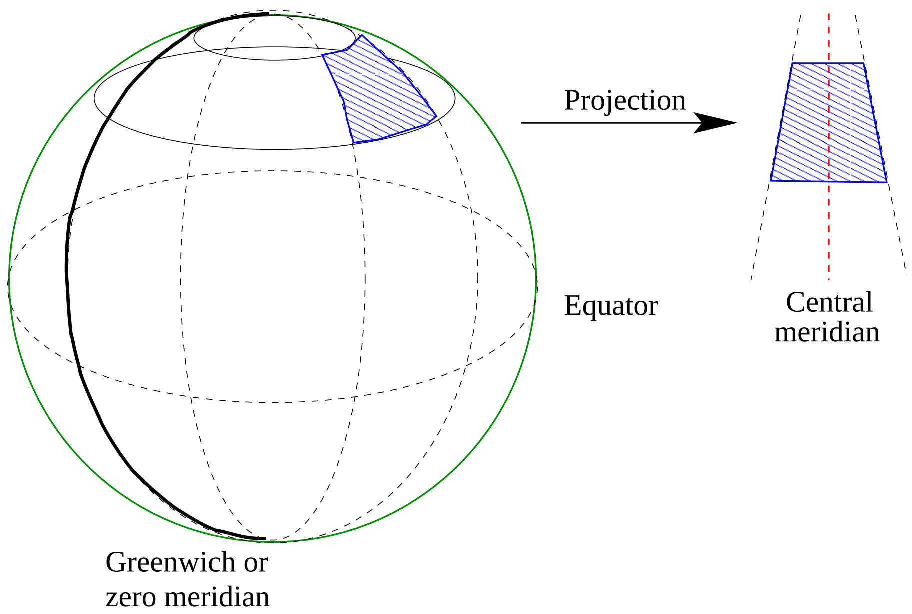


Figure 2-2. Map projection. From three-dimensional (spatial) to two-dimensional (map plane) co-ordinates.

E.g., in Finland, the Finnish Geodetic Institute's FIN95/FIN2000 geoid models provide ±5 cm in most places; globally EGM96 provides ±0.5 m in most places.

2.1.4 Bodies of geolocated information

The problems of handling large bodies of databased, often moderate accuracy, co-ordinate material, i.e. geolocated information, are special. Methods for handling such material, and especially the parallel existence of two of more alternative co-ordinate representations and connections between them, should be provided with the general-purpose software used in such connections. Little exists currently.

2.1.5 Co-ordinate quality

Co-ordinate quality metrics are needed. The starting point would be, as is the current practice, the "point standard error" (precision) m_P:

$$m_P = \sqrt{m_x^2 + m_y^2 + m_z^2}$$

in three dimensions. In map projection (plane) co-ordinates, the term with subscript z can be simply left off.

$\pm m_P$ stands for standard error; if we want to use tolerance, commonly a value of $\pm 3m_P$ is specified.

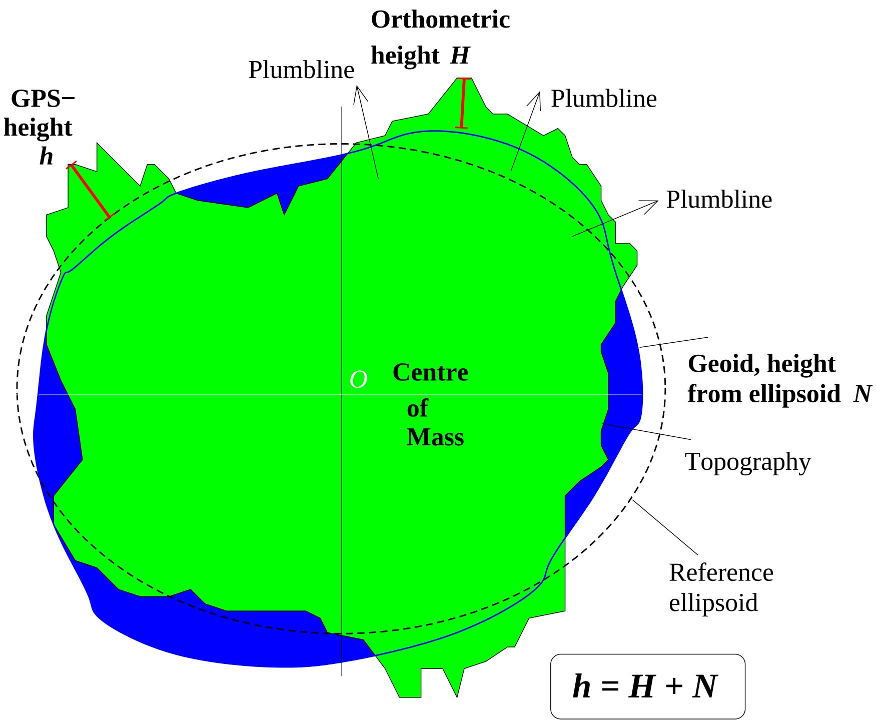


Figure 2-3. Height systems and reference surfaces. Orthometric heights, ellipsoidal (GPS) heights, geoidal heights; mean sea surface, geoid, plumbline.

Alternatively, this numerical quality metric could be used to specify a discrete set of "quality classes", as is the custom in measurement guidelines like the Finnish Regulations on Zoning Surveying (Kaavoitusmittausohjeet).

2.1.6 Motion

Co-ordinates of moving objects will be time dependent. One simple method of description of motion specifies a location and a velocity vector in 2D or 3D co-ordinates. Velocity can also be specified as heading and magnitude.

Often one will want to model motion some time into the future (prediction). Simple prediction techniques like dead reckoning work well short term but deteriorate quickly.

Advanced modelling techniques like predictive linear filtering (e.g., Kalman filtering) could be part of future navigation equipment, allowing integration of sensors, such as inertial (acceleration, rotation) sensors, which are becoming more affordable. Also vehicle motion sensors could be integrated in this way, a viewpoint to be aware of.

2.1.7 Distance metrics

A number of alternative distance metrics is available, such as:

o As the crow flies, great circle distance; in small areas, "straight" distance using Pythagoras:

$$s = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \, .$$

In somewhat bigger areas:

$$s = R\sqrt{(\phi_2 - \phi_1)^2 + (\lambda_2 - \lambda_1)^2 \cos^2 \phi} \, ,$$

where R is mean Earth radius (if ϕ, λ in radians) or length of a degree in metric units (if ϕ, λ in degrees and decimals).

o Road distance

o Distance in terms of other networks

Geometric distance can be obtained from co-ordinates only, a simple operation that should always be available.

Network distances on the other hand require descriptive map information on the network concerned. Representation of this data chosen should readily allow the determination of network distances between points.

2.1.8 Useful links

Organisations responsible for the monitoring of the Earth's rotation and the creation of consistent geocentric co-ordinate systems are:

International GPS Service: http://igscb.jpl.nasa.gov/ .

International Earth Rotation Service: http://www.iers.org/iers/

EUREF (IAG Subcommission for the European Reference Frame) home page:
http://www.euref-iag.org/ .

EUREF Central Bureau: http://www.epncb.oma.be/ .

2.2 Spatial Data Services[1]

2.2.1 General

The display of map data on mobile devices is currently under intensive attention, especially because of the recent introduction of the concept of Location Based Services (LBS). Many useful location-aware services can be built without map display on the mobile terminal and a few service categories can be realised even completely without access to spatial data resources. However, in some service types a significant improvement can be achieved in the usability if map data can be utilised. Map displays are most useful e.g. in various guidance and navigation services. A fundamental design principle for this kind of service is that map display must be brought to the terminal via a wireless network connection on the moment the service is accessed. A service architecture based on pre-loaded map data, does not seem appropriate in the context of dynamic mobile services.

The limited computing facilities available in current mobile devices sets significant limitations for the map display. The processing power can be assumed to be constantly increasing, but on the other hand in the future smaller and smaller devices will probably be introduced. So limited capacity terminals will be used also in the future. This kind of devices can typically display map data only as raster images or in the form of textual or audible information. An example of the latter would be a navigational service based on audible turning-point instructions.

In mobile services up-to-date information is vital. Access to current data, independently of the time of the day or location of the user, is a fundamental requirement in these services. The first operative mobile services are specifically designed for checking the current value of the subject in question, examples ranging from stock prices to news feeds to bank accounts. When developing location based services, the same demand for up-to-date information concerns also map data. This demand is specially important in the case of road information used in operative car navigation services. If the introduced road block does not instantly show up in the road database, the usefulness of the navigation service is questionable.

Currently the map display on mobile terminals is just being introduced. The delivery of map data to the terminal as a raster image is available for the WAP devices. The current WAP phones support display of one-bit raster images. The resolution of the existing WAP phone screens is rather limited (e.g. Nokia 6310: 96*65 pixels, Ericsson RS380: 120*360 pixels). The recently introduced Benefon ESC! GSM/GPS-phone supports two-bit images with screen resolution of 100*160 pixels, but the map data must be

[1] Contact:
Lassi Lehto, Finnish Geodetic Institute

downloaded to the device via a cable connection from a PC. The Nokia's latest Communicator Model 9210 has a 12 bit (4096 colour) screen with a resolution of 640*200 pixels. Cell phones with colour screens are gradually being introduced to the market. The latest camera phones have slightly increased screen resolutions (for instance, the Nokia 7650 Model: 176 * 208 pixels).

Because of their open programming interfaces, PDA devices offer adequate facilities for client application development. Generally PDA's provide also better processing and memory capabilities than mobile phones. Display resolutions are typically in the range of 200-400 pixels (e.g. Pocket PC 240*320 pixels). Devices supporting colour display are increasingly been introduced to the market. The main problem with these devices is the missing wireless network connection. Frequently an external mobile phone is used as a solution for the connectivity problem. The recent emergence of the Wireless LAN technology is changing the situation in appositive way, but the area of the radio coverage in the existing systems has so far been disappointedly limited.

2.2.2 Technical Architecture

A mobile service than makes use of the map display on the user terminal could be seen in the framework of a four-tier technical architecture. On the first tier are the basic data services providing access, through network service interface, to continuously updated spatial databases for value-added service developers. On the second tier those data services are used to build up various information services. On this level different sources of spatial data are possibly integrated, service-specific location-dependent information is added, and the resulting information product is offered to the next layer in the architecture. In this process the location of the actual user, available from the applied mobile location technology, might also be made use of.

The third level in the service architecture consists of a portal service tier, which has a two-fold task. As seen from the user point of view, the portal functions as a easy-to-use catalogue or directory service facilitating the discovery of location based services. The catalogue could be arranged in a theme or location-dependent way. Another task of a portal layer, as seen from the service provider's side, is to adapt the resulting service information appropriately for each category of end user devices. When speaking about map information, this means adapting the map layout and contents to the display capabilities of the used terminal. A part of this process is to decide whether the map can be sent to the terminal in the form of a vector or raster based representation. For the both categories of graphics there are various further considerations like the bit-depth of the raster image, available support for colours, display resolution etc.

The role of the third tier in the service architecture in adapting the information content to the individual characteristics of the terminal device in use, represents the functionality that in the context of Web text documents has recently been introduced as multi-purpose or multi-channel publishing. The same need is present in the device-specific personalization of the service information and introduces, in the case of map display, special requirements for multi-purpose publishing of graphic information.

The fourth tier in the service architecture consists of the mobile devices and the client applications run on those devices. Mobile services can be accessed by a wide set of different terminals. The visualisation capabilities vary from the large 15 inch screen of a powerful portable computer to the miniature 100*100 pixel display of a mobile phone.

Also the facilities available for user interaction change significantly from device to device. This fact naturally sets considerable demand for the device-specific personalising function of the portal service.

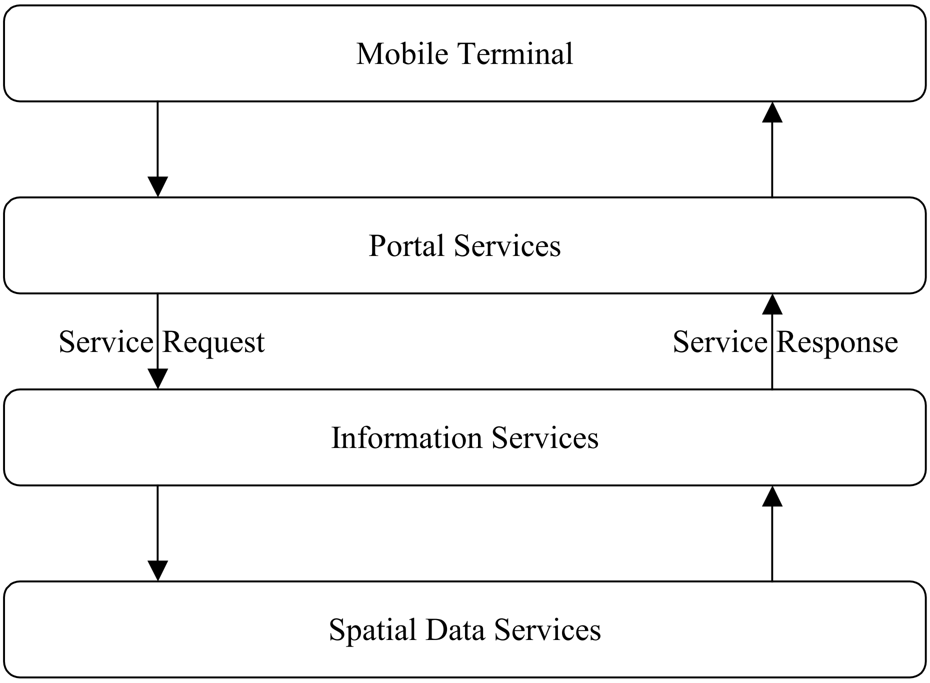


Figure 2-4. Four-tier technical architecture of mobile service.

The four-tier technical service framework is shown in the Figure 2-4. In a practical service case these tiers do not necessarily show up as separate layers. However, as logical entities they should always be discernible to facilitate flexible maintenance, scalability and personalization of the service.

2.3 Spatial Referencing by Geographic Identifiers[1]

2.3.1 Scope

ISO 19112 Standard defines the conceptual schema for spatial references based on geographic identifiers.

It establishes a general model for spatial referencing using geographic identifiers, defines the components of a spatial reference system and defines the essential components of a gazetteer.

[1] Contact:
Reino Ruotsalainen, National Land Survey of Finland

Spatial referencing by co-ordinates is addressed in ISO 19111. However, a mechanism for recording complementary co-ordinate references is included.

ISO 19112 Standard enables producers of data to define spatial reference systems using geographic identifiers and assists users to understand the spatial references used in datasets. It enables gazetteers to be constructed in a consistent manner and supports the development of other standards in the field of geographic information.

2.3.2 Spatial referencing using geographic identifiers

The position of a feature is identified by a spatial reference. Where a geographic identifier is used as this spatial reference, it uniquely identifies a location. This location is a feature used to reference other features.

NOTE The spatial reference of a feature in a geographic dataset is usually held as an attribute of the feature, and defines an association with a location. The relationship with the location is usually that of containment within. However, more complex spatial references may be constructed using relationships such as ‘adjacent to’ and ‘distance along’ together with a measured distance and direction from the location identified. Reference systems for roads and railways are often based on a measured distance form one node (end point or intersection) among a link (road or track). The spatial reference system used in a dataset forms part of the metadata for that dataset, as defined in ISO 19115.

These concepts are illustrated in Figure 2-5, which applies at both the type and instance level.

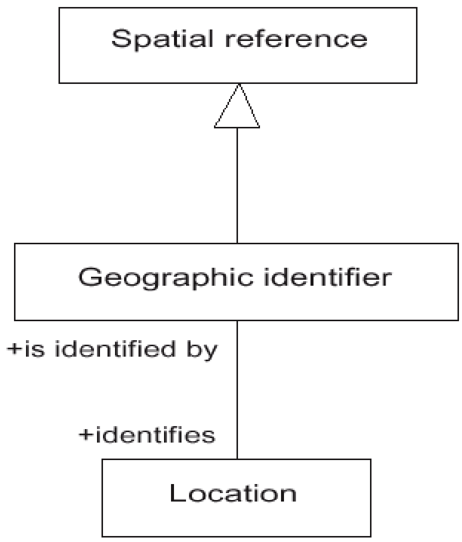


Figure 2-5. Spatial reference concept.

2.3.3 Spatial reference systems using geographic identifiers

A spatial reference system using geographic identifiers comprises a related set of one or more location types, together with their corresponding geographic identifiers. These location types may be related to each other through aggregation or disaggregation, possibly forming a hierarchy.

NOTE Examples of spatial reference systems using geographic identifiers are shown in Table 2-1.

Table 2-1. Examples of spatial reference systems.

Spatial reference system	Location type	Geographic identifiers
countries as defined in ISO 3166	country	country name, country code
set of population centres in a region	town	town name
addresses in a town	property	property address
hydrological hierarchy	river basin river river reach	river basin name river name river reach reference
link - node	link	link code

2.3.4 Gazetteers

A gazetteer provides a master record of all location instances for a particular location type or types. It will contain additional information regarding position of each location instance. This may include a co-ordinate reference, but it may be purely descriptive. If it contains a co-ordinate reference, this will enable transformation from the spatial reference system using geographic identifiers to the co-ordinate reference system. If it contains a descriptive reference, this will be a spatial reference using a different spatial reference system using geographic identifiers, for example the postcode of a property. For any location type, there may be more than one gazetteer.

2.3.5 Examples of gazetteer data

Streets

A gazetteer of streets would be a described as follows:

identifier	National Street Gazetteer
scope	UK streets
territory of use	UK
custodian	Ordnance Survey
coordinate reference system	National Grid of Great Britain
location type	street

The following would be a valid record:

geographic identifier	Church Street
temporal extent	19980401
alternative geographic identifier	54672
geographic extent	5461 2598, 5463 2598
position	5463 2597
administrator	Cambridgeshire
parent location instance	Chesterton

3 Location Information Services

3.1 Mobile location methods[1]

The PAM project focuses primarily on service architectures. The architectures are, in principle, independent of the underlying location technique, but the used technique has a direct impact on the achieved accuracy and availability, and therefore it is important to be aware of the available location techniques and their characteristics.

A number of techniques are proposed for mobile phone location, but it seems that none of them is clearly better than the others: each have advantages and disadvantages. At least so far, the mobile operators seem not to be interested in investing to expensive infrastructures, but prefer to use Cell ID or signal-level methods. However, it is probable that the teleoperators are prepared to take advantage of more accurate and expensive methods at later stages when the usage of wireless data services increases.

Review on outdoor location technologies can be found in http://location.vtt.fi and in [12].

For indoor use, several technologies have been suggested, with very different physical bases and service concepts, ranging from satellites and cellular networks to infrared, ultrasound, RF beacons, and visual methods.

3.1.1 Cellular network location methods

Several techniques for obtaining mobile location are currently being developed and tested. The most frequently referred techniques are listed in Table 3-1. The most simple approach for mobile location is to use only the information of the serving cell (Cell ID). This is a robust and economical approach. This method is used in the most of the commercial services so far. However, the accuracy depends strongly on the cell size and is not sufficient for many applications. The signal level [1], database correlation method [2, 3] and pattern recognition [4] methods are based on measuring the received signal levels at the mobile. Since these are typically measured anyway by the mobile phone, the techniques do not require additional functionality of the terminal or the network. Each technique involve some computations at the network side, which require rather strong computing power when large number of terminals has to be located.

Enhanced observed time difference (E-OTD) [5] and time of arrival (TOA) [6] methods are based on measuring time delays between the base station and the mobile. These techniques yield rather good performance in open areas, but suffer from multipath propagation in urban areas. The other drawback is high implementation cost due to required enhancements of the network infrastructure. Also signature matching [7] and angle of arrival (AOA) methods [8] require considerable enhancements to the base station equipment and are therefore rather expensive to implement.

In indoor use, cellular location techniques, such as the E-OTD method, are typically capable of providing the building or block of buildings where the mobile terminal is.

[1] Contact:
Jaakko Lähteenmäki, VTT

More precise location information is available only if there is a network of indoor base stations. Even in this case, the time delay techniques suffer from limited measurement accuracy relative to the building dimensions. For example, in GSM the symbol length is 3,7 μs. The obtained distance measurement accuracy is then of the order of 50 m, assuming that time delay can be measured at the accuracy of 5 % of the symbol length. This is a substantial error concerning positioning within a building. Instead of time delay techniques, the signal level and correlation methods are more attractive approaches in buildings with indoor base stations.

Table 3-1. Cellular network location methods.

	Coverage	Infra-struct. cost	GSM/ UMTS standard	Accuracy results, m	Accuracy results based on
Cell ID	excellent	small	yes	200-25000	Estimated based on typical cell size
Signal level	moderate, requires several BS's	small	no	300	Estimated in [1] for mean BS spacing of 2.4 km
Correlation methods	moderate, requires several BS's	moderate	no	45	Test results for urban environment (67% of time) [2]
Pattern recognition	moderate, relevant in urban areas	moderate	no	not known	
E-OTD	moderate, requires three BS's	high	yes	100 - 169	Test results for suburban environments (67% of time) [5]
TOA	moderate, requires three BS's	high	yes	not known	
Signature matching	good, even one BS provides a solution	high	no	63-126	Test results for light urban and suburban environments [19].
Angle of arrival (AOA)	moderate-good requires two BS's	high	no	45	Test results for suburban environment (67% of time) [8].

3.1.2 Satellite location methods

GPS receiver integrated to the mobile phone yields good location accuracy. The network assisted GPS technique (A-GPS) takes advantage of satellite information provided to the terminal via the cellular network [10, 11]. In initial tests this technique has been reported to enable increased coverage and accuracy.

GPS is originally designed as an outdoor positioning system. However, in some cases also limited indoor use is possible. By using the A-GPS techniques the dynamic range can be increased based on the longer integration time of the satellite signal. This is possible, since the navigation message is received via the cellular base station and can be discarded when receiving the satellite signal. However, the attenuation of buildings is very high especially in the inner parts of buildings and GPS coverage is possible typically only in small houses [17].The commercial development in this area is rather slow, largely due to lack of standards. On the other hand, the choice of available technologies is broadening quickly, and a clear technical winners are not yet identifiable. This tends to further postpone the commercial breakthrough.

Galileo, the European global navigation satellite system, is expected to start with four satellites in 2006, and offer the full commercial service with 30 satellites in 2008. It will deliver real-time positioning accuracy down to the metre range. More information is available at http://europa.eu.int/comm/dgs/energy_transport/galileo/index_en.htm.

Table 3-2. Satellite location methods.

	Coverage	Infra-struct. cost	GSM/ UMTS standard	Accuracy results, m	Accuracy results based on
GPS	good, problems indoors and in city centres	none	yes	20	Test results in [9].
A-GPS	good +, indoor and city coverage possible	high	yes	17-51	Test results for hybrid A-GPS/E-OTD -method in urban and indoor environments (67% of time) [11].
Galileo	good, problems expected indoors and in dense urban areas	none		1-10	Design goals of the system to be developed.

3.1.3 Local networked location methods

"Local" techniques are most often considered for indoor use, to overcome the inherent difficulties here. The indoor location accuracy can be enhanced by increasing the density of indoor signal sources. Wireless Local Area Networks (WLAN) typically consist of a dense network of access points, which offers good possibility for signal level positioning [10, 13, 16]. Test results for signal level method showing accuracy of 2-4 metres have been reported in [10]. Ekahau Inc. is developing correlation based techniques and claims accuracy of the level of 2 metres [13]. It is clear that the accuracy with both techniques is highly dependent on the access point network density and topology.

Other signal sources can also be used. Bluetooth is a short range technique essentially designed for connecting mobile phones with computers and other equipment [14]. As in the case of WLAN access points, a network of Bluetooth transceivers can provide indoor location capability. In this case, the additional advantage would be the operation without the need of a WLAN terminal - mobile phone with a Bluetooth module would be sufficient.

3.1.4 Local non-networked location methods

This group covers all methods that are based on inherently separate signal sources. The sources may, and in practice very often will, be connected into a common system, thus approaching the networked concept. But inherently they keep their independent character.

Passive RFID tags are a potential technique for a low-cost system. RFID tags can be distributed around the building to fixed locations. The location information is stored in the memory of the tag. The tag reader, possibly integrated to a mobile phone, reads the information typically at range of 1-3 metres. The potential of low-cost RFID applications in a few years may be large, provided RDIF readers become commonly available for the public. An obvious way would be integration with wireless terminals, like cellular phones.

In addition to radio frequencies, it is possible to use other techniques such as ultrasound or infrared. For example, pseudo random signals of ultrasonic beacons can be used for distance measurements by using cross-correlation techniques. Measurement between the mobile terminal and three or more beacons provides the location in similar way as in GPS. The achieved accuracy is even of the order of a few centimetres as reported in [18]. The technique is cheap and is suitable, for example, for locating of autonomous vehicles in restricted area. In [15] an in-building location system based on concurred radio and ultrasound signals is reported. The location algorithm determines the closest RF/ultrasound beacon taking advantage of the different propagation speeds of the electromagnetic and acoustical waves.

3.1.5 Image positioning-based location method [1]

Terms image positioning, exterior orientation of an image and image georeferencing mean that the location and the viewing direction of a camera are solved. An oriented digital image, if properly handled, includes measurable information about the scene. Image positioning is a basis for versatile navigation applications, and oriented images are suitable for both outdoor and indoor applications. Special interest about digital images has become topical because of the development of mobile terminals with digital cameras. Figure 3-1 is taken with a commercially available mobile phone and gives one application example basing on an oriented image. In the future it is expected that digital terrestrial images will be beside map-based applications.

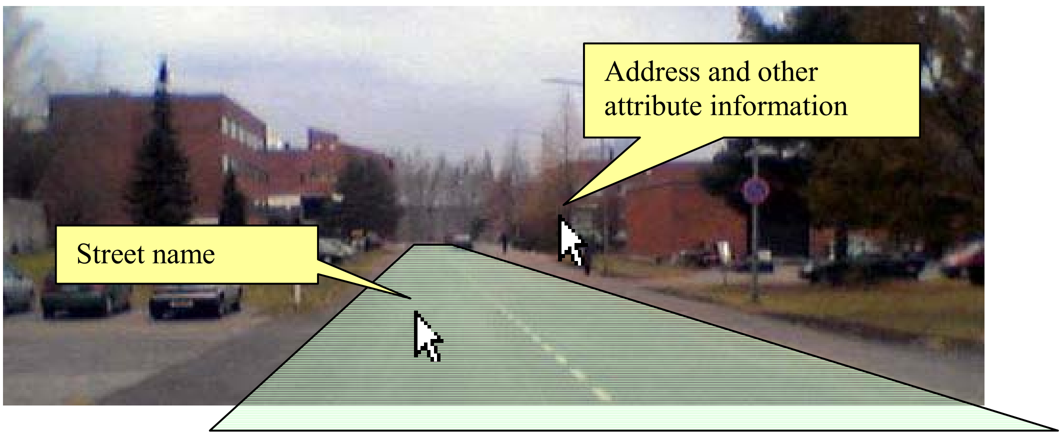


Figure 3-1. Image positioning versatile applications built on digital images. For example, when a user points a target from the oriented image some attribute information appears. It is also possible to visualise the targets of interest with transparent bitmaps, like in the case of the street.

[1] Contact:
Petri Rönnholm, Helsinki University of Technology

Normally, an image does not satisfy the projective geometry conditions, if it is taken with a camera having simple lens system. Lens distortions cause the biggest problems. A classical example of this problem is when straight lines in reality look curved on the image. This phenomenon can be visually very disturbing. In the Figure 3-2 there is one example, how clearly lens distortions can affect to an image. Lens distortions are usually solved by a camera calibration.

Figure 3-2. Left image: original image taken with a mobile phone camera. Right image: the same image after lens distortion removal.

The exterior orientation of an image gives the relationship between 2D image co-ordinate system and 3D ground co-ordinate system. A proper image orientation requires quite accurate location and viewing direction information. With a set of different sensors it is possible to find orientation parameters, but with present technology this might become expensive and unpractical. Camera location could be solved for example with Real-Time Kinematic GPS (RTK), virtual RTK or any other accurate positioning method. Viewing direction could be solved with inclinometers and compass.

An alternative method for image orientation is to use existing simplified 3D ground information from databases and to correct interactively approximates of the orientation. Approximations can be obtained from GPS, A-GPS or they can even be pointed from a map. If some 3D data is projected onto an image, it is visually easy to see errors of the orientation values (Figure 3-3). It is also easy to correct interactively the camera orientation parameters, until all the data fits on the image (Figure 3-4). For solving a camera location there should be functions for shifts: left, right, forward, backward, up and down. To correct the viewing direction of a camera functions for azimuth, tilt and swing rotations are needed.

Accuracy of an interactive orientation method mainly depends on how close the targets are from the camera location, how well the targets can be seen from the image and how accurate the 3D data is. The location of a camera is the most robust to solve, if there are targets close to the camera position. The viewing direction of a camera is easy to solve also with targets more far away. In the future there might be possibilities to automate or semi-automate matching process, but so far the human intelligence is superior to the machine vision – specially, if all the 3D data is not accurate.

Interactive image positioning method and applications basing on oriented images require special services from database servers. The main difference compared to current map based services is that the spatial information must be visualised at the oblique perspective projection. Figure 3-5 gives an example about a mobile navigation application with interactive orientation and data transfer rates between terminal and servers.

Figure 3-3. The camera location is shifted one meter. Error is clearly visible and easy to correct interactively. The image is taken with a normal digital camera that has been calibrated.

Figure 3-4. Exterior orientation of the image is solved by interactive method. Simplified 3D vector data projected onto the image fits quite well.

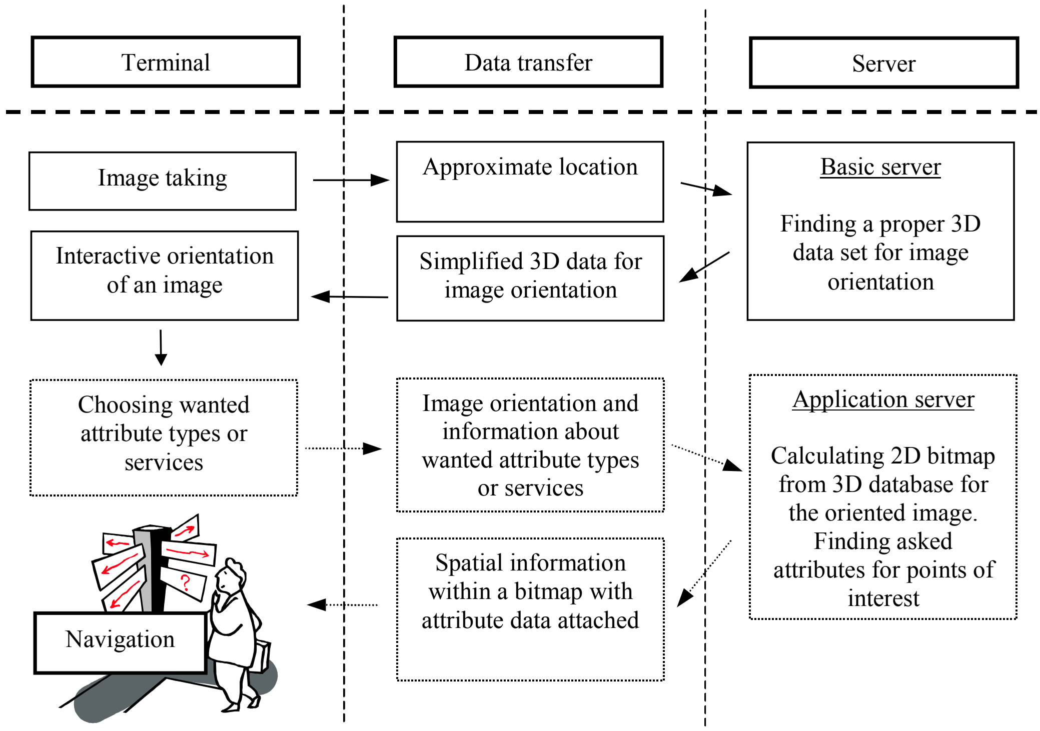


Figure 3-5. Example of interactive image positioning and an application basing on oriented images. Requirements for data transfer rates between terminals and servers are not very high.

3.2 Location information transfer[1]

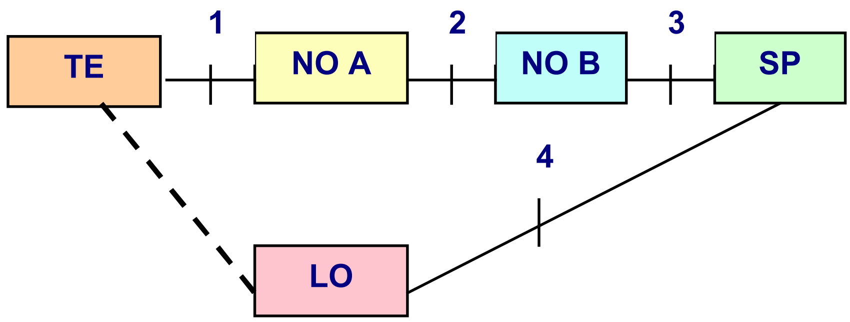
Location based services are implemented using many different location methods and architectures. One common feature to all these implementations is the need to transfer the location information from the point where the information is generated to the point where the location information is utilised. A simplified architecture covering different scenarios and the parties involved in the transfer of location information and interfaces between them is shown in Figure 3-6.

In the network based location methods the location information is normally available directly from the locating operator so that there is no need for location information transfer between operators. However, in cases like roaming and mobile number portability it might be necessary to transfer location information also between operators.

Location information may pass through a couple of network operators before arriving at the service provider which utilises the information. Many alternative protocols can be used in the interfaces and in the protocols there are currently several options e.g. in relation to location information coding. The service provider must know exactly how it will get the location information. Otherwise it is not possible to handle the received information correctly. For example in case of emergency call the location information is

[1] Contact:
Timo Leppinen, Finnish Communications Regulatory Authority

transferred (if technically possible) to the emergency centre where the information can be used to show the appropriate map to the operator. In order to help the network operators and service providers to negotiate the appropriate location information transfer method upon which to build their services they should know the different alternatives available.



TE	**terminal equipment (which the location information concerns)**
NO A	***network operator, to which the TE is connected***
NO B	***network operator, to which the SP is connected***
SP	***service provider, which uses the location information, when offering its***
own	***services***
LO	***network operator independent location operator***
1,2,3,4	***interfaces***

Figure 3-6. Simplified architecture related to location information transfer

Users of the location based services must be able to decide in which cases and in which services their location information is used. This requirement is included in the new directive concerning privacy in the electronic communications networks. The directive was approved in 2002 and it shall be implemented in 2003.

There is not yet clear knowledge how the requirements of the directive can be implemented in the network (or in the terminal if the location information is generated in the terminal and transferred transparently through the network). In implementations where the network generates the location information there are many open issues related e.g. to the procedures how the user gives his/her consent or denial to the use of the information.

The procedures in the case that the user denies the use of the information can in principle be technically implemented in three different ways:

- the location information is not generated
- the location information is generated and transferred in the network to a point which has the knowledge of the denial and the information is stopped/deleted there
- the location information is transferred in the network with the indication that its use to services or transfer outside the network is not allowed (in the case of an emergency call this indication can be overridden)

The legal aspects of the issue are studied in the Legal framework project of the NAVI program. The technical aspects and their implementation in different protocol standards is another important aspect of the issue.

At this moment it can be foreseen that the most commonly used interface between the operator (location information provider) and service provider (location information user) will be the interface specified by LIF (Location Information Forum) and adopted e.g. by 3GPP. This means that e.g. the requirements related to privacy must be met at this interface.

3.3 Location Based Services

Location Based Services (LBS) are defined in many different ways, depending on the ranges of services it is applied to. As a general rule, applications of *location based services* need and use the information given by *location services* as an essential component.

3.3.1 OGC/ Location based services[1]

The Open Location Services (OpenLS) initiative is a process started by the OGC to develop standard interfaces for Location Based Services (LBS). The testbed started in Sep 2001 and the first set of interface specifications was finalised in March 2002. The initiative has organised two public demonstrations of the defined services in the fall 2002, but the specifications themselves have not yet been published. The fundamental task of the initiative is to integrate the spatial datasets and spatial services in a standardised way into the other location based services of the emerging Mobile Internet.

In the OpenLS initiative location based services are divided into Application services, Gateway services and services already defined by the OGC. As examples of Application services are listed the Yellow Pages service, route optimisation, map display and map interaction. As possible Gateway services are listed the services like device location service, content transcoder service and portal service (including tasks like customisation, privacy and security). The services already defined by the OGC, and seen as supporting Application services, contain services like spatial data services (WMS, WFS, WCS), geocoding, co-ordinate transformation, directory service, map style description and encoding of spatial data (GML).

The services being first specified in the OpenLS include Directory Service, Route Service, Presentation Service, Location Utility Service and Gateway Service. In Directory Service an interface is defined for a Web service instance that provides information about localised points of interest (POI) like business locations, public services etc. The query specification supports parameters for constraining the query spatially. The Route Service provides access interface to the route optimisation functionality. Presentation Service is a map interface - similar with the WMS specification, but more sophisticated. Location Utility Service provides geocoding and reverse geocoding processing and Gateway Service is basically an envelope for Location Interoperability Forum's (LIF) Standard Location Immediate Request (SLIR) query.

[1] Contact:
Lassi Lehto, Finnish Geodetic Institute

3.3.2 ISO TC211/ Location based services[1]

ISO/TC211 has had Advisory Group for location based services (in co-operation with OGC). This group has prepared the following 3 new work items, which will be managed by the new Working Group 8: Location based services.

Location based services - possible standards

This Stage 0 report will investigate the need for the following LBS standards:

- Format for the expressions of location (including orientation).
  Co-ordinates.
  Addresses.
  Route “mile markers”.
  Orientation expressions (angle, bearings, offset angle).
- Formats for the expression of routes.
- Segment sequences.
- Turning instructions.
- Formats and rules for the expression of navigational “commands”.
- Formats for the expression of choice by clients of forms of commands; potentially expression of personal preferences.
- Formats for the expression of traffic conditions.
- Formats for the transfer between client and servers of request and responses for each of the above applications.
- The scope will include the consideration of both local (server side) and client aspects of cultural and linguistic adaptability.

Location based services - tracking and navigation

This international standard (under preparation) describes the data types, and operations associated to those types, for the implementation of navigation and tracking services. This standard is designed to specify web services that may be made available to wireless devices through web-resident proxy applications, but is not restricted to that environment.

Multimodal location based services for routing and navigation

This proposed International Standard will specify:

- Route finding or navigation between two targets using two or more modes of transportation, i.e. finding the most desirable route from an origin to a destination using various available modes of transportation; and calculating a set of procedural “navigation decisions” or route following commands that will execute that route on a single network or on multimodal networks.
- Rerouting as conditions along the route, or nearby alternate routes of alternative modes change.

---

[1] Contact:
Reino Ruotsalainen, National Land Survey of Finland

- Route Instruction traversal; ability to synchronise the target's position through its networks; to allow scrolling through route commands as appropriate.
- How to maintain a multimodal database in support of this application, including conditions along potential routes such as Traffic Monitoring on multi networks.

4 Metadata

Metadata has several interpretations, depending on context, but it is generally considered to be information about data.

4.1 The Semantic Web[1]

The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in co-operation [22]. This "well-defined meaning" comes in the form of metadata. Metadata descriptions are XML-based and conform to the layered model depicted in Figure 4-1. Each layer is dependent on the layers below it. The core idea of the Semantic Web is that people can provide semantically enriched descriptions about information in the web. This is not possible with today's markup languages such as HTML, which concentrate solely on the layout of web pages.

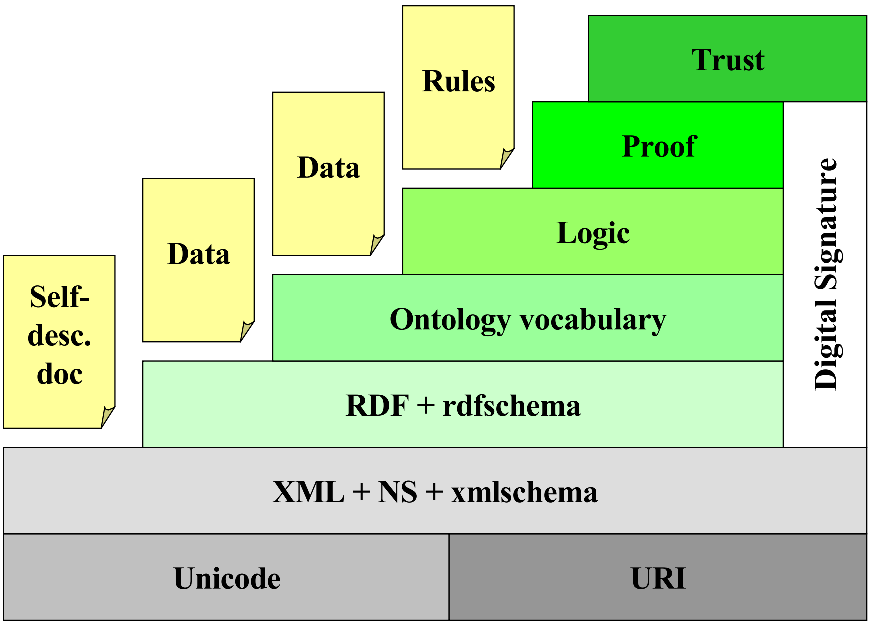


Figure 4-1. Layered model of the Semantic Web[2]

Although everything in Figure 4-1 is vital for the Semantic Web, only the layers from RDF + rdfschema upwards are truly Semantic Web specific. XML layer, let alone Unicode and URI, has nothing to do with semantics. An RDF description has a simple triple data model consisting of the resource to be defined, a property characterising the resource, and some value for the property in question. Domains and ranges for the properties' values can be specified in RDF Schemas. In addition to simpler data types, the

[1] Contact:
Santtu Toivonen, VTT
[2] Modified from a presentation given by Tim Berners-Lee at XML-2000 Conference (Washington DC, Dec, 2000).

values of properties can be also other resources. It is therefore possible to nest RDFdescriptions. With the usage of XML Namespaces different parts of nested RDF descriptions can reside anywhere in the Internet.

DARPA and W3C are perhaps the most important standardisation bodies with respect to the Semantic Web. DARPA is responsible for DAML (DARPA Agent Markup Language), an extension of RDF Schema. In January 2001 OIL (Ontology Interchange Language, alternatively Ontology Inference Layer) was integrated with DAML. The result was a language called DAML+OIL. Prior to integration DAML was developed in the USA and OIL in Europe. Integrating these two separately developed languages was thereby important; it enabled researchers in both sides of the Atlantic Ocean to join forces. DAML+OIL is intended for specifying ontologies that provide definitions for concepts and their interrelations in the Semantic Web.

W3C has since the beginning of 2002 adopted further development of DAML+OIL. The Semantic Web activity of W3C was formed in 2001 as a successor of earlier Metadata Activity. One of the present goals of the people working within the activity is an ontology language for the web, with the working title OWL (Ontology Web Language). OWL will receive input from DAML+OIL specifications. The requirements document for OWL specifies eight design goals for the language [29]. These are: shared ontologies, ontology evolution, ontology interoperability, inconsistency detection, balance of expressivity and scalability, ease of use, XML syntax, and internationalisation. For more on W3C, see Chapter 6.9.

Until now most of the standardisation work of the Semantic Web has concentrated on the RDF + rdfschema layer of Figure 4-1 and the ontology layer on top of it. Since the upper layers are dependent on the lower ones, this is understandable. These two layers have to be completed before logic, proof, and trust can function properly. There is however some work done in the uppermost layers as well. The purpose of logic layer is to define inference rules for deducing in the Semantic Web. RuleML[1] is intended for this. The ultimate goal of the Semantic Web is to build a "web of trust". In such a web people can provide information about trusted parties. Based on this information software agents can reason and carry out different kinds of tasks autonomously, provided that they are compatible with all the layers of Figure 4-1.

4.1.1 Semantic Web Technologies and Geographic Information

Semantic Web technologies enable a framework for providing metadata descriptions about information in the web. One important type of metadata is geographic information. Naturally there exists vast amount of information in the web with no need or possibility to be characterised by providing geographic metadata. However, some information is definitely describable with such. People, companies, and other instances located in the physical world might well benefit from their geographic representations in the digital world. People could inform about the addresses of their houses or jobs in their home pages, mobile Internet users could utilise information about nearby restaurants, etc.

At the moment there is no established way of providing geographic metadata with Semantic Web technologies. Some geographic metadata is found in DAML ontology

[1] http://www.dfki.uni-kl.de/ruleml/

library[1], but these are created with no consensus apart from specialising concepts of the general DAML+OIL ontology. RDF encoding was present in GML 1.0 but has since been put aside (at least for now).

One way of attaching geographic metadata to Semantic Web descriptions is through Web Services. DAML-S is a language for providing semantic markup for Web Services. In October 2002, DARPA released version 0.7 of DAML-S [26]. In earlier releases of DAML-S, there were concepts `Location` and `geographicRadius`, but they are missing in release 0.7 with the comment of being too domain-specific for generic DAML-S. DAML-S can be mapped to for example to WSDL [24]. Should the Web Service description contain geographic metadata, it can be taken into account when adding DAML-S markup for the service in question. For more on WSDL and Web Services, see Chapter 4.2.

4.2 Web Services[2]

Web Services is an initiative to provide means for publishing, finding, and using services effectively. IBM, Microsoft, and Hewlett Packard are among the key players behind Web Services.

Figure 4-2 depicts the three components of Web Services. Service Providers offer different kinds of services. They publish themselves on service registries maintained by Service Brokers. Service Brokers find and are found by Service Requesters that include both end-users and enterprises. After finding a suitable Service Provider with the help of a Service Broker, the Service Requester is bound directly to the Service Provider.

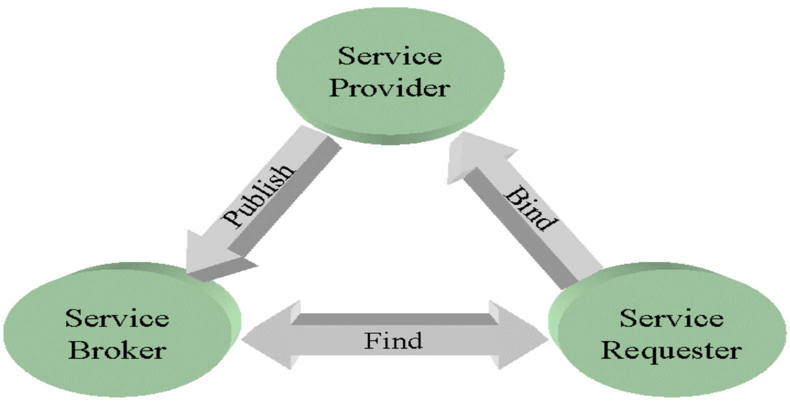


Figure 4-2. Main components of Web Services

[1] http://www.daml.org/ontologies/
[2] Contact:
Santtu Toivonen, VTT

Each of the interfaces between the three components of Web Services are under standardisation. Most important standardisation efforts are WSDL, UDDI, and SOAP. In [29], the authors propose the following roles for the three technologies: WSDL is utilised in relation between Service Providers and Service Brokers. Service Brokers maintain UDDI registries to be used by Service Requesters. Finally, Service Requesters are connected to the Service Providers via SOAP. However, this does not capture the entire picture. SOAP, for example, can in practice be used in every arrow presented in Figure 4-2.

4.2.1 UDDI

UDDI project creates a platform-independent, open framework for describing services, discovering businesses, and integrating business services using the Internet, as well as an operational registry that is available today[1]. In UDDI registries services can be found according to different attributes describing what they do. An UDDI registry thereby corresponds to trader in CORBA architecture [31] or to directory facilitator in FIPA architecture [33]. In December 2002, there exists four UDDI registry node operators. Those are IBM, Microsoft, SAP, and NTT Communications.

4.2.2 WSDL

WSDL (Web Services Description Language) is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information [25]. The Service Providers describe their services in a standardised way, namely WSDL, so that the Brokers are able to understand and categorise the services properly.

4.2.3 SOAP

SOAP (Simple Object Access Protocol) is an XML based protocol that was originally put forward by Microsoft. It was afterwards submitted to W3C by IBM and Microsoft. In December 2002 SOAP is in version 1.2 in W3C with a Working Draft status [28]. SOAP is typically used atop HTTP as a means to connect Service Providers and Service Requesters.

4.2.4 WSMF

Besides DAML-S (see Chapter 4.1.1), an attempt to bridge the gap between Web Services and the Semantic Web is a modelling framework called WSMF (Web Services Modelling Framework) [27]. WSMF takes the state of the art of Web Services, i.e. SOAP, UDDI, and WSDL, as its background, but proposes a modelling framework that stretches far beyond the capabilities of those technologies.

In [27], the authors give a detailed description of WSMF. In a nutshell their purpose is to provide a framework for Web Service modelling that combines

- *maximal de-coupling* of components that realise an e-commerce application with
- a *scalable mediation service* allowing anyone to speak with everyone.

[1] http://www.uddi.org/

Four main elements of WSMF can be recognised:

1. *Ontologies* that provide the terminology used by other elements. This includes both formal and real-world semantics.

2. *Goal repositories* that define the problems that should be solved by web services. A goal specification consists of **pre-conditions** describing the states of affairs to be true in order for the service in question to function and **post-conditions** describing the assumed results of the service's functioning. There can exist an *n2m* mapping between the services and goals, i.e., one service can fulfil several goals and one goal can in turn be fulfilled by several independent services.

3. *Web services* descriptions that define various aspects of a web service. The authors of [27] provide thirteen characterisations for a web service to be taken into account in terms of WSMF. These are:

    1) Name, i.e. a unique identifier for the web service
    2) A purpose the service is fulfilling
    3) Pre- and post-conditions
    4) Input and output data
    5) Error data
    6) Invoked web service proxy, because a web service might need other services in order to function
    7) Input and output ports
    8) Control flow sequence defining the correct process execution sequence
    9) Exception handling
    10) Compensation mechanisms for undesired situations
    11) Acknowledge mechanisms for notifying that the messages are understood
    12) Message exchange protocol
    13) Non-functional properties such as geographical reach of the service

4. *Mediators* which bypass interoperability problems. More specifically, mediators are needed for **data structures**, **business logics**, **message exchange protocols**, and **service invocation**. The authors of [27] call their vision "Mediation enabled Peer-to-peer approach" for web services. In such approach a trusted third party mediator transforms the messages sent via peers into a form understandable by both.

The authors of [27] aim for what they call *Intelligent Web Services* (or *Semantic Web enabled Web Services*) as depicted in Figure 4-3.

Semantic Web aims at providing machine-understandable content into the web. Web Services, on the other hand, aim at producing services that are executable via the web. Intelligent Web Services, then, on the top-right corner of Figure 4-3, aim at providing services that are executable via the web and that have machine-understandable and -processable descriptions.

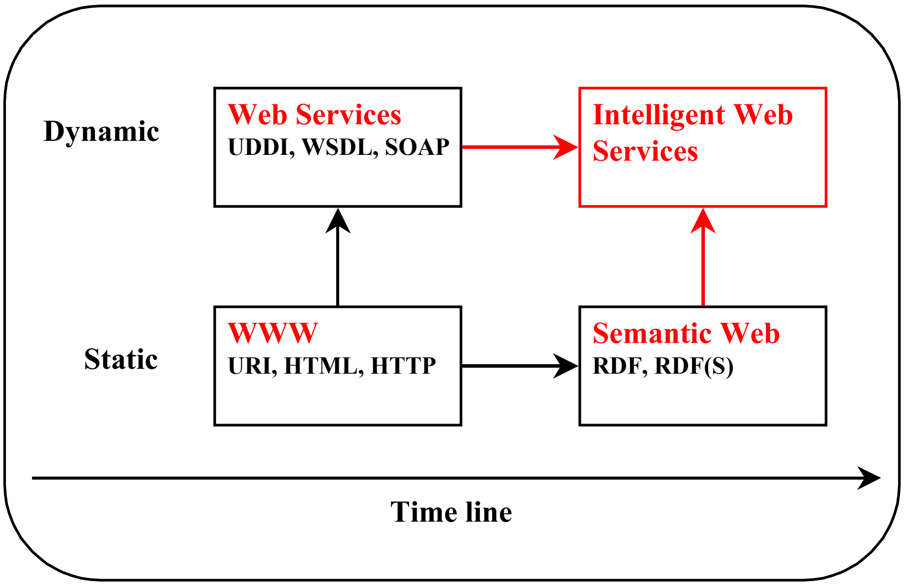


Figure 4-3. Semantic Web enabled Web Services[1]

4.2.5 Web Service Technologies and Geographic Information

Web Services provides a framework for describing different kinds of services by explicating their properties. In UDDI registries there is possible to define service types. Service Descriptions (tModels) conform to a canonical model for providing information about services. It is possible for example to categorise a service based on the products it offers or the business branch it is in [32].

In UDDI registries there is also a namespace for providing geographic information. UDDI GeographicTaxonomy conforms to the ISO 3166 geographic classification [32]. The namespace is called `uddi:org:iso-ch:3166:1999`. Basically the ISO 3166 geographic classification defines two-letter codes for countries, dependencies, and other areas of special geopolitical interest. Clearly some more specific means of providing geographic information would be more useful. Geographic information is also briefly recognised in WSMF as a non-functional property of a web service [27].

4.3 Metadata of datasets[2]

Metadata about collections of data can be stored in catalogues. If a catalogue holds many different metadata records about many different collections, it becomes possible to find data based on metadata.

[1] Figure redesigned from [**27**].
[2] Contact:
Reino Ruotsalainen, National Land Survey of Finland

4.3.1 Scope

ISO 19115 Geographic information - Metadata Standard defines the schema required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data.

ISO 19115 Metadata Standard is applicable to:

- the cataloguing of datasets, clearinghouse activities, and the full description of datasets;
- geographic datasets, dataset series, and individual geographic features and feature properties.

This International Standard defines:

- mandatory and conditional metadata sections, metadata entities, and metadata elements;
- the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- optional metadata elements – to allow for a more extensive standard description of geographic data, if required;
- a method for extending metadata to fit specialised needs.

4.3.2 Core metadata for geographic datasets

ISO 19115 Metadata Standard defines an extensive set of metadata elements; typically only a subset of the full number of elements is used. However, it is essential that a basic minimum number of metadata elements be maintained for a dataset. Listed are the core metadata elements required to identify a dataset, typically for catalogue purposes. This list contains metadata elements answering the following questions: "Does a dataset on a specific topic exist ('what')?", "For a specific place ('where')?", "For a specific date or period ('when')?" and "A point of contact to learn more about or order the dataset ('who')?". Using the recommended optional elements in addition to the mandatory elements will increase interoperability, allowing users to understand without ambiguity the geographic data and the related metadata provided by either the producer or the distributor. Dataset metadata profiles of this International Standard shall include this core.

Listed in Table 4-1 are the core metadata elements (mandatory and recommended optional) required for describing a dataset. An "M" indicates that the element is mandatory. An "O" indicates that the element is optional. A "C" indicates that the element is mandatory under certain conditions.

Table 4-1 Core metadata for geographic datasets

Dataset title (M)	Spatial representation type (O)
Dataset reference date (M)	Reference system (O)
Dataset responsible party (O)	Lineage statement (O)
Geographic location of the dataset (by four co-ordinates or by geographic identifier) (C)	On-line resource (O)
Dataset language (M)	Metadata file identifier (O)
Dataset character set (C)	Metadata standard name (O)
Dataset topic category (M)	Metadata standard version (O)
Spatial resolution of the dataset (O)	Metadata language (C)
Abstract describing the dataset (M)	Metadata character set (C)
Distribution format (O)	Metadata point of contact (M)
Additional extent information for the dataset (vertical and temporal) (O)	Metadata date stamp (M)

4.3.3 Metadata - Implementation specification

ISO 19115 Geographic information - Metadata defines the guidelines for describing geographic information and services. It provides information about the identification, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data. A new technical specification (ISO 19139) is proposed for guiding the implementation of this standard. This technical specification will define a UML implementation model that is based on the ISO 19115 abstract UML model. This specification and the associated implementation model will be used in conjunction with an XML schema that will also be defined in this document to describe digital geographic datasets. The implementation described in this document can also be used to describe many other forms of geographic data such as maps, charts and textual documents. It will illustrate how to provide information about the identification, the quality, the spatial reference, and the distribution of digital geographic data.

4.4 Initiatives of Open GIS Consortium[1]

4.4.1 GetCapabilities

One of the interfaces defined initially in the WMS specification and subsequently adopted also in the WFS and WCS specs is the GetCapabilities interface. Being an interface through which the server is supposed to advertise its capability to provide different services, this specification forms part of the metadata and directory infrastructure of the OGC's emerging Web Services framework. In the case of the WMS the response for a GetCapabilities query consists of parameters like the spatial extent of the dataset being

[1] Contact:
Lassi Lehto, Finnish Geodetic Institute

served, thematic map layers contained in the server and their visualisation styles available, supported co-ordinate systems, set of supported data formats etc. For the WFS service the GetCapabilities request provides information about the supported schema description and Feature encoding languages (presumably XML Schema and GML, respectively), available Feature Types, their spatial reference systems, spatial extents, and a possible metadata description URL address (metadata to be expressed in either ISO TC211 or FGDC format). Also a list of operations (insert, update, delete, query, lock) supported by the WFS for each of the Feature Types is to be included. The GetCapabilities query of the WCS is quite similar with that of the WMS, but provides more complicated layer information, e.g. because of the implemented multidimensional data model.

Because the GetCapabilities interface is so similar in all of the various defined OGC Web Services, the common part of this service metadata query is detailed in a OGC Discussion Paper called Basic Services Model. This document is an attempt to formulate the general framework of the OGC Web Services along the general principles set up in the ISO TC211 document ISO 19119: Geographic Information – Services. The OGC's work in this field continues in the form of the recently announced initiative: OGC Web Services, published as an RFT, which aims at creating a common conceptual framework for interoperable spatial Web Services.

4.4.2 Web Registry Service

The Web Registry Service (WRS) is a specification of a directory service which provides a central metadata registry describing several OGC-compliant (WMS, WFS, WCS) spatial data services. The WRS specification is an attempt to adapt the ideas of the OGC's existing, more generic Catalog Service specification into the conditions of the stateless computing architecture of the Web. An essential element of the WRS specification is the GetCapabilities request. The content of this request is separately defined for each service type. A WRS directory service provides an opportunity for individual services to register their offerings in the directory. This is done using the RegisterService interface. The stored service metadata can subsequently be requested from the registry via the GetDescriptors interface. The WRS specification is currently available as a OGC discussion paper only, so its contents could still significantly change during the further work to be done on the subject.

5 Intelligent transport system (ITS)[1]

5.1 Introduction

Intelligent Transport Systems (ITS) are generically defined as the integrated application of advanced technologies, such as computing and communication technologies, to improve the transport system by making it more efficient, safer and sustainable in terms of technology, society and the environment. In the aimed situation, different systems are incorporated together in order to maximise the benefit of ITS. There exist some comprehensive system architectures in the world that aim to describe the high-level connections between different system components. In the context of personal navigation services most interesting services are associated with the planning of multimodal travel chains before the journey as well as supporting travelling during the journey.

5.2 ITS System Architectures in the World

The most significant ITS Architectures are developed both in the U.S. and in the European Union. The first version of the U.S. Architecture finished 1998 and of the European Architecture 2000. The main emphasis of the U.S. Architecture is on Physical Architecture and so-called Market Packages where the European Architecture is concentrated on Functional Viewpoint. In addition to those large architectures, there exist Finnish National ITS Framework architecture since 2000.

5.2.1 The U.S. National ITS Architecture

The U.S. National ITS Architecture (http://www.iteris.com/itsarch/) provides a common structure for the design of intelligent transportation systems. It is the framework around which multiple design approaches can be developed, each one specifically tailored to meet the individual needs of the user. The architecture defines the functions that must be performed to implement a given user service, the physical entities or subsystem where these functions reside, the interfaces/ information flows between the physical subsystems, and the communication requirements for the information flows. In addition, it identifies and specifies the requirements for the standards needed to support national and regional interoperability, as well as product standards needed to support economy of scale considerations in deployment.

The Logical Architecture presents a functional view of the ITS user services. This perspective is divorced from likely implementations and physical interface requirements. It defines the functions or process specifications that are required to perform ITS user services and the information or data flows that need to be exchanged between these functions. The functional decomposition process begins by defining those elements that are inside the architecture, and those that are not. For example, travellers are external to the architecture, but the equipment that they use to obtain information or provide inputs is

[1] Contact:
Mikko Lehtonen, VTT

inside. In other words, the architecture defines the functions ITS must perform in support of a traveller's requirements, not the functions of the traveller.

The Physical Architecture partitions the functions defined by the Logical Architecture into classes, and at lower level, subsystems, based on the functional similarity of the process specifications and the location, where the functions are being performed. A top-level diagram of the physical architecture is shown on the Figure 5-1.

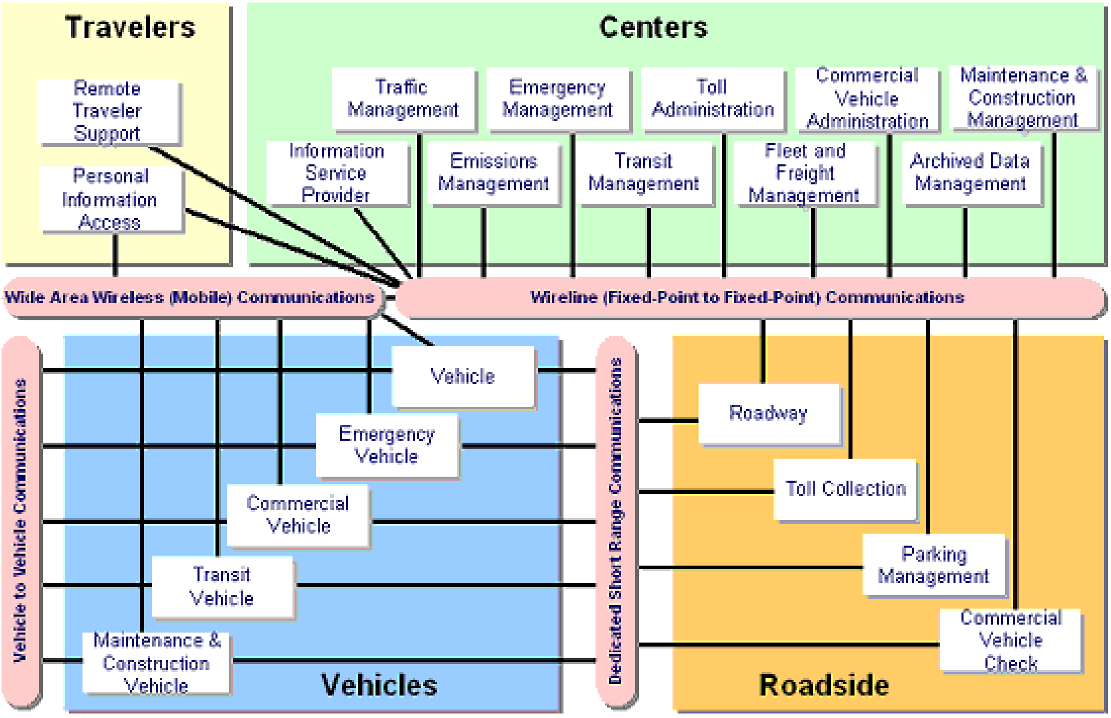


Figure 5-1. A top-level diagram of the U.S. Physical Architecture.

There are twenty-one subsystems in the physical architecture distributed among four classes: Traveler, Center, Roadside, and Vehicle. The specific choice of twenty-one subsystems represents a lower level of partitioning of functions that is intended to capture all anticipated subsystem boundaries for the present, and 20 years into the future.

In deployments, the character of a subsystem deployment is determined by the specific equipment packages chosen. In addition, subsystems may be deployed individually or in "aggregations" or combinations that will vary by geography and time based on local deployment choices.

The U.S. National ITS Architecture provides the framework that ties the transportation and telecommunication worlds together to enable the development and effective implementation of the broad range of ITS user services. There are multiple communications options available to the system designer. The flexibility in choosing between various options allows each implementer the ability to select the specific technology that meets the local, regional, or national needs. The architecture identifies and assesses the capabilities of candidate communications technologies, but it does not select or recommend systems and technologies.

The U.S. National ITS Architecture provides a framework from which the ITS standards activities can be partitioned and then mapped back to the Architecture as the ITS standards are defined. The standards should be developed based on the architecture interfaces and data flows packaged in the Standards Requirements Packages. For each of the standards packages, a detailed list of architecture data flows is provided so that standards development organisations (SDO) can readily apply the architecture to each interface under consideration.

The basic continuing benefit of the architecture is to provide a structure that supports the development of open standards. This results following benefits: integration, compatibility, support for multiple ranges of functionality and synergy [36].

5.2.2 The European ITS Framework Architecture

The European ITS Framework Architecture (http://www.frame-online.net) defines the underlying vision as being "the minimum stable framework necessary for the deployment of working and workable ITS within the European Union until 2010". The framework architecture provides:

- he definition of the necessary elements for an open market of ITS products throughout Europe and the rest of the world, thereby supporting European ITS industry;
- the basis for building consensus on issues that still prevent wide-spread deployment of ITS in Europe. This will permit all categories of users to purchase cost effective ITS products that will work in the same way throughout Europe;
- a bridge between the ITS community and those creating current and future technologies that may be used by ITS;
- a guide for public investment on basic infrastructure necessary for the deployment of ITS services;
- support for the identification of areas where new research and demonstrators are needed.

The first version of the European ITS Framework Architecture was published in September 2000. The Architecture is providing:

- Compatibility of information delivered to end-users through different media;
- Compatibility of equipment with infrastructures, thus enabling seamless travel across Europe;
- A basis for regional, national and European authorities to produce master plans and recommendations to facilitate ITS deployment;
- An open market for services and equipment where compatible sub-systems are offered (no more ad-hoc solutions);
- Economies of scale in equipment manufacture permitting competitive prices and cheaper investments with compatibility guaranteed;
- A known market place into which producers can supply products with reduced financial risk.

The European ITS Framework Architecture stays on a level of abstraction that is high enough to avoid constraints on any design and implementation plans, which will have to be developed by each country, region or manufacturer using the Framework Architecture. It provides a Reference Framework, a Common Terminology and a Set of Recommendations.

- As a Reference Framework, it includes the architecture elements needed to describe an architecture from the logical, physical and communication points of view. It also provides high level user needs and system requirements to be used as reference and a database of available standards that concern specific aspects of ITS applications. As such the Framework Architecture acts as an important source for identifying integration opportunities and for deriving useful methodology and modelling techniques.
- As a Common Terminology it facilitates the exchange of activities and results between ITS operators in Europe by providing reference lists (e.g. user needs, functions, terminators, etc.) organised into defined categories; it provides also definitions and descriptions of the steps for deployment.
- Recommendations are provided with reference to all those aspects that might have an important impact on the successful deployment of ITS. Practical examples are provided to highlight key issues. Guidance and suggestions are provided for the deployment process, and recommendations for new and needed standards are included. There are other documents, which report on e.g. cost-benefit analysis, review of existing experiences.

The full documentation of the European ITS Framework Architecture is organised into three main sets. The structure of the architecture is illustrated in Figure 5-2.

- List of European ITS User Needs, which offers a structured and comprehensive list of high level user needs for ITS applications and services to serve as check list for lower level architectures.
- Framework Architecture consisting the following documents:
  - European ITS Framework Architecture Overview
  - European ITS Functional Architecture
  - European ITS Physical Architecture
  - European ITS Communication Architecture
- Supporting material consisting the following documents:
  - European ITS Cost Benefit Study
  - Deployment Approach and Scenarios
  - Framework of Required Standards

The need for a European Framework Architecture derives from the need to “harmonise” ITS systems throughout Europe. A co-ordinated approach is required in order to overcome the diversity of practices in development, implementation and operation throughout Europe. In order to respect the subsidiary principle and different ITS environments in the European regions, a European Framework Architecture can serve as a generic instrument to harmonise these national and commercial architectures. It is therefore a useful tool for the implementation of compatible ITS, respecting the macro-characteristics which can be defined by keywords such as “interoperability”, “openness”, “flexibility”, “modularity”, etc. at the European level [35].

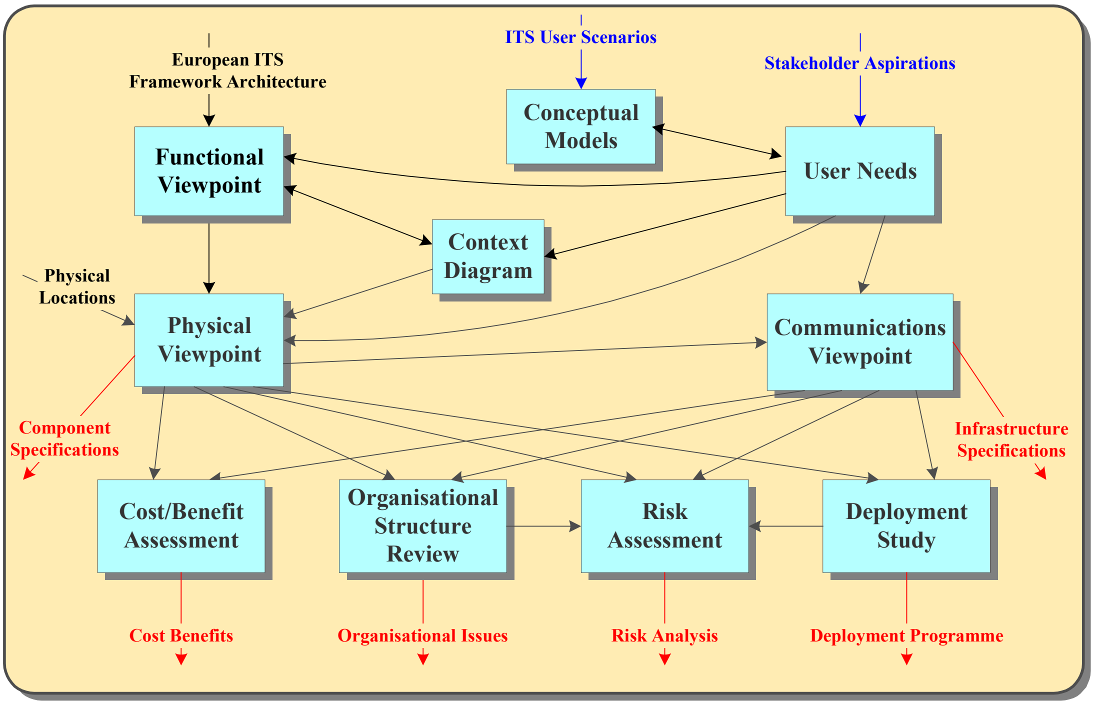


Figure 5-2. The structure of the European ITS Framework Architecture.

The Functional Viewpoint of the European Framework Architecture enables description of the most important components of multimodal travel chain. In Figure x, a high-level description of planning of multimodal travel chain before the journey as well as supporting travelling during the journey is illustrated.

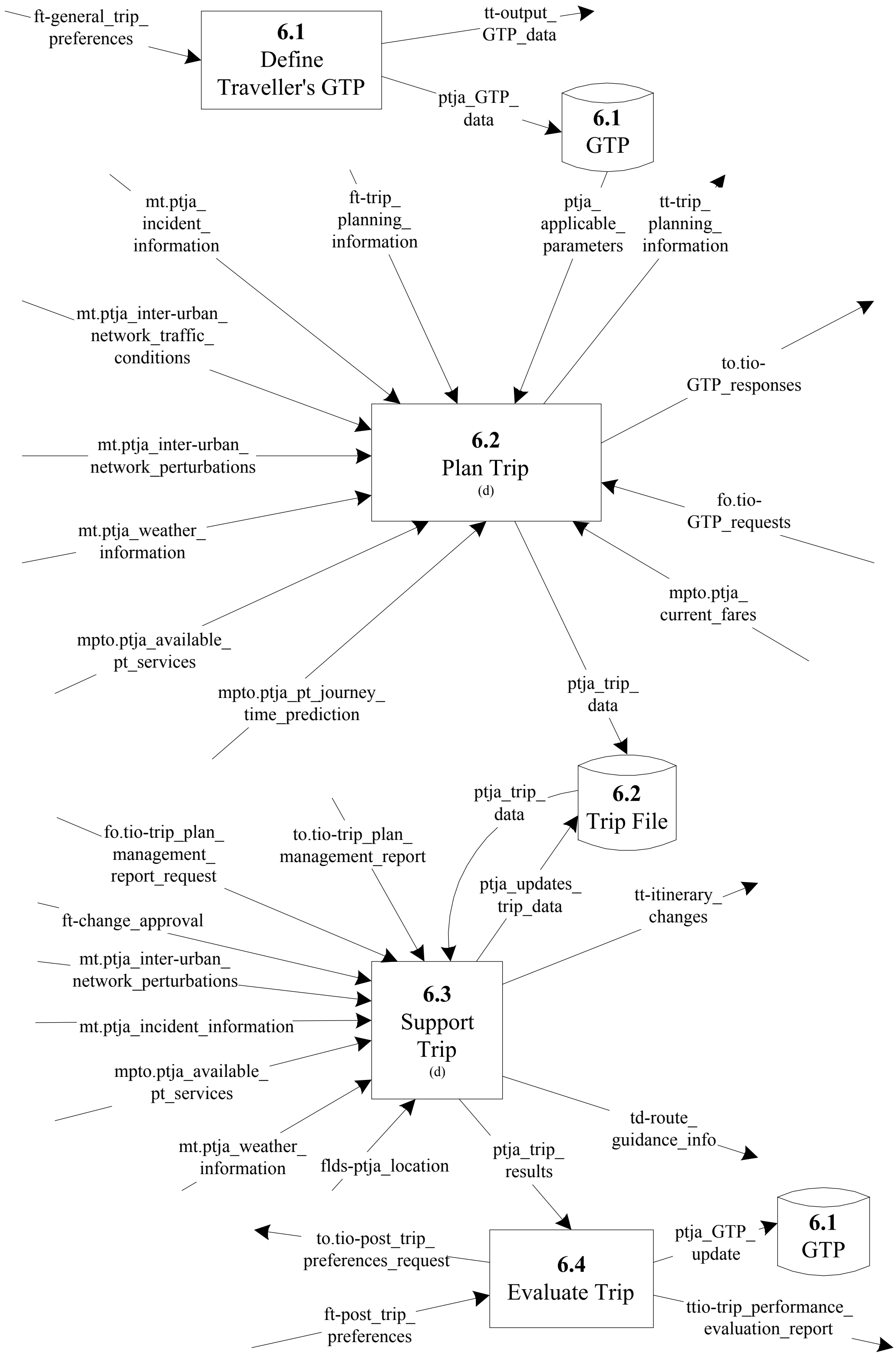


Figure 5-3. A Functional Viewpoint of the European Framework Architecture describing the planning and supporting of a multimodal travel chain [37].

5.2.3 The Finnish National ITS Framework architecture

The Finnish national ITS Framework Architecture is called Telemark. Telemark is an architecture, which describes the actors involved and the information systems used in the field of transport telematics and even more importantly the relationship between the actors and the systems. TelemArk describes roughly how the telematic services will look like in the next decade. The actors (travellers, road users, transport operators, authorities, service providers, etc.), major IT systems and the inter-relationships between them are shown by TelemArk. Moreover, TelemArk attempts to point out strategies and policy measures that will enable the telematic services to get rooted and flourish. Legislative, organisational and commercial obstacles are identified in the Deployment Strategy. Preventive and counteractive measures are recommended by the Strategy in order to overcome these obstacles. TelemArk is considered as a unique effort with an exceptional breadth of scope. It covers all transport modes (road, rail, air, water).

The objective was to create prerequisites for the introduction of the different transport modes and common services by developing a common framework architecture for transport telematics. Telemark offers a description of the operating environment, within the limits of which the development and use of the different systems and services can take place. Furthermore a description of the relations of the actors involved is produced. An open common framework architecture creates prerequisites for data and functional interoperability, data exchange, the combination of services and systems as well as for the development of the standards associated with them. TelemArk provides a tool for the Ministry to direct the efforts of operators, sector authorities and service providers. These actors may use the architecture for service and business process development as well as in the development of actual ITS applications.

The advantages that are sought through developing a National Architecture for Transport Telematics are:

- interoperability/ compatibility
- transparent basis for promoting PP-partnerships
- faster implementation of new systems
- reduction in need for support
- better reliability and flexibility
- uniform terminology
- less problems caused by complex systems, non-interoperable systems
- better traceability.

The main interest of the TelemArk-project lies on the system description and does not therefore include information on physical designs nor technical solutions for any particular system. At the other end, the scope ranges all the way to legislative processes and organisational structures in order to disclose the hindrances for creating a uniform telematic-utilising transport system. The current project does not include functionality internal to a party. Nevertheless, future projects sequel to TelemArk will presumable explore deployment of systems and also technical issues.

The areas of functionality and actual services included in Telemark are as follows:

- Public transport information
- Information to drivers
- Park & ride
- Demand-responded public transport and public transport chains
- Access control
- Payments for transport
- Road traffic management
- Hazardous goods
- Incident management, private transport
- Incident management, public transport
- Traffic enforcement

The architecture was created in different phases. The work was started in 1998 and the architecture was finished in 2000. The intensive work done in several workshops turned into a conceptual and logical architecture. The phases are illustrated in Figure 5-4 [34].

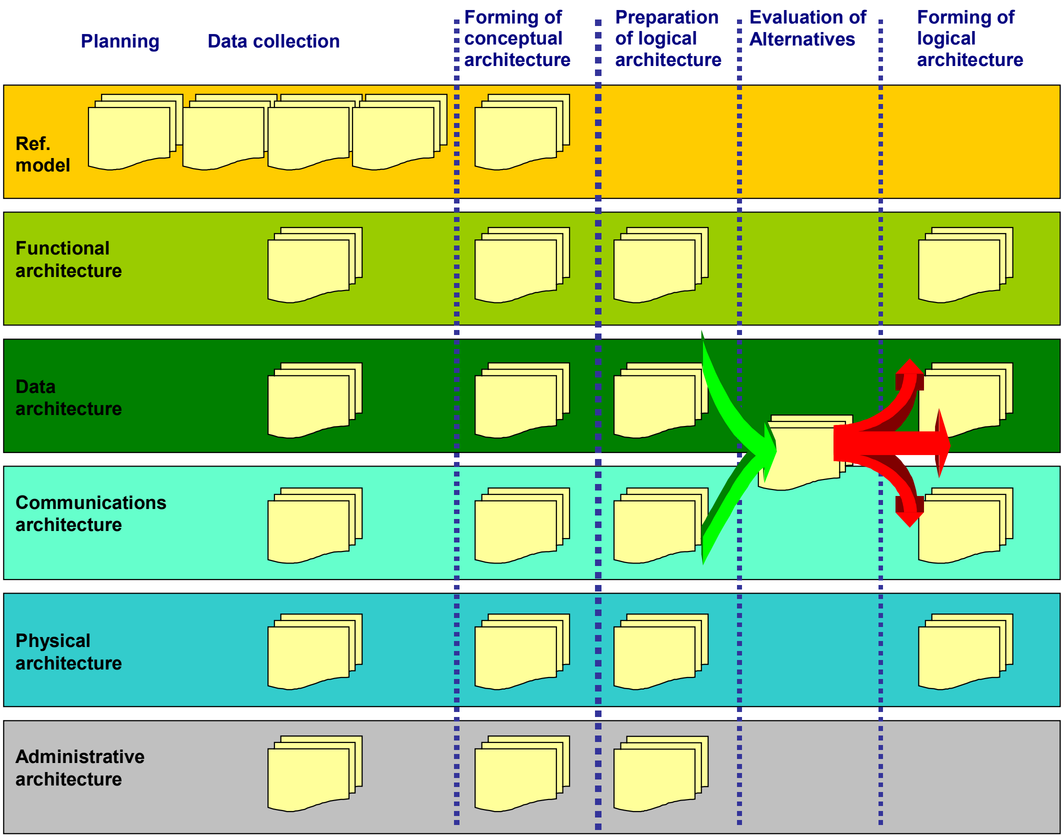


Figure 5-4. The phases of the creation process of Telemark.

5.3 Multimodal information services

5.3.1 Background

As mentioned before, the most important ITS services from the viewpoint of the personal navigation are planning and supporting of multimodal travel chains. With multimodal information services different transport modes can be networked to support each other, travellers can be guided to using the traffic modes most favourable to the resources and the environment and unnecessary traffic can be avoided.

With multimodal information every party will benefit. The beneficiaries are the traffic sector, producers of information services, passengers, the environment and the society as a whole. The passengers can take advantage of the traffic network optimally due to the services and satisfy their travel needs economically and in a way that is ecologically sustainable. The providing of multimodal information services calls for an existing information infrastructure. The biggest challenge is solving the organisational and institutional problems of service implementation.

The objective is to provide the passenger with multimodal information services before and during the trip. Automatic travel planning and comprehensive information systems are essential for the planning of multimodal travel chains. Travel planning is by nature an automatic function where the door to door travel chain is planned using the precedent conditions input by the user. The information services are by nature manual and offer the traveller means for obtaining travel related information.

5.3.2 Travel planning

Travel planning produces a travel plan automatically. The trip is planned to use travel modes in an optimal way. Through the use of preconditions the traveller can influence the plan by emphasising travel speed, costs, length or the number of transfers. The objective is that individual route planning systems network enabling the compilation of local, regional, national and international route plans.

The networking of travel planning systems requires that the databases of the systems be merged. The databases can be merged either directly or using API interfaces. The method is chosen case-specifically. In addition to the merging of the databases other problem areas are rights of ownership and use and how the data is presented. The routing is based on a reference method that enables precise routing by combining geographical data and time. A consistent list of links is a key element for all quality traffic data.

A door to door travel planning process is realised by combining local and long-distance traffic route planning. Inter-regional travel planning process is realised by implementing a route planning system on a long-distance network consisting of road, rail, air and sea networks. Local travel planning is done by realising a route planning system on a local network. An example of user interface of a travel planning system is shown on Figure 5-5.

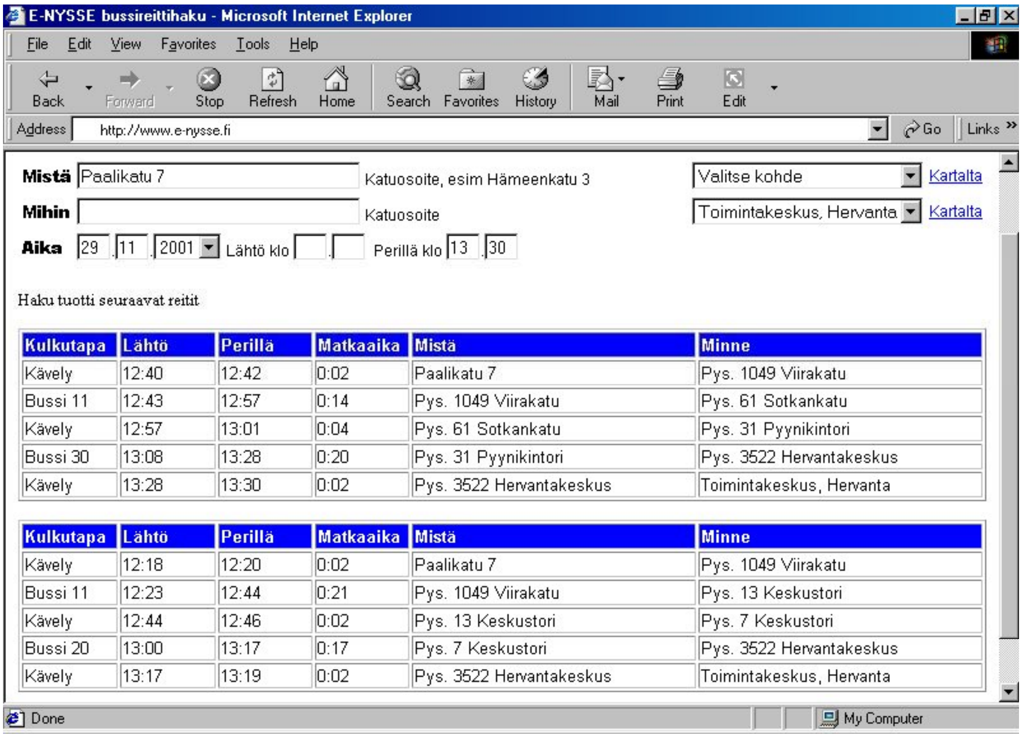


Figure 5-5. An example of user interface of a travel planning system.

In e.g. Germany local and regional travel planning systems have been in use for years. Currently the development is emphasised towards networking the local systems into broader regional systems. The most important German travel planning systems and their Internet locations are listed below:

- Deutsche Bahn AG (www.bahn.de)
- Weser-Ems-Bus (www.weser-ems-bus.de)
- EFA Elektronische Fahrplanauskunft Niedersachsen/Bremen (www.efa.hs-bremen.de)
- EFA Baden-Württemberg (www.efa-bw.de)
- VBB fahrinfo-online Berlin-Brandenburg (http://www.vbbonline.de)
- BVG Berlin, S-Bahn Berlin (http://www.fahrinfo-berlin.de)
- HVV/Geofox (http://www.geofox.de)
- BayernInfo (http://www.bayerninfo.de)
- TransBasel (http://www.transbale.com)
- StadtInfo Köln (www.stadinfo-koeln.de)
- DOM (www.der-orientierte-mensch.de)
- AVV (Busspur-Online Verbindungsabfrage) (http://www.avv.de)

5.3.3 Information and guidance

The objective of information and guidance services is to provide passengers with required information at the different phases of a trip chain. Unlike route planning systems the information and guidance services are manual so the passenger is left in charge of planning the trip. The passenger can get information about e.g. timetables, prices and other events, delays and disturbances on the public traffic network and the departure time of the next coach from the stop. The information and guidance services are particularly useful in the event of delays and disturbances. Using the navigation services the passenger can be guided all the way to the destination according to the address or name of destination. The guidance can be based on text and graphics or automated speech. In low population areas where the quality of service is lower than in built-up areas the passenger is given the possibility of demand responsive public transport.

5.3.4 Incident management

The objective of incident management is to alleviate the effects of observed of predicted traffic problems on a macroscopic, multimodal level taking into consideration the overall traffic situation. The traffic incident requiring actions should be defined in co-operation with different authorities. The incidents can be defined in time, reliably and comprehensively if traffic data is gathered widely from different sources. The multimodal strategies should be defined and approved co-operation with different authorities, a strategic tool should be developed, the approved strategies should be utilised and tested in the real traffic environment. The different strategies consist mainly of four levels: the definition of a traffic problem, the detection of a traffic problem, the checking of preconditions before employing a strategy and the definition of operative measures.

5.3.5 Communication channels

Different data terminal equipment is used as communication channels for multimodal traffic information. The objective is that the passenger can make a route plan before the trip and check or change it during the trip. Before the trip service interfaces include e.g. Internet, text-TV, phone and mobile phones. During the trip service interfaces include e.g. mobile terminals, the information systems at stops, terminals and trip centres, on-vehicle information systems and info centres. In the future the significance of the Internet and mobile terminals will increase as they enable interactive information exchange. In e.g. Germany multimodal Internet services have been realised for some time and their popularity is increasing. Mobile terminal equipment has also been tested within different projects.

5.3.6 Merging information systems

The producing of multimodal information systems requires the gathering of basic data from various different databases and systems. Their organisational liabilities, functional principles, internal data models and physical locations differ considerably. Information exchange should also be feasible regionally, over national boundaries and between different traffic modes. The different systems are merged using standardised data links and communication protocols. Common data models and libraries should also be developed so that the systems would have a common conception about the data content. Interoperable interfaces and common data libraries and models are essential for the objective.

The following three projects are all working with establishment of multimodal travel planners. Two of them are supported by the European research program, while the third one, DELFI, is a national project. DELFI is interesting, as it is aiming at covering the whole Germany, which is somewhat bigger than the Nordic area.

- The object of the EU TRIDENT-project is to create a general system to be used in data distribution and communication between different traffic operators and modes. The object is pursued by developing general data models and interfaces based on DATEX. The goal is to extend the DATEX definitions to meet better also the needs of public traffic and multimodal communications. The TRIDENT system supports multimodal travel services and tries to create and develop a general mechanism and system to be used in communications between transport operators and authorities.
- DELFI is a German project that started in 1995. The aim was to establish a travel planner with decentralised storage of data, as the different federal states did not support a collection of data in one system. Furthermore, there was no tradition for different transport modes to work together with information to the clients, but with DELFI it became possible to integrate the information in favour of the clients. DELFI is continuously updated and extended. Among other things there is work going on to integrate addresses in the search system as an alternative to train and bus stops. DELFI has contributed much to EU-SPIRIT, a third European project, and there is a tight connection between the partners in DELFI and EU-SPIRIT.
- EU-SPIRIT is a project with decentralised integrated data, which a.o. is based upon experiences from the DELFI project. EU-SPIRIT gives the users a possibility to search either internally in one of the regions or between the regions on addresses, sights as well on towns. EU-SPIRIT includes regions in five different countries: Sweden, Denmark, Germany, Austria and Italy but will be currently extended, which will be easily done due to the decentralised structure.

5.3.7 Co-operation between transport modes

The travel chain could include private car trips, park and ride, and local and long-distance public transport trips. It is essential that travellers can easily access the information services of different traffic modes and combine the services.

The goal is that travellers can plan their travel chains optimally and utilise all available traffic modes. The amount of users should increase when travellers are able to utilise all available traffic modes effectively.

Park and ride is vital in the integration of private and public traffic. Therefore park and ride should be arranged widely and the park and ride areas and facilities should be included in the multimodal information system. The significance of park and ride is emphasised during different incidents such as the congestion of arteries to city centre, running out of parking capacity at the centre and when the air quality at city centre falls.

5.3.8 Co-operation between the public and private sectors

The availability of basic data and the definition of information service providers is essential for the production of multimodal services. The basis could be a value chain of different participants. The value chain would include the content owner, content provider, service operator, service provider and end user. Before the standing organisation is set up a study should be made about the best structure of such an organisation. The roles of the public and private sectors in the providing of the service should also be studied [38].

5.4 The Finnish Multimodal Traffic Data Dictionary

The Ministry of Transport and Communications Finland has launched a project that produced the multimodal traffic data library. The work was carried out in interaction with interested actors utilising the current international standards and the information systems of the various organisations. The end product of the work is the Traffic Data Dictionary, which contains the definitions and tools for the implementation of standardised data communication interfaces. The principles of the Traffic Data Dictionary are presented in the Figure 5-6.

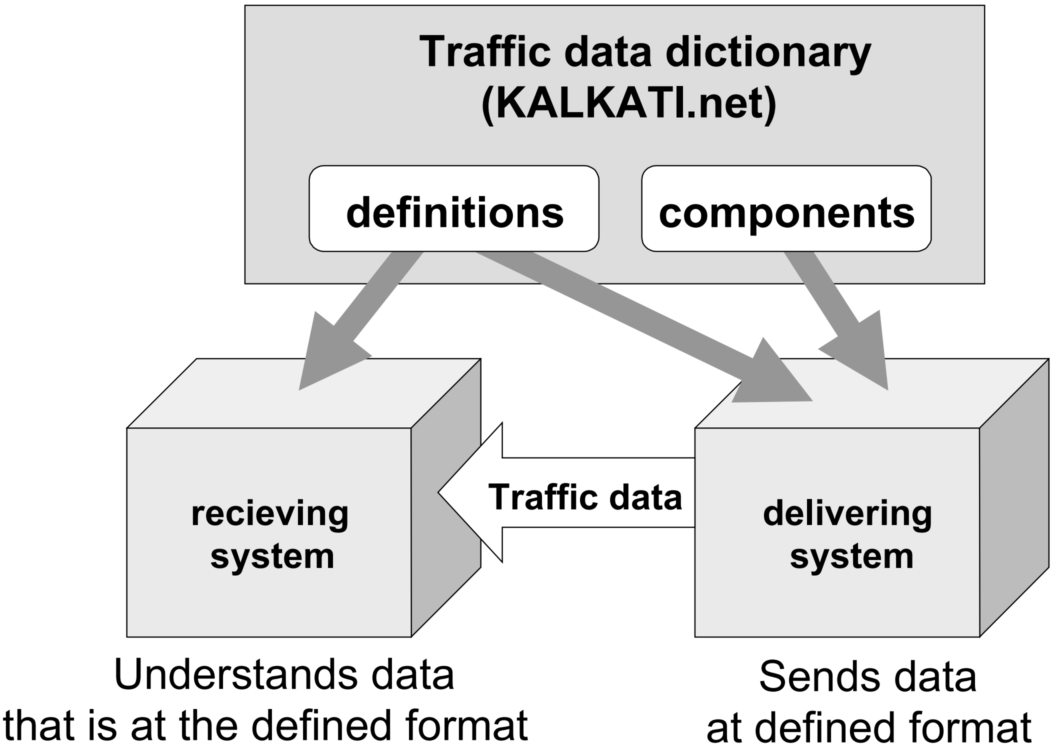


Figure 5-6. The principles of the Traffic Data Dictionary.

The Traffic Information Library can be found at the KALKATI.net web site (http://www.kalkati.net/). The web pages include data models and XML schemas and definitions for the attributes in the messages for certain most important traffic data interfaces.. The user can also retrieve and update message interface descriptions. Organisations can also utilise the pages for retrieving and updating Java application components for the support of their message information programming activities. New interfaces are attached to the library as organisations and projects produce those. The overall structure of the Traffic Data Dictionary are presented in the Figure 5-7 [39].

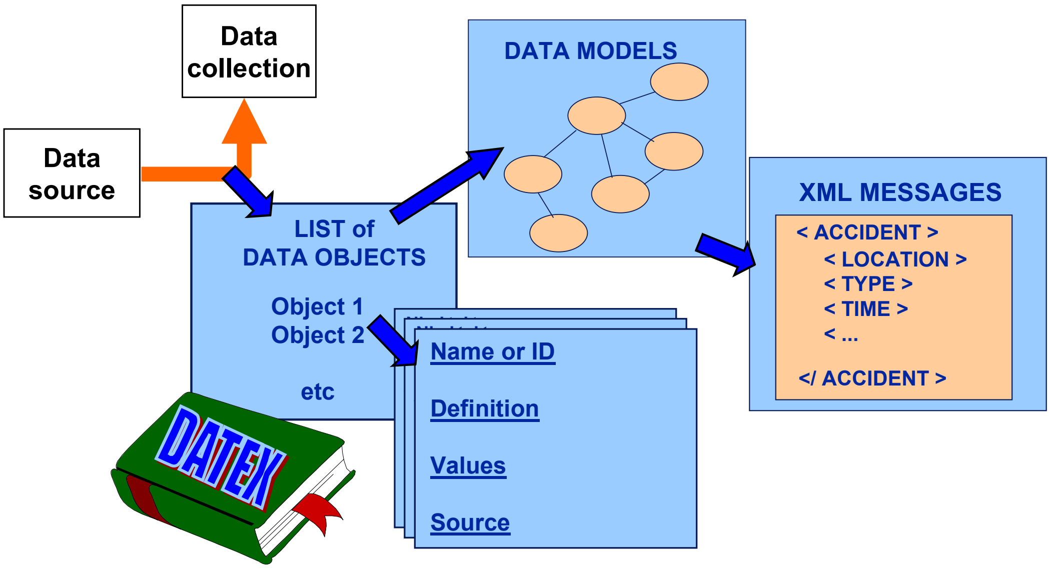


Figure 5-7. The overall structure of the Traffic Data Dictionary.

6 Standardisation

The standards and de-facto standards having considerable impact on personal navigation architecture, are described in this chapter. The descriptions are grouped mainly by organisation. The organisations concerned are:

- Bluetooth Special Interest Group
- Cell Broadcast Forum (CBF)
- CEN/TC287
- Internet Engineering Task Force (IETF)
- International Organization for Standardization/Technical Committee 211: Geographic information/Geomatics (ISO/TC211)
- Open Mobile Alliance (OMA), including the former
  - Location Interoperability Forum (LIF)
  - SyncML
  - WAP Forum
  - Wireless Village
- Open GIS Consortium, Inc. (OGC)
- WorldWideWeb Consortium (W3C)
- Third Generation Partnership Project (3GPP).

In addition, a survey of standardisation of international transport telematics.

6.1 Bluetooth SIG[1]

Bluetooth Special Interest Group is an industry consortium whose objective is to promote development of Bluetooth technology, and to help it to gain market. The members are largely leading telecommunications and information technology companies like 3Com, Ericsson, IBM, Intel, Lucent, Microsoft, Motorola, Nokia and Toshiba, as well as more than 2000 Adopter/Associate member organisations.

6.1.1 SIG activities in local positioning

Local Positioning Work Group is currently working on a local positioning profile draft and a local positioning marketing requirements document. The aim of this work is to define a specification for the exchange of position information over Bluetooth for position determination. The main usage scenarios are the ability to enable the user or device to accurately determine its position indoors and in other built up environments, and to augment GPS and cellular positioning indoors where its performance is reduced. Application areas include for instance ubiquitous computing (location awareness), services for finding people, items and events, and guide services (museums, exhibitions).

---

[1] Contact:
Jari Ahola, VTT

Targeted accuracy is 3-30 meters indoors based on position determination by signal level. A mobile terminal can measure received power levels from access points and either calculate the location by itself or provide the measurement data to a server responsible for the resolving the location of the terminal in relation to the access points. This is accomplished by using a simple propagation model and co-ordinate solution based on geometry. The measurement process is simple but on the other hand the correlation to distance is not exact due to multipath fading characteristics of the frequency used by Bluetooth devices. Currently there are no plans to support other measurement methods, for instance time delay.

As of writing this there is no publicly available version of the draft specification.

6.2 3GPP[1]

Third Generation Partnership Project (3GPP) is a co-operation project between six standardisation organisations, with the following goals:

- The Partners have agreed to co-operate in the production of globally applicable Technical Specifications and Technical Reports for a 3rd Generation Mobile System based on evolved GSM core networks and the radio access technologies that they support (i.e., Universal Terrestrial Radio Access (UTRA) both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) modes).
- The Partners have further agreed to co-operate in the maintenance and development of the Global System for Mobile communication (GSM) Technical Specifications and Technical Reports including evolved radio access technologies (e.g. General Packet Radio Service (GPRS) and Enhanced Data rates for GSM Evolution (EDGE))."

3GPP specifications are drafted and published as releases. Each release contains a full set of specifications covering the whole system. Release 99 specifications were functionally frozen in 2000, Release 4 at the beginning of 2001 and Release 5 in summer 2002. The main focus of the work is now on Release 6 and in stabilising the Release 4 and 5 specifications.

The whole Release 4, which is now nearing stabilisation, contains more than 500 specifications. The number of location services related specifications is 12. The main focus in the specifications is to define different positioning methods and interfaces between positioning related functional entities in mobile networks.

The Release 4 standards related to location services are the following:

TS 22.071 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Location Services (LCS); Service description, Stage 1 (Release 4)

TS 23.032 3rd Generation Partnership Project; Technical Specification Group Core Network; Universal Geographical Area Description (GAD) (Release 4)

[1] Contact:
Timo Leppinen, Finnish Communications Regulatory Authority

TS 23.271 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Functional stage 2 description of LCS (Release 4)

TS 24.030 3rd Generation Partnership Project; Technical Specification Group Core Network; Location Services (LCS); Supplementary service operations - Stage 3 (Release 4)

TS 25.305 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Stage 2 Functional Specification of UE Positioning in UTRAN (Release 4)

TS 43.059 3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; Functional Stage 2 Description of Location Services in GERAN (Release 4)

TS 44.031 3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; Location Services (LCS); Mobile Station (MS) - Serving Mobile Location Centre (SMLC) Radio Resource LCS Protocol (RRLP) (Release 4)

TS 44.035 3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; Location Services (LCS); Broadcast Network Assistance for Enhanced Observed Time Difference (E-OTD) and Global Positioning System (GPS) Positioning Methods (Release 4)

TS 44.071 3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; Location Services (LCS); Mobile radio interface layer 3 Location Services (LCS) Specification (Release 4)

TS 48.031 3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; Location Services (LCS); Serving Mobile Location Centre - Serving Mobile Location Centre (SMLC - SMLC); SMLCPP specification (Release 4)

TS 48.071 3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; Location Services (LCS); Serving Mobile Location Centre - Base Station System (SMLC - BSS) interface; Layer 3 specification (Release 4)

TS 49.031 3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; Location Services (LCS); Base Station System Application Part LCS Extension (BSSAP - LE) (Release 4)

All Release 4 documents can be found in ftp://ftp.3gpp.org/Specs/2002-09/Rel-4/

In 3GPP specifications the interface Le is defined as an interface between LCS network and LCS client. In Release 5 specifications a reference to the LIF MLP specification for the Le interface has been added.

In Release 5 and Release 6 specifications some possible enhancements relating to privacy mechanisms are added. The new privacy features are e.g. Codeword (target subscriber defined access code which must be provided by the requestor when requesting location), Requestor (in addition to the LCS Client also the identity of the originator of the request is provided) and Service Type Privacy (target user is offered the possibility to differentiate the privacy demands for different services).

In Release 6 work it will be studied which changes are required to the standards when assisted Galileo method is supported in addition to assisted GPS location method.

6.3 Cell Broadcast Forum[1]

The Cell Broadcast Forum (CBF), (http://www.cellbroadcastforum.org) is an industry-wide initiative to promote simple and easy-to-use, interoperable Cell Broadcast service solutions, to improve the technology and underlying standards, and to maximise business for the mobile and related industry. CBF is open to all members of the mobile communications community involved in Cell Broadcast.

CBF objectives are to contribute to the development of the CB market, to promote and stimulate interest in it, to establish contact between involved parties, to share ideas and experiences, to create common standpoint regarding handset, BSS and Cell Broadcast Centre functionality, to promote and demonstrate interoperability, to secure long term evolution of the Cell Broadcast technology, to address standardisation issues, to liaise with other bodies (GSM Association, ETSI, WAP Forum, LIF, 3GPP, and others). The CBF states that all its objectives and operations shall be built on an open and non-discriminatory basis.

CB is one of the very few mobile network technologies, if not the only one, that enables a user to receive location specific information without having to disclose his or her current position. The capacity of GSM CB is, however, limited to approximately one CB message every 1.883 seconds per CB channel.

At the time of writing, there were no published personal navigation-related results or publication plans available from CBF.

6.4 IETF[2]

Internet Engineering Task Force (IETF) is an open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. It is open to any interested individual.

In IETF working group Geographic Location/Privacy (geopriv) in the Applications Area handles issues related to location information coding and privacy. The primary task of the working group is to assess the authorisation, integrity and privacy requirements that must be met in order to transfer location information, or authorise the release or representation of location information through an agent. In addition, the working group will select an already standardised format to recommend for use in representing location per se.

[1] Contact:
Juha Törönen, VTT
[2] Contact:
Timo Leppinen, Finnish Communications Regulatory Authority

A key task will be to enhance this format and protocol approaches using the enhanced format, to ensure that the security and privacy methods are available to diverse location aware applications. Approaches to be considered will include (among others) data formats incorporating fields directing the privacy handling of the location information and possible methods of specifying variable precision of location.

For reasons of both future interoperability and assurance of the security and privacy goals, it is a goal of the working group to deliver a specification that has broad applicability and will become mandatory to implement for IETF protocols that are location-aware.

The aim of the working group is to conclude work in March 2003.

Under the charter of WG GeoPriv several internet drafts from individuals have been processed. The first "official" internet draft from the working group is available as http://www.ersue.de/nsis/draft-ietf-geopriv-reqs-01.txt . It describes the requirements for the geopriv Location Object (used to securely transfer location data and other privacy-enabling information) and for the protocols that use this Location Object.

Other drafts in the process are e.g.

http://www.ersue.de/nsis/draft-cuellar-geopriv-scenarios-02.txt, which describes location-based service scenarios for Geopriv. It complements the Geopriv Requirements document by providing a set of examples in which the Geopriv Location Object (LO) may be used.

http://www.ietf.org/internet-drafts/draft-polk-dhcp-geo-loc-option-00.txt, which specifies a Dynamic Host Configuration Protocol option for the geographic location of the client. The location includes longitude, latitude and altitude, with accuracy indicators for each. The DHCP server is assumed to have determined the location of the client from the Circuit-ID. In order to translate the circuit (switch port identifier) into a location, the DHCP server is assumed to have access to a service that maps from circuit-ID to the location at which the circuit connected to that port terminates in the building; for example, the location of the wall jack.

6.5 CEN/TC287[1]

CEN/TC 287 is at the moment in a passive state, but during the 1990's it produced the following pre-standards (ENV) and reports (CR):

Reference	Date	Title
ENV 12009:1997	1997-06-23	Reference model
ENV 12160:1997	1997-08-13	Data description - Spatial schema
ENV 12656:1998	1998-10-09	Data description - Quality
ENV 12657:1998	1998-10-09	Data description - Metadata
ENV 12658:1998	1998-10-09	Data description - Transfer
ENV 12661:1998	1998-10-10	Referencing - Geographic identifiers
ENV 12762:1998	1998-11-08	Referencing - Position

[1] Contact:
Reino Ruotsalainen, National Land Survey of Finland

ENV 13376:1999	1998-11-10	Data description - Rules for application schema
CR 12660:1998	1998-07-01	Processing - Query and update: spatial aspects
CR 13435:1998	1998-10-14	Vocabulary
CR 13425:1998	1998-10-14	Overview
CR 13568:1999	1996-11-27	Conceptual schema language

According to CEN's rules, the destiny of each ENV should be decided in two years after its three-year trial period. The Nordic Countries propose an extension for those ENV's (two years maximum), so that they could then be replaced by the ISO 19100 series.

6.6 ISO/TC 211 Geographic Information / Geomatics[1]

Area covered
Standardisation in the field of digital geographic information

Secretary: http://www.isotc211.org/

Target dates of the ISO/TC211 programme of work can be found at http://www.isotc211.org/pow.htm .

6.6.1 Source documents (under preparation)

- ISO 19101: Geographic Information - Reference model
- ISO 19103: Geographic Information - Conceptual schema language
- ISO 19104: Geographic Information - Terminology
- ISO 19105: Geographic Information - Conformance and Testing
- ISO 19106: Geographic Information - Profiles
- ISO 19107: Geographic Information - Spatial schema
- ISO 19108: Geographic Information - Temporal schema
- ISO 19109: Geographic Information - Rules for application schema
- ISO 19110: Geographic Information - Feature cataloguing methodology
- ISO 19111: Geographic Information - Spatial referencing by co-ordinates
- ISO 19112: Geographic Information - Spatial referencing by geographic identifiers
- ISO 19113: Geographic Information - Quality principles
- ISO 19114: Geographic Information - Quality evaluation principles
- ISO 19115: Geographic Information - Metadata
- ISO 19116: Geographic Information - Positioning services
- ISO 19117: Geographic Information - Portrayal
- ISO 19118: Geographic Information - Encoding
- ISO 19119: Geographic Information - Services
- ISO/TR 19120: Geographic Information - Functional standards

[1] Contact:
Reino Ruotsalainen, National Land Survey of Finland

- ISO/TR 19121: Geographic Information - Imagery and gridded data
- ISO/TR 19122: Geographic Information - Qualifications and certification of personnel
- ISO 19123: Geographic Information - Schema for coverage geometry and functions
- ISO 19124: Geographic Information - Imagery and gridded data components
- ISO 19125-1 Geographic information - Common architecture
- ISO 19125-2 Geographic information - Simple feature access - SQL options
- ISO 19125-3 Geographic information - Simple feature access - COM/OLE options
- ISO 19126 Geographic information - Geographic information - Profile - FACC Data Dictionary
- ISO 19127 Geographic information - Geodetic codes and parameters
- ISO 19128 Geographic information - Web Map server interface
- ISO 19129 Geographic information - Imagery, gridded and coverage data framework
- ISO 19130 Geographic information - Sensor and data models for imagery and gridded data
- ISO 19130 Geographic information - Sensor and data model for imagery and gridded data
- ISO 19131 Geographic information - Data product specifications
- ISO 19132 Geographic information - Location based services possible standards
- ISO 19133 Geographic information - Location based services tracking and navigation
- ISO 19134 Geographic information - Multimodal Location based services for routing and navigation
- ISO 19135 Geographic information - Procedures for registration of geographical information items
- ISO 19136 Geographic information - Geography Markup Language
- ISO 19137 Geographic information - Generally used profiles of the spatial schema and of similar important other schemas
- ISO 19138 Geographic information – Data quality measures
- ISO 19139 Geographic information – Metadata – Implementation specifications
- ISO 19140 Geographic information – Technical Amendment to the ISO 191** Geographic information series of standards for harmonisation and enhancements

6.6.2 Characteristics / description

The ISO 19101 reference model describes the environment within which the standardisation of geographic information takes place, the fundamental principles that apply, and the architectural framework for standardisation.

A conceptual schema language (CSL) has been defined for use in development of conceptual schemata in other standards. The following subschemas have been defined using the CSL:

- Spatial schema: used for describing the spatial characteristics of geographic information, particularly the geometry and topology
- Temporal schema: allows geographic information to be integrated with other aspects of information technology.

In addition a set of Rules for Application Schema are defined to allow applications to define schemata in a consistent way. These rules are used to define a number of reference systems, including:

- Geodetic Reference Systems
- Indirect Reference Systems.

ISO 19110 defines a methodology for creating geographic object, attribute and relationship catalogues. The feasibility of setting up a single international multilingual catalogue are also studied. Metadata about the currency, accuracy, data content and attributes, sources, prices, coverage, and suit-ability for a particular use of a data set is standardised in ISO 19115.

The identification and definition of the service interfaces used for geographic information, and definition of the relationship to the Open Systems Environment model, are also covered by ISO 19119.

ISO 19125 defines a set of spatial operators for access, query, management and processing.

6.7 Open Mobile Alliance (OMA)[1]

Open Mobile Alliance was founded in June 2002 as a consolidation of *WAP Forum* and the *Open Mobile Architecture* initiative. Since then, four other industrial consortia, i.e. *Location Interoperability Forum* (*LIF*), *SyncML*, *MMS Interoperability Group* (*MMS-IOP*), and *Wireless Village* have announced having signed a *Memorandums of Understanding* of their intent to consolidate with the Open Mobile Alliance.

At the time of writing, the consolidation projects are still in progress. It is expected to take some time until novel specifications based on work of some of the former consortia (e.g. LIF) become available via OMA after the completion. On the other hand, because of the early start and the natural consequence of process adoption from WapForum, WAP-related specification work has already resulted in published specifications (for comments). Unfortunately, *location based services* are not expected to benefit from such favourable circumstances, since previous work by WapForum and LIF need mutual adaptation, even though sharing a common origin. So at present there are no specific OMA specifications for the location based services, but predecessors prepared by LIF and WAPF must be used instead. Similarly the instant messaging and presence services shall benefit on work done in WAPF and Wireless Village.

The web site for OMA is at http://www.openmobilealliance.org/. As e.g. the LIF and Wireless Village web sites have been closed down, it is likely that the published

[1] Contact:
Atte Kortekangas, VTT

specifications will become soon available via the OMA site in the original or modified OMA-specific format.

6.7.1 Location Interoperability Forum (LIF)[1]

Motorola, Nokia and Ericsson founded *Location Interoperability Forum* (*LIF*) in autumn 2000 as an industrial consortium to address issues related with standardisation and interoperability of *location-based services*. Close to 100 companies and organisations were members of LIF. LIF has ceased its operations and has been consolidated with *Open Mobile Alliance*, *OMA* (cf. http://www.openmobilealliance.org/) during autumn 2002, expected to be finished by the end of 2002. The published contributions by LIF were only available via the original public LIF WWW-site at http://www.locationforum.org/. These results are expected to be obtainable via the OMA site in the future, possibly in some more or less revised format.

The main technical work items for LIF resulted as published recommendations has been so far been involved with

- authoring of a general-purpose protocol specification for location-based services in the mobile environment, i.e. the LIF Mobile Location Query API or *LIF-MLP*, (Mobile Location Protocol)
- authoring of test specifications for services conformance for interfaces,
- authoring a recommendation for privacy guidelines associated with location-based services.

Other recent technical activities included recommendations for *roaming of location-related services*, but results were not completed nor made public before LIF ceased its operations.

The most recent version of the *LIF Mobile Location Query Protocol* was made public for comments during summer 2002. It was available via the *Public Area* of the web site of the consortium at http://www.locationforum.org/ until November 2002 as document *LIF TS 101 "Mobile Location Protocol Specification v. 3.0.0"* (directly at http://www.locationforum.org/publicdownload/LIF-TS-101-v3.0.0.zip).

Another set of available public specifications by LIF dealt with general issues on conformance verification, i.e. *TD 201 "The Challenge with Interoperability in Location Services" v. 3.0.0* and a more detailed one targeting on GSM-specific issues, i.e. *TS 202 "Location Services Interoperability Test Specification in GSM" v. 3.0.0*. Both of them were available from LIF public document area mentioned above (directly as http://www.locationforum.org/publicdownload/LIF-TD-201-v3.0.0.zip and http://www.locationforum.org/publicdownload/LIF-TS-202-v3.0.0.zip).

The recommendations on privacy guidelines, i.e. *TR 101 "Privacy Guidelines" v. 2.0.0* was also made public in September 2002 via the site above (directly as http://www.locationforum.org/publicdownload/LIF-TR-101-V2.0.0.zip).

---

[1] Contact:
Atte Kortekangas, VTT

Most recent work initiatives with LIF dealt with *Location Roaming* and associated interfaces, but no results were made public before LIF closed down. It is likely that the results will come out via OMA in the near future.

The inaugural meeting of LIF took place in Sophia Antipolis, France in Nov 2000. Since then, LIF had regular meetings quarterly until the final meeting in Vienna in September 2002.

6.7.2 WAP Forum[1]

The public information of WAP Forum™ (Wireless Application Protocol) is available at the WWW-site at http://www.wapforum.org . The link is now showing some OMA specific information. Nokia, Unwired Planet, Motorola and LM Ericsson originally founded WAP Forum™ in 1997, and since 1998 the membership was opened for all interested partners.

The following three proposals (http://www.wapforum.org/what/review.htm) were prepared by WAP Forum™ in collaboration with LIF and their focus is on location based services. Location based WAP services, i.e., services dependent on a geographical location, represent a class of applications with specific needs. The WAP location framework addresses these needs by providing a transparent and position procedure independent location application interface. It also provides considerations for location related privacy. These specifications have been approved by the WAP Forum, but were not included in a conformance release. The work will continue in OMA.

- **Location Framework Overview** [WAP-256-LOCFW-20010912-a] - This specification defines the overall architecture (Figure 6-1) for the access of location (and position) information. The *WAP Location Attachment Functionality* and the *WAP Location Query Functionality* are logical functionalities, which may (or may not) be implemented in different physical entities, such as WAP client, WAP gateway, GMLC, MPC etc. The scope of this document is harmonised, as much as possible, with similar emerging standards for access of location information. It is out of the scope, how the location (and position) information is actually gathered.
- **Location Protocols** [WAP-257-LOCPROT-20010912-a] - This specification defines the services in the WAP location framework and the protocol mappings (to HTTP, WSP and PUSH) used to convey location information. The location services (Figure 6-1) provided to applications by the WAP location framework are:
  - *Immediate Query Service*, which allows an application to query WAP Location Query Functionality for the location of a WAP client, with an immediate response; e.g. for tracking by request.
  - *Deferred Query Service*, which allows an application to query WAP Location Query Functionality for the location of a WAP client, with (possibly multiple) deferred responses; e.g. for tracking periodically.
  - *Location Attachment Service*, which attaches location information to a WAP client request.

---

[1] Contact:
Juha Leppänen, VTT

Each service has an *Initiator* (calls the functionality that gathers and delivers the requested location info), an *Originator* (gathers and delivers the info according to invocation) and a *Recipient* (receives the info).

- **Location XML Document Formats** [WAP-258-LOCFORM-20010912-a] - The WAP location framework uses two XML Documents to carry location information. This specification defines the exact document formats, which are defined by DTDs and may contain but are not limited to the following information:
  - *XML Invocation Document* to request location information:
    - Requested location format (co-ordinate systems and datum)
    - Requested Quality of Position
    - Requested criteria for response (e.g. "how often", "what conditions")
    - Client address (PLMN=phone number, IPv4=IP version 4 address, IPv6=IP version 6 address, PAP-USER=a WAP Push user defined address)
  - *XML Delivery Document to deliver location information:*
    - Location information (e.g. Latitude/longitude co-ordinates using the WGS -84 datum, UTM co-ordinates using the WGS -84 datum, Spatial reference systems, geo-codes, speed, direction, heading, altitude)
    - Provided Location format
    - Provided Quality of Position (age of the location information, accuracy of the location information, confidence in the accuracy information)
    - Status code (e.g. "accepted", "access denied").

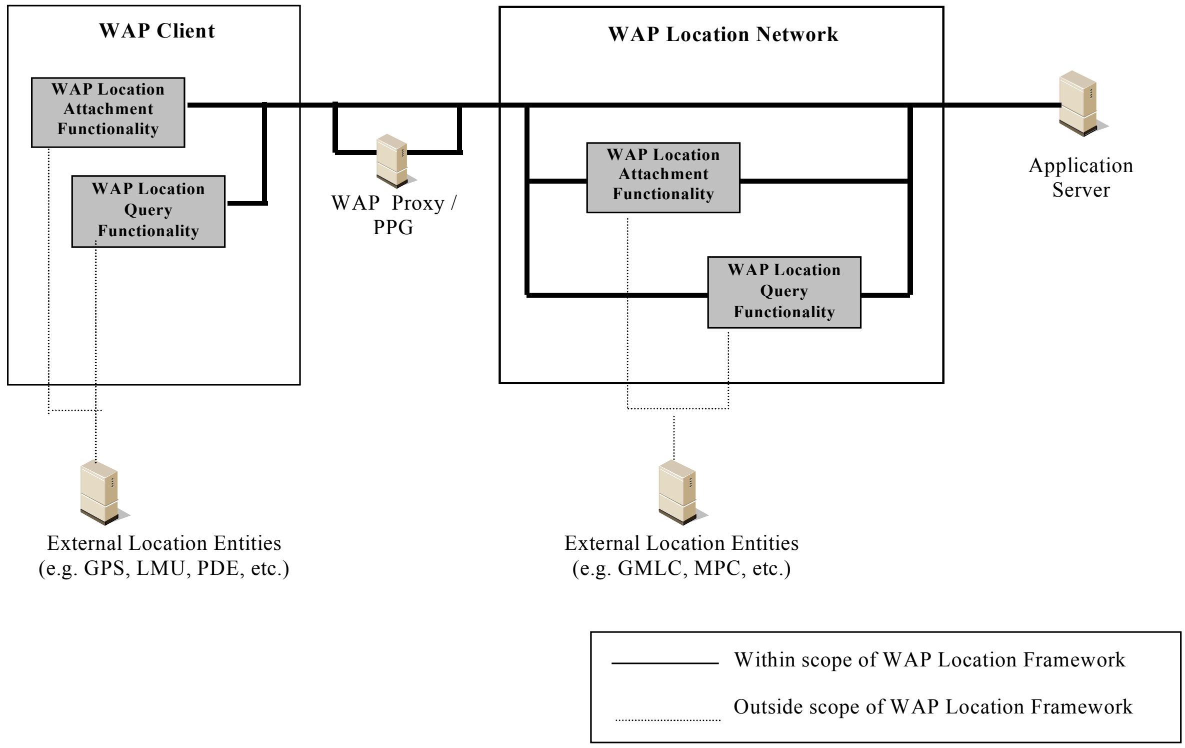


Figure 6-1. WAP Location Framework Architecture

6.7.3 SyncML

SyncML is an open standard initiative driving data mobility by a common communications language between devices, applications and networks.

The foundation of the SyncML open standard, SyncML Data Sync (SyncML DS) offers a consistent set of data that is available on any device or application at any time. SyncML Device Management (SyncML DM) enables OTA administration of devices and applications, simplifying configuration, updates and support.

SyncML is sponsored by Ericsson, IBM, Lotus, Matsushita, Motorola, Nokia, Openwave, Starfish Software and Symbian, and supported by wireless companies.

SyncML homepage is http://www.openmobilealliance.org/syncml/index.html at the OMA website. Their set of Specifications, version 1.1 (February 2002), is available at http://www.openmobilealliance.org/syncml/technology.html.

6.7.4 Wireless Village

Wireless Village, the Mobile Instant Messaging and Presence Services (IMPS) Initiative was founded by Ericsson, Motorola, and Nokia, in April 2001 to define and promote a set of universal specifications for mobile instant messaging and presence services. The specifications are intended for exchanging messages and presence information between mobile devices, mobile services and Internet-based instant messaging services, interoperable and leveraging existing web technologies. The initiative aims to build a community of users and business partners where Internet and wireless domains converge.

The Instant Messaging and Presence Service (IMPS) includes four primary features:

- *Presence.* Includes client device availability (phone is on/off), user status (available, unavailable, in meeting), location, client device capabilities and personal status such as mood and hobbies. The personal presence information control in the users' hands.
- *Instant Messaging.* Wireless Village enables mobile IM with other features.
- *Groups*. Both operators and end-users can create and manage groups. Operators can build common interest groups.
- *Shared Content*. Users and operators can set up their own storage areas where they can post multimedia content while enabling sharing with other individuals and groups.

Wireless Village home page is http://www.openmobilealliance.org/wirelessvillage/ on the OMA website. Their Architecture Specifications, version 1.1 (July 2002) are available at http://www.openmobilealliance.org/wirelessvillage/downloads.html .

The IEEE Industry Standards and Technology Organization (IEEE) provides administrative support to Wireless Village.

6.8 Open GIS Consortium[1]

6.8.1 Introduction

The Open GIS Consortium is a GIS industry group with a vision to improve the mutual interoperability of the various existing GIS systems and to achieve a better integration of geographic information resources and geoprocessing capabilities into the general information technology. The work of the OGC is mainly driven by the GIS vendor community, but various governmental institutions have also a significant role in the consortium. The organisation has its HQ in the USA and a major part of the membership is of American origin. A European branch of the OGC has also been founded and an increasing percentage of the members come from Europe (currently around 25%).

The OGC has been active in the area of network-based GIS solutions and started its Web-related development already in 1997. This work was initiated by the Web Mapping SIG of the Consortium. The main results of the Web-centric activity of the OGC have been published in the form of two official OGC specifications: the Web Map Service (WMS) Implementation Specification and the Geography Markup Language (GML) Implementation Specification. The WMS specification defines the functionality and access interface of a standardised Web-based map server that is able to produce pre-styled maps in the form of a raster image. The GML specification is an XML vocabulary for encoding datasets containing spatial data itself, not visualised representation (a map), as is the case in the WMS.

[1] Contact:
Lassi Lehto, Finnish Geodetic Institute

Both of the two released specifications of the OGC have a significant role in the development of mobile services involving spatial data. The WMS interface, or some further evolution of it, can provide a standardised access interface for various mobile service providers to retrieve up-to-date map information from different sources producing spatial data. More sophisticated services, needing a possibility to further process the spatial dataset or to tightly integrate it with some other data elements, would find the use of XML-encoded geodatasets as being more appropriate approach. In this case the GML specification provides a proper solution.

The work of the OGC on the Web services environment will continue. A couple of Discussion Papers have been published on the issues like Web Feature Service, Web Coverage Service, Web Registry Service, and alike. The OGC has also started a new initiative, called OGC Web Services, aimed at creating a general framework for search, discovery and access of mutually interoperable spatial OGC-compliant Web service components.

6.8.2 Standardised interfaces

For the independent development of the different tiers in the service architecture, it is necessary to standardise the access interface between the layers. The integration of datasets from various sources is difficult to carry out on the service production layer, if the spatial data services are not based on a common access interface. Catalogue and directory services on the portal layer can be built in a consistent way only if basic service types are categorised and the query interfaces are standardised. Terminal devices must be able to communicate with various portals in a consistent way for a reasonable service provision, e.g. when roaming from one local portal to another.

Several standardisation organisations work to develop a common understanding of the essential communication interfaces. As mobile terminals of future are widely seen as being closely integrated with the global Internet network, the basic infrastructure of the future mobile map services is going to be based on the Internet protocols and specifically on the Web standards. The World Wide Web Consortium (W3C) is therefore seen as a central player in this field. In standardisation activities specifically related to the Web based delivery of map displays and spatial data, the Open GIS Consortium (OGC), an industry group predominantly driven by GIS vendors, has been the most active player.

The communication protocol between the layers of the architecture is presumably the HyperText Transfer Protocol (http). The Wireless Application Protocol (WAP) and the Short Message Service (SMS) are protocols that are being applied, at least in near future, between the portal service and the mobile terminal. The OGC has developed a few spatial data related specifications for the service interfaces between the layers in the hierarchy. Some of the OGC's specifications are official documents, others are available only as discussion papers. Figure 6-2 depicts a few significant specifications in the framework of the above introduced four-tier service architecture.

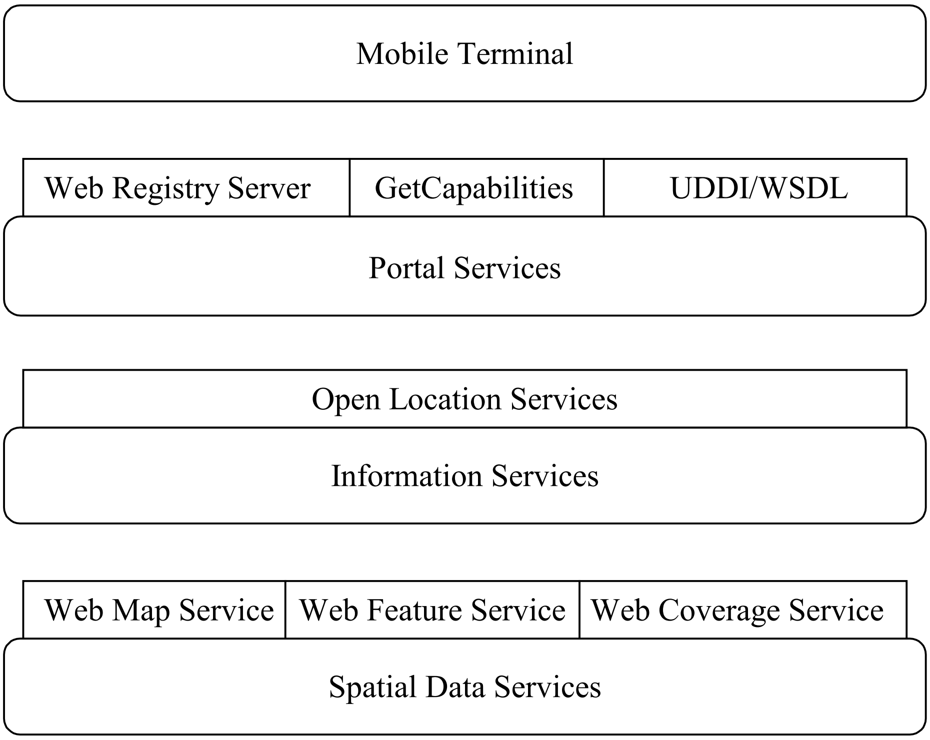


Figure 6-2. Standard proposals for inter-layer communication.

Spatial data services can be based on various different database and data management systems. There is a diverse set of varying GIS software and database server solutions available on the market. Most of these support also Web based delivery and visualisation of spatial data. The solutions used are technologically individual, proprietary and often even closed. The work of the OGC in the area of Web based map services has so far produced five official specifications: OpenGIS Web Map Service (WMS) version 1.1.1 (16 Jan 2002), OpenGIS Geography Markup Language (GML) version 2.1.2 (17 Sep 2002), Web Feature Service (WFS) version 1.0 (19 Sep 2002), Filter Encoding (FE) version 1.0 (19 Sep 2002) and Styled Layer Descriptor (SLD) version 1.0 (19 Sep 2002). These and other upcoming Web-related OGC specifications are collectively called OGC Web Services. The main characteristics of these specifications are discussed in the chapters below. Metadata related standards, like WRS, GetCapabilities and UDDI/WSDL are treated in Chapter 4.2.

6.8.3 Encoding of Geographic Information

A precondition for wide utilisation of geospatial data sources in the development of mobile services is that also the data encoding has to be standardised. The general trend towards XML-based data encodings, both in wired and wireless networks, naturally strengthens the need for XML-based processing of spatial data. The OGC has actually already released a specification of an XML-vocabulary for geospatial data, named Geography Markup Language (GML). The XML Schema-based version 2.0 of the specification was officially accepted as an OGC's implementation specification in April 2001. The next release of the GML, the significantly expanded version 3.0, is expected to be finalised by the end of the year 2002. The role of the GML specification and a few other proposed encoding standards in the general four-tier system framework is presented in Figure 6-3.

The mobile terminals of future may be able to process vector images. However, in short run this is not probable. For a limited capacity terminal the vector map will still be transformed into a raster image, for example by a portal service. A more powerful terminal might be able to display SVG images, thus providing much better interactivity properties for the client application. The recent work by the W3C, carried out under the title SVG Mobile, to develop light-weight profiles of the SVG specification, named SVG Basic and SVG Tiny, will hopefully facilitate the use of SVG images in less powerful terminals. The SVG Mobile specification reached the status of Proposed Recommendation on 15th of November 2002 and is thus rapidly approaching final acceptance as official W3C Recommendation.

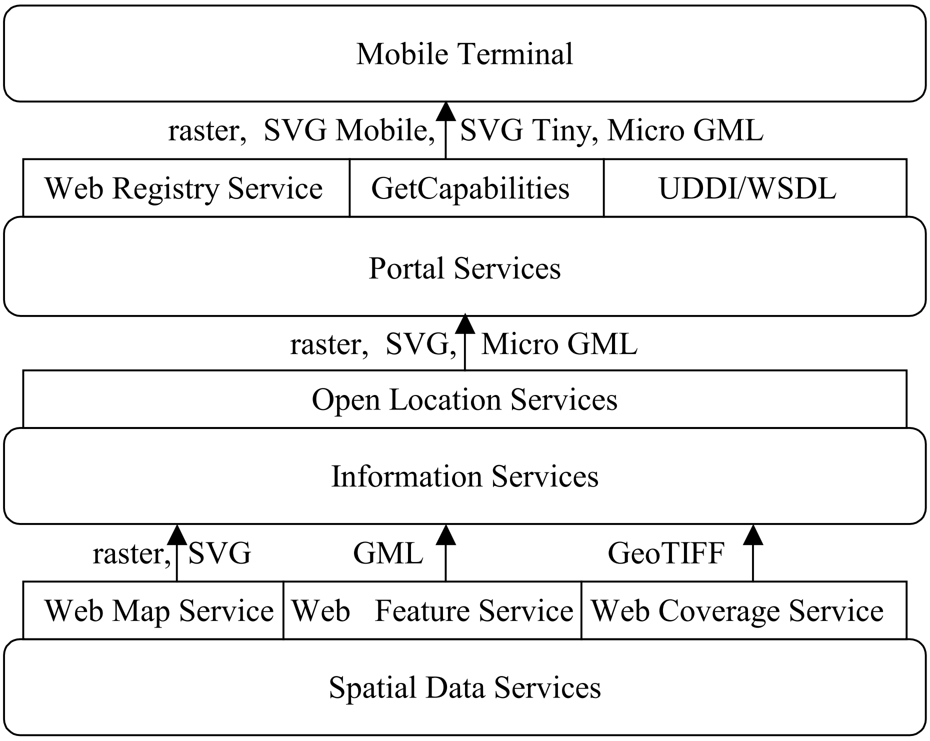


Figure 6-3. Data encoding in mobile map architecture.

6.8.4 Data Service Interfaces

OpenGIS Web Map Service

A WMS-compliant map service provides map data for its client applications in the form of a raster image. Independently of the applied internal data management solutions, a WMS-service always delivers a raster or vector map image as a response to the query message it receives. The most typical application for a WMS-service is a case where the client device is a limited-capacity terminal needing a pre-computed visualisation of the spatial data in the form of a raster image. When requested, a map server must be able to describe its services in a response to the GetCapabilities-query. The response is expressed in an XML-formatted metadata file.

The map information is requested from the WMS-service by sending a GetMap-message. The contents of the map are divided into themes or map layers. The client application must indicate which layers to include into the map image. For each map layer the server may provide a list of styles by which the corresponding layer can be visualised. The client again selects which style to use for each layer. In the GetMap-request the area of interest is indicated by four co-ordinate values, given in a specified co-ordinate system. Also the desired map co-ordinate system, pixel dimensions of the resulting raster image, and the raster format to be applied, can be indicated by the request parameters.

In concrete form the WMS specification is a list of CGI parameters with well-defined semantics. In the following is an example of a WMS GetMap-request, which asks the service to produce road network information, visualised as a 250*200 pixels PNG image. The area of the request is indicated with WGS84 co-ordinates.

```
http://www.mapservice.com/cgi-bin/wms.exe?
            VERSION=1.1.0&REQUEST=GetMap&
            SRS=EPSG:4326&BBOX=26.38,63.43,26.42,63.46&
            LAYERS=road&STYLES=default&
            WIDTH=250&HEIGHT=200&FORMAT=png
```

The integration of maps coming from a set of WMS-compliant map servers is based on a simple idea of overlaying transparent raster images in the client application. The resulting images coincide, because the maps requested from the different servers are limited into the same geographical area. Making use of transparency properties available in some raster formats, it is thus possible to combine maps, coming from various different servers, into an integrated visual representation. This idea works only with maps having predominantly linear information.

The WMS specification defines one additional user interaction functionality, named GetFeatureInfo, to the map visualisation process. It specifies a simple mechanism by which the user may click with a mouse on the map image, and get as a result detailed information about the spatial object that was clicked on. This functionality is defined as optional in the WMS specification.

Web Feature Service

Web Feature Service (WFS) specification document has been published as an OGC implementation level specification. A WFS-compliant service provides the client applications with real spatial data, geospatial Features in OGC's terminology, not with a pre-visualised map image like in a WMS-service. The resulting spatial dataset is typically expressed as an XML-encoded file. The pre-assumption in the WFS specification is that the result message is encoded according to the Geography Markup Language (GML) specification, an XML vocabulary developed by the OGC for storing and processing spatial data.

The WFS services can be divided in two separate classes. A Basic WFS is a read-only server providing only data output facilities. This kind of service supports only the

GetFeature interface of the WFS specification. A Transaction WFS will let the client application also to update the database (create new Features, delete and update existing Features). A service supporting Transaction WFS specification would implement Transaction interface and its defined operations Create, Delete and Update. Only the Basic WFS is discussed in the following.

The GetFeature interface enables sophisticated queries to be processed on the server. The desired set of spatial Features can be limited spatially and thematically. To be able to construct a reasonable query sentence, the client application needs to get a detailed information about the Features stored in a WFS service. This information can be requested from the WFS service using the message format defined in the GetFeatureType interface. The result for this request is provided in the form of an XML Schema document, which describes the data model of the corresponding Feature type (attributes and their data types, geometries and their types).

The actual request for spatial data is formulated as a message complying with the Filter interface specification. The Filter specification, based on the OGC's earlier Common Query Language (CQL) specification, defines the detailed format of the request parameters as an XML document. After parsing and interpreting the Filter query sentence, the WFS service can construct the corresponding query instruction for its internal data management system. In the following an example request, which asks for road network attributes "classification" and "speedlimit" and geometry "centerLineOf", inside the indicated rectangle and limited to roads belonging to the classification 12490.

```
<GetFeature>
   <Query typeName="road">
      <PropertyName>classification</PropertyName>
      <PropertyName>speedlimit</PropertyName>
      <PropertyName>centerLineOf</PropertyName>
      <Filter>
         <And>
            <PropertyIsEqualTo>
               <PropertyName>classification</PropertyName>
               <Literal>12490</Literal>
            </PropertyIsEqualTo>
            <Not>
               <Disjoint>
                  <PropertyName>
                     road.centerLineOf
                  </PropertyName>
                  <gml:Box srsName=”EPSG:4326”>
                     <gml:coordinates>
                        26.38,63.43 26.42,63.46
                     </gml:coordinates>
                  </gml:Box>
               </Disjoint>
            </Not>
        </Filter>
     </Query>
</GetFeature>
```

A WFS service enables a sophisticated spatial query to be performed on a database. The resulting dataset is supposed to be returned as a GML-encoded XML-message. This geospatial dataset, expressed in the real world co-ordinates, can freely be processed by the value-added service developers on the upper layers of the service framework, to develop the desired service product. The integration of XML-encoded spatial data with other data sources is simple, sophisticated analysis and other processing of geospatial data on service production layer becomes possible, and the visual layout and style of the resulting map representation can be decided as seen appropriate. Compared with the WMS specification, the WFS provides much more flexible processing opportunities for the subsequent phases of the service chain.

Web Coverage Server

The Web Coverage Server (WCS) specification provides the client applications with datasets, called as Coverage in the OGC terminology. The term Coverage includes datasets like satellite images, digital elevation models, and other spatial datasets that can be expressed as regular matrix. A WCS service is functionally quite close to a WMS service. The most significant difference is the fact that a WCS server does not form a raster image from the original database, but rather returns the real data values of the matrix cells to the client. Based on these values the client application can run many different computing processes, which possibly finally result in a visualised image. The WCS specification expands the simple 2D spatial model of the original WMS specification into the 3D and 4D models (elevation, time). The data values of the matrix cells can also represent multidimensional measures. As a possible result format the WCS specification mentions the GeoTIFF raster format.

6.8.5 Data Encoding Specifications

The basis for the GML specification lays on the OGC's work concentrating on object-oriented modelling of geospatial data. The first implementation specification of the OGC, the Simple Features (SF) Specification accepted in 1998, defines a simple practical realisation of a spatial Feature, a digital representation of a real world geographical object, schematically specified in the OGC's abstract reference model. An OGC Simple Feature consists of a set of Properties, some of which are spatial and the rest ordinary scalar attributes. It is worth noting that in the SF model a single Feature can contain multiple geometries. The SF model does not provide any support for an explicit representation of topology.

A set of spatial objects forms an entity called a FeatureCollection, which is also a Feature. This arrangement enables a hierarchical structure in which an individual spatial object can be represented as a collection of other objects. The geometry in the SF model is two-dimensional and linearly interpolated. The principal geometry types are Point, LineString and Polygon. The Polygon model supports internal holes. The specification also recognises homogeneous multi-geometries consisting of several individual geometry entities (MultiPoint, MultiLineString and MultiPolygon) and a heterogeneous set of varying geometries (GeometryCollection). In the Figure 6-4 the OGC's abstract Feature is depicted.

The GML specification defines an XML-based encoding vocabulary for SF-compliant spatial data. The use of XML Schema as modelling language in GML 2.0 enables the use named types, instead of the former mechanism in which the XML element and attribute names were fixed. XML Schema-based data model also facilitates the use of a genuine object-oriented approach while designing local Application Schemas. The GML 2.0 specification defines an abstract data type, called AbstractFeatureType, that can be inherited when developing concrete application level types. The defined abstract spatial Feature is actually very simple framework in which the local application properties can be added. A GML-compliant data model has to implement the geometry level data structure, specified quite in detail in the GML specification.

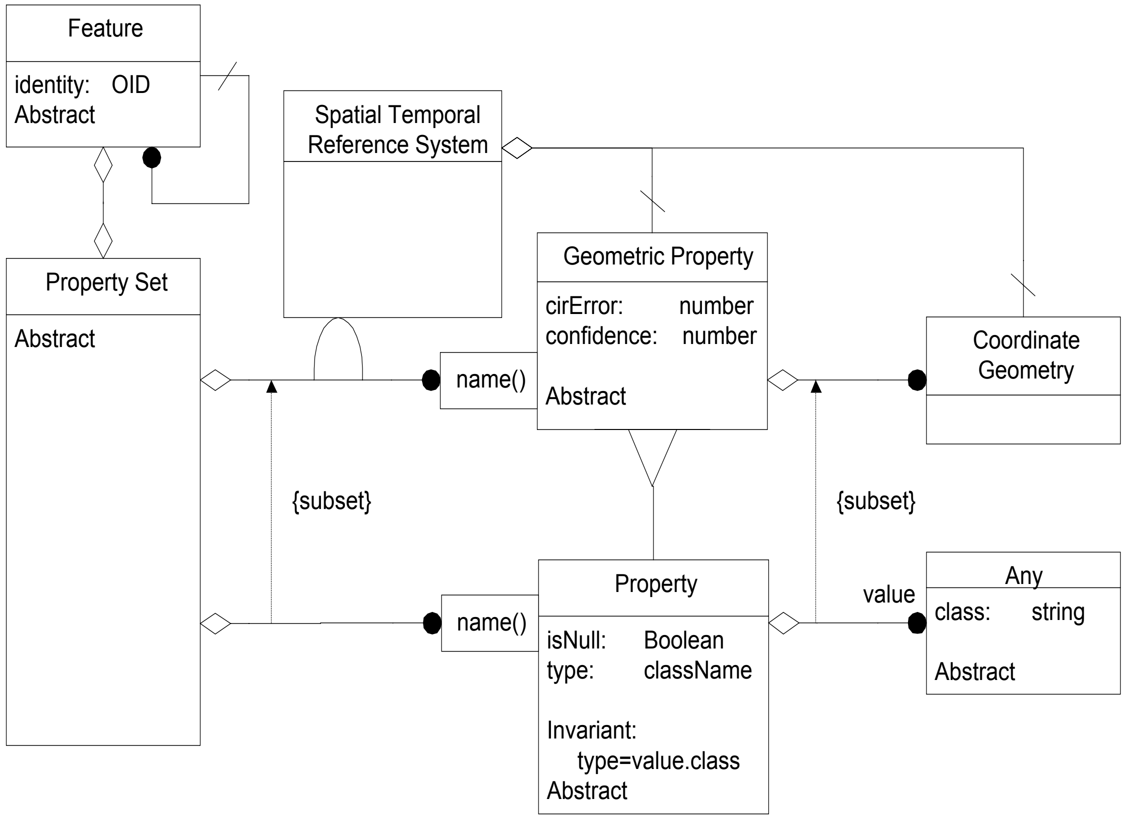


Figure 6-4. The abstract model of the OGC's spatial Feature.

In the following is an XML Schema-based definition of the OGC's abstract Feature type.

```
<complexType name="AbstractFeatureType" abstract="true">
 <annotation>
  <documentation>An abstract feature provides a set of common
properties. A concrete feature type must derive from this type
and specify additional properties in an application schema. A
feature may optionally possess an identifying attribute
('fid').
   </documentation>
 </annotation>
  <sequence>
  <element ref="gml:description" minOccurs="0" />
  <element ref="gml:name" minOccurs="0" />
  <element ref="gml:boundedBy" minOccurs="0" />
   <!--
  additional properties must be specified in an application
schema
   -->
  </sequence>
  <attribute name="fid" type="ID" use="optional" />
 </complexType>
```

The GML 2.0 specification expands the original SF model at least in two respects: complex, structured data types are supported also in the case of non-spatial properties of the Feature and the geometry of the Feature can be expressed by three co-ordinate values. Although GML 2.0 thus seems to support three-dimensional geometry, it is worth to note that the data model does not provide any support for sophisticated 3D modelling.

The role of GML in development of mobile services is currently clearly constrained to the server side solutions. Mobile terminals won't presumably support handling of GML at client side in near future. A wide implementation of GML specification could however significantly facilitate development of services in which there is a need for further processing of spatial data on the service production layer of the architecture. GML-encoded spatial data will be exceptionally easy to integrate with processes that already apply XML-based data processing techniques. Also the integration of datasets coming from several different data sources is simplified when data are available in a uniform encoding, accessible from each spatial data service through a common query interface (WFS).

As a result of the data processing there might be a need to express the resulting dataset as a visual representation. In the GML there isn't any mechanism available for indicating the visualisation parameters of the dataset. A dedicated client application could in principle process the GML-encoded dataset into a visual map display, but the solutions will then be vendor or even application-specific. The XML technology however provides an already existing tool for data visualisation – the stylesheet mechanism.

The Extensible Stylesheet Language (XSL) mechanism and specifically its transformations-related part, XSL Transformation (XSLT), provides a flexible, standardised solution for spatial data visualisation. Using the XSLT technology a transformation can be defined from one XML vocabulary into another XML vocabulary. This way a GML-encoded dataset can be transformed e.g. into a Scalable Vector Graphics (SVG) image. The transformation would be done by defining the transformation in an XML-file, delivering this transformation declaration, together with the source document (GML), to an XSLT processor that would then proceed to process the source document and produce the transformed document (SVG) as a result.

6.9 W3C[1]

WorldWideWeb Consortium (W3C) was created in 1994 to lead the World Wide Web to its full potential by developing common protocols that promote its evolution and ensure its interoperability. W3C has more than 500 Member organisations from around the world and has earned international recognition for its contributions to the growth of the Web. W3C's long term goals for the Web are:

[1] Contacts:
Markku Kylänpää, VTT
Timo Laakko, VTT
Lassi Lehto, Finnish Geodetic Institute
Atte Kortekangas, VTT

- Universal Access: To make the Web accessible to all by promoting technologies that take into account the vast differences in culture, education, ability, material resources, and physical limitations of users on all continents;
- Semantic Web : To develop a software environment that permits each user to make the best use of the resources available on the Web;
- Web of Trust : To guide the Web's development with careful consideration for the novel legal, commercial, and social issues raised by this technology.

In practice, W3C is the authority specifying these media formats, essential and critical in personal navigation applications:

- XML standards, like SVG (Scalable Vector Graphics) and RDF (Resource Description Framework
- evolution of HTML
- support and further development of HTTP
- basic applications of XML (and possibly development of location dependent data, depending on the interests among the members).

Members include vendors of technology products and services, content providers, corporate users, research laboratories, standards bodies, and governments.

The public information of the World Wide Web Consortium (W3C) is available through the link http://www.w3.org/. Several of W3C activities have significance to personal navigation.

6.9.1 Semantic Web Activity

The Semantic Web Activity (http://www.w3.org/2001/sw/) is a successor to the previous W3C Metadata Activity.

"The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in co-operation." (http://www.scientificamerican.com/2001/0501issue/0501berners-lee.html).

Specifications

- Resource Description Framework (RDF) Model and Syntax Specification. W3C Recommendation 22 February 1999: http://www.w3.org/TR/1999/REC-rdf-syntax-19990222
- Resource Description Framework (RDF) Schemas. RDF Vocabulary Description Language 1.0: RDF Schema. W3C Working Draft 30 April 2002 http://www.w3.org/TR/rdf-schema/

Interest and Working Groups

- RDF Interest Group (http://www.w3c.org/RDF/Interest)
- RDF Core Working Group (http://www.w3c.org/2001/sw/RDFCore/)
- Web Ontology Working Group (http://www.w3c.org/2001/sw/WebOnt/)

A target of the Web Ontology Working Group is to define structured web based ontologies, which will provide richer integration and interoperability of data among descriptive communities. The group has published a working draft for a Web Ontology Language: http://www.w3.org/TR/webont-req/

Additional support for the Semantic Web Activity has been provided, for instance, in DAML program (http://www.daml.org) by DARPA (http://www.darpa.mil).

See Chapter 4.1.

6.9.2 XML Protocol Activity

http://www.w3.org/2000/xp/

The target of the activity is to develop technologies which allow two or more peers to communicate in a distributed environment.

A goal is to allow a layered architecture on top of an extensible and simple messaging format

- SOAP (Simple Object Access Protocol) candidate recommendations (December 2002) for version 1.2:
  http://www.w3.org/TR/soap12-part1/
  http://www.w3.org/TR/soap12-part2/
- XMLP (XML Protocol Requirement Document) http://www.w3.org/TR/xmlp-reqs/

The XML Protocol Activity was incorporated in the Web Services Activity (see Chapter 4.2) in January 2002.

6.9.3 Device Independence Activity

This activity is working towards seamless Web access and authoring. The activity is a successor of Composite Capabilities/Preference Profiles (CC/PP) working group, which developed a series of specifications to describe terminal and user profiles. Related work is carried out in Open Mobile Alliance within UAProf activity [WAP-248-UAPROF-2001020-a] (see Chapter 6.7.2). More information is available at http://www.w3.org/2001/di/ and http://www.w3.org/Mobile/CCPP/.

The Device Independence Working Group has released a Working Draft of Device Independence Principles: http://www.w3.org/TR/2001/WD-di-princ-20010918/

6.9.4 SVG

The Scalable Vector Graphics (SVG) specification is an XML technology, with the purpose to create a standardised vector graphics format for the Web environment. The specification has recently reached the status of a W3C Recommendation (4 Sep 2001). The SVG format is widely seen as probable future standard for all kinds of vector graphics in the Web. In the texts dealing with the SVG technology, maps are frequently mentioned as a typical application area for the SVG format. Currently SVG images can be visualised in a Web browser e.g. by using an Adobe provided SVG Viewer plugin.

http://www.w3.org/Graphics/SVG/

SVG is an XML language for describing two-dimensional graphics. SVG supports three types of graphic objects: vector graphic shapes, images and text. Graphical objects can be grouped, styled, transformed and composited. SVG drawings can be dynamic and interactive.

SVG 1.0 is a W3C Recommendation 04 September 2001 (http://www.w3.org/TR/SVG/).

Work continues on the modular SVG 1.1 and on the Mobile SVG profiles. Version 1.1 W3C Proposed Recommendation (15 November 2002) is at http://www.w3.org/TR/SVG11/ .

The two SVG 1.1 profiles (SVG Tiny and SVG Basic) are collectively known as Mobile SVG. Two Mobile SVG Profiles have been defined: SVG Tiny and SVG Basic. The Proposed Recommendation (15 November 2002) is at http://www.w3.org/TR/SVGMobile.

An introduction to SVG Document Object Model (DOM) is available at http://www.w3.org/TR/SVG/svgdom.html.

6.9.5 Extensible Stylesheet Language (XSL)

The Extensible Stylesheet Language (XSL, http://www.w3.org/Style/XSL/) mechanism and specifically its transformations-related part, XSL Transformation (XSLT, http://www.w3.org/TR/xslt), provides a flexible, standardised solution for spatial data visualisation. Using the XSLT technology a transformation can be defined from one XML vocabulary into another XML vocabulary. XSLT is a part of XSL, which is a stylesheet language for XML. XSL includes also an XML vocabulary for specifying formatting.

In particular, XSLT can be applied to transform documents written in an XML language (for example, GML) to an other XML language (for example, SVG).

6.9.6 XML Schema

XML Schemas (http://www.w3.org/XML/Schema) provide a means for defining the structure, content and semantics of XML documents.

6.9.7 Web services Activity

The Web Services Activity aims to develop a set of technologies in order to "bring Web services to their full potential." For details see: http://www.w3.org/2002/ws/

See Chapter 4.2.

6.9.8 Annotea Project

Annotea (http://www.w3.org/2001/Annotea/) is a project enhancing the W3C collaboration environment with shared annotations. Annotations are "comments, notes, explanations, or other types of external remarks that can be attached to any Web document or a selected part of the document without actually needing to touch the document".

Annotea is a part of the Semantic Web efforts.

6.9.9 Some other XML languages

The following are two relatively old W3C notes. Both are submissions from W3C member organisations that are made available by the W3 Consortium for discussion only.

NaVigation Markup Language (NVML) W3C Note 6 Aug 1999

- http://www.w3.org/TR/NVML

POIX: Point Of Interest eXchange Language Specification

W3C Note - 24 June 1999

- http://www.w3.org/TR/poix/

6.9.10 Workshop

Joint W3C/WAP Forum Workshop on Position Dependent Information Services in Sophia-Antipolis, Nice, France, February 15 - 16 2000.

- http://www.w3.org/Mobile/posdep/

6.10 International Transport telematics' standardisation[1]

Work is progressing on standards relevant to transport telematics in international organisation ISO and the European organisations CEN, CENELEC and ETSI. The following technical committees are particularly important to transport telematics:

- CEN/TC 278 Road transport and traffic telematics
- CEN/TC 224 Machine readable cards, related device interfaces and operations
- CEN/TC 226 Road Equipment
- ISO/TC 204 Transport information and control systems
- CENELEC/TC 214 Electrotechnical aspects of surface transport systems
- ETSI
- ISO/TC22 Road vehicles

The FITS Programme of Ministry of Transport and Communications in Finland, in its project T9-Web, observes the development of international standardisation.

6.10.1 CEN TC 278 Road Transport and Traffic Telematics

CEN/TC 278 Road Transport and Traffic Telematics was established in 1991. Its scope was then defined as follows: Standardisation in the field of telematics to be applied to

[1] Contact:
Juuso Kummala, VTT

road traffic and transport, including those elements that need technical harmonisation for intermodal operation in the case of other means of transport. The work comprises Work Items (WI) classed either as application specific, databases, interfaces or basic concepts. These work items are addressed by 14 Working Groups (WG):

WG 1: Electronic fee collection
WG 2: Freight and fleet management systems
WG 3: Public transport
WG 4: Traffic and traveller information
WG 5: Traffic control systems
WG 7: Geographic data files
WG 8: Road databases
WG 9: Dedicated short-range communication
WG 10: Human-machine interfaces
WG 12: Automatic vehicle and equipment identification
WG 13: Architecture
WG 14: Recovery of stolen vehicles

6.10.2 CEN TC 224 Machine readable cards, related device interfaces and operations

Organisation, co-ordination and monitoring of the development of standards (including testing standards) for cards, related device interface and operations with special emphasis on inter-industry standardisation and on Integrated Circuits Cards, and without restriction to payment cards or bank cards.

Since first meeting in February 1990, more than 60 standards were adopted as a response to the market requirements in various areas of intersector and sector related card systems characteristics:

- Cards (including all physical, electrical, logistical and protocol specifications)
- Devices (including all physical, electrical, logistical and protocol specifications as well as ergonomic aspects and transaction management)
- Communication (all protocols between cards devices and hosts)
- Applications (banking, surface transport, healthcare, telecommunications).

6.10.3 CEN TC 226 Road Equipment

Scope of CEN TC 226 is to prepare specifications for safety, traffic control and other road equipment in the following fields:

- Safety fences and barriers, including guard rails, safety fences, crash barriers, crash absorbers and bridge parapets
- Horizontal signs including road studs and road markings
- Vertical signs including signs, cones and marker posts
- Traffic lights including signals, traffic control and danger lamps
- Street lighting, performance requirements only
- Other equipment including bollards, anti-glare screens and noise protection devices.

6.10.4 ISO/TC 204 Transport Information and Control Systems

ISO/TC 204 is the partner of CEN/TC 278 in ISO, responsible for the international standardisation of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveller information, traffic management, public transport, commercial transport, emergency services and commercial services in the transport information and control systems (TICS) field.

6.10.5 GDF[1]

What is GDF ?

GDF Geographic Data Files is a standard, that is used to describe and transfer road networks and road related data. It is much more than a generic GIS standard, because GDF gives rules how to capture the data, how the features, attributes and relations have been defined.

ISO/TR 14825, which is a Technical Report of type 2, was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee ISO/TC 204, Transport information and control systems, in accordance with the Agreement on technical co-operation between ISO and CEN (Vienna Agreement).

GDF has been developed in a European project namely EDRM (European Digital Road Map). Its primary use will be for car navigation systems, but it is very usable for many other transport and traffic applications like Fleet Management, Dispatch Management, Traffic Analysis, Traffic Management, Automatic Vehicle Locations etc.

(Mis)Understanding GDF

In the past year there were quite some misunderstanding when using or considering GDF. Below of few of these are given:

- GDF in not only an exchange format. GDF contains an exchange format , but much more. There are rules for data capturing, visualisations etc...
- A GDF map has no scale. It depends on the application where it is used. A GDF map does contain accuracy (e.g. < 5m).
- A GDF map can be detailed, but this is not always needed. Quite often people say that the GDF map is too detailed for their application. They probably mean : the GDF map that a car navigation system uses is too detailed for me.
- A GDF database (in the exchange format) will never be used as such. The first thing that a user will do, is to transform it into their system. This could be a GIS (Geographic Information System), Car navigation system, routing algorithm. Therefore you cannot talk about a GDF application, but rather an application that uses GDF.
- GDF is not a CD standard for car navigation systems. GDF is used and converted onto the CD-ROM in the internal format of the navigation system.

---

[1] Contact:
Reijo Martamo, VTT

- GDF is application independent.
- Building a spaghetti road map is simple, building an accurate road map for ITS(Intelligent Transport Systems) is a professional task.

GDF Structure

GDF has a three level structure :

Level 0 Topology. This is a common GIS topology description that is widely accepted. i.e. everything has been described by Nodes, Edges and Faces. This toplogy description is similar to for instance DIGEST.

Level 1 Features. Level 1 is the most used level of GDF. It contains simple features like Road elements, Rivers, Boundaries, signposts etc. Features can have attributes that are specific to the feature. i.e. one way, width of the road, number of lanes. Features can also have relations. These relations are very important for car navigation systems. relations can be "forbidden turn from road element 1 to road element 2" or "road element 1 has priority over road element 2".

Level 2 Complex Features. At this level the "simple features" are aggregated to a higher level feature. For instance at level 1 all road element of an intersection should be represented. At level 2, the intersection is only represented with a single point.

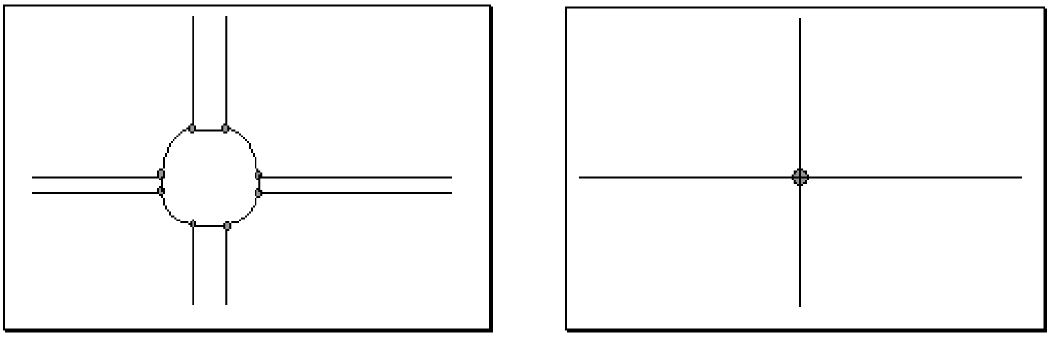


Figure 6-5. Level 1 Representation of a roundabout -------------> Level 2 Representation

Level 2 is mostly used when a simplified description of the road network is sufficient. For instance inter urban route calculation does not require a high level of detail. Vehicle location by means of a GPS receiver however, does need the detailed description of the road network. References: [40] and http://www.ertico.com/links/gdf/gdfintro/gdfintro.htm (16.12.2002).

7 Summary

This document aims to be a compact review of the technologies and specifications available for personal navigation services. The contents of such collections tend to become rather fragmentary, and this is also the case here. A few observations may still be given, as a summary.

At the time of writing, a number of technologies and specifications have achieved a more or less common acceptance, even though their degree of mandatoriness seems to diminish as the technology advances. Examples of these are the LIF specifications (now under the OMA) and OpenLS by the OGC. The success of these, and others, is still very much dependent on the availability and feasibility of basic technologies. A number of technologies, e.g. cell-based location, is already established, but a large group of potential new technologies are waiting for a chance to gain a foothold on challenging, new, still unconquered technology and application areas. As an example, a number of competing short-range location technologies are available, with no clear winner yet. The maturation of these technologies may open unexpected business opportunities. One technology key, even though not the only one, to personal navigation market is mass-marketability, either through integration with existing terminals and infrastructure, or, in the more dramatic case, by entering totally new areas of end users' everyday activities. Potential examples of these are the various virtual community concepts that, at the moment, seem to attract word-wide interest. New technologies supporting these are developing. Personal navigation is a natural component in these services.

The standards and technologies introduced in this survey aim at contributing to the problem of defining geographical or geography-related information in one way or another. Modelling geographical objects and features is by no means an easy task. Geographical concepts have highly complex relationships to underlying physical reality. Temporality, for example, is an important factor when defining geographical concepts. Borders between nations vary over time, forests are planted and chopped down, villages grow into towns, etc.

Geographical concepts are often vague and ambiguous. What constitutes a forest, for example [41]? How many trees there has to be and in how small area? One reason for vagueness of geographical concepts is the large number of different criteria that people use when defining them. A geographical concept is typically defined along a physical criterion, such as material properties and geometry. Other candidates for criteria are functional (i.e. what the object(s) classified by the concept in question do), historical (e.g. how the object came into being or a process affecting the object), and legal or conventional (ownership, rights of way, etc.). The problem arises if the user is required to interpret these concepts, and measures may be needed to alleviate this in end-user application interfaces.

The actual elaboration of the personal navigation service architecture is presented in another document, Deliverable PAM-7, *Core Service Architecture For Personal Navigation*.

References

1. W. G. Figel, N. H. Shepherd, and W. F. Trammel, "Vehicle Location by a Signal Attenuation Method," IEEE Transactions on Vehicular Technology, 18(3):105-109, November 1969.
2. H. Laitinen, J. Lähteenmäki and T. Nordström, "Database Correlation Method for GSM Location," Proceedings of the VTC 2001 Spring Conference, May 7-9, 2001, Rodos, Greece.
3. M. Hellebrandt, R.Mathar, "Location tracking of mobiles in cellular radio networks," IEEE Transactions on Vehicular Technology, vol. 48, no. 5, Sept. 1999, pp. 1558-1562.
4. S. Mangold, S. Kyriazakos, "Applying pattern recognition techniques based on hidden Markov Models for vehicular position location in cellular networks," Proceedings of the VTC 1999 Fall Conference, Sept. 19-22, 1999, Amsterdam.
5. V. Ruutu, M. Alanen, G. Gunnarsson, T. Rantalainen and V-M Teittinen, "Mobile phone location in dedicated and idle modes, Proc. of the PIMRC '98, Sept. 8, 1998, Boston, MA.
6. L. Lopes, E. Villier, and B. Ludden, "GSM Standards Activity on Location," in IEE Colloquium on Novel Methods of Location and Tracking of Cellular Mobiles and Their System Applications, London, May 1999.
7. M. Wax and O. Hilsenrath, "Signature matching for location determination in wireless communication systems," U.S. Patent 6,112,095.
8. S. C. Swales, J. E. Maloney, and J. O. Stevenson, "Locating Mobile Phones & the US Wireless E-911 Mandate," in IEE Colloquium on Novel Methods of Location and Tracking of Cellular Mobiles and Their System Applications, London, May 1999.
9. S. Kyriazakos, D.Drakoulis, M. Theologou, J.-A. Sanchez-P., "Localization of Mobile Terminals, based on a Hybrid Satellite-assisted and Network-based Techniques", IEEE WCNC, September 2000, Chicago, United States.
10. J. Syrjärinne, "Studies of modern techniques for personal positioning," Dissertation, Tampere University of Technology, 2001.
11. N. Freiberg, "Hybrid location technology: The best of both worlds, Mobile Location Workshop, June 7-8, 2001, Espoo, Finland (http://location.vtt.fi/mlw2001/source/program.html)
12. H. Laitinen, "Cellular location techniques," Mobile Location Workshop, June 7-8, 2001, Espoo, Finland (http://location.vtt.fi/mlw2001/source/program.html)
13. http://www.ekahau.com
14. http://www.bluetooth.com
15. N. B. Priyantha, A. Chakraborty, H. Balakrishnan, "The Cricket Location Support System," 6th ACM International Conf. on Mobile Computing and Networking (ACM

MOBICOM), Boston MA, August 2000. (available at http://nms.lcs.mit.edu/projects/cricket/).

16. P. Bahl, V. Padmanabhan, "User Location and Tracking in an In-Building Radio Network," Microsoft Research, Technical Report MSR-TR-99-12.
17. Lahti, "Usability of Global Positioning System within buildings," Masters Thesis, University of Helsinki Department of Physics/VTT, Helsinki 2001
18. I. Kauppi, H. Seppä, K. Koskinen, "Sonic localization system using pseudo random noise and cross-correlation technique," Proceedings of Second Int. Conference on Automation, Robotics and Computer Vision, 16-18 Sept. 1992, Singapore.
19. State of Montana Department of Administration, Information Services Division: Montana Wireless E9-1-1 Trial: Final Report, May 2000 (http://www.uswcorp.com/Montana%20Wireless%20E911%20Final%20Report.pdf)
20. Mike Overy, "Local Positioning", presentation at the Bluetooth Developer's Conference, Dec 5 2000.
21. Bahl & Padmanabhan, "RADAR: An RF-Based In-Building User Location and Tracking System", Proc. IEEE Infocom, March 2000.
22. T. Berners-Lee, J. Hendler, O. Lassila, "The Semantic Web", Scientific American 284(5), pp. 34—43, May 2001.
23. J. Heflin, R. Volz, J. Dale (eds.), "Requirements for a Web Ontology Language", W3C Working Draft, March 2002. http://www.w3.org/TR/webont-req/
24. A. Ankolenkar et al. "DAML-S: Web Service Description for the Semantic Web", First International Semantic Web Conference, pp. 348—363, Sardinia, Italy, June 2001.
25. E. Christensen (Microsoft), F. Curbera (IBM Research), G. Meredith (Microsoft), and S. Weerawarana (IBM Research): Web Services Description Language (WSDL) 1.1. W3C Note 15-March-2001. http://www.w3.org/TR/2001/NOTE-wsdl-20010315
26. DARPA: DAML-S 0.7 Draft Release, http://www.daml.org/services/daml-s/0.7/
27. D. Fensel and C. Bussler: The Web Service Modeling Framework WSMF. In White Paper and Internal Report Vrije Unversiteit Amsterdam, 2002, available at http://www.cs.vu.nl/swws/download/wsmf.paper.pdf, 2002.
28. M. Gudgin (DevelopMentor), M. Hadley (Sun Microsystems), J. Moreau (Canon), H. F. Nielsen (Microsoft): Simple Object Access Protocol (SOAP). W3C Working Draft, 2-October-2001. http://www.w3.org/TR/2001/WD-soap12-part1-20011002/ and http://www.w3.org/TR/2001/WD-soap12-part2-20011002/
29. J. Heflin, R. Volz, J. Dale (eds.), "Requirements for a Web Ontology Language", W3C Working Draft, March 2002. http://www.w3.org/TR/webont-req/
30. C. Nelson and W. Farrell: Transforming legacy applications with Web Services. http://www6.software.ibm.com/devtools/news0801/art4.htm
31. Object Management Group: Trading Object Service Specification. OMG Document formal/00-06-27, May 2000. Version 1.0. http://www.omg.org/cgi-bin/doc?formal/2000-06-27
32. UDDI Version 2.0 Programmer's API Specification. 8-June-2001. http://www.uddi.org/pubs/ProgrammersAPI-V2.00-Open-20010608.pdf

33. Foundation for Intelligent Physical Agents: FIPA Agent Management Specification. Geneva, Switzerland, December 2002. Specification number SC00023J. http://www.fipa.org/specs/fipa00023/SC00023J.html
34. Appel, K. Deployment Approach and Scenarios. European ITS Framework Architecture. 2002. http://www.frame-online.net/library.htm
35. Franco, G. Deployment of European ITS Framework Architecture. IEEE, ITSC Oakland. Oakland. 2001
36. Lockheed, M. The U.S. National ITS System Architecture, Executive Summary. Federal Highway Administration, US Department of Transportation. Washington D.C. 2002
37. Infoten – Multimodal Information and Traffic Management Systems on Trans-European Networks. (1999). Addendum to deliverable 3. European Commission DG XIII.
38. Lehtonen, M., Kummala, J. & Lähesmaa, J., Review of multimodal traffic information services, Reports and Memoranda of the Ministry of Transport and Communications B 25/2002).
39. Lähesmaa, J., www.kalkati.net
40. Geographic Data Files (GDF) (ISO/TR 14825:1996(E)). First edition 1996-11-15.
41. Bennett, Brandon, What is a Forest? on the vagueness of certain geographic concepts, *Topoi*, 20(2), pp. 189—201, (2001).