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COSTE - Enabling Interoperability and Integration of Spatial and Traffic eContents for European Regions

Marco BOERO[1], Reinhard ERSTLING[2], Michael FELDGES[3],
Manfred SCHÄFER[4], Daniela SCHENONE[5]
[1]*Softeco Sismat SpA, Via De Marini 1- WTC Tower, Genoa, 16149, Italy*
Tel: +39 010 6026329, Fax: + 39 010 6026350, Email: marco.boero@softeco.it,
[2]*Interactive Instruments GmbH, Trierer Straße 70-72, Bonn, D-53115, Germany*
Tel: +49 228 9141071, Fax: + 49 228 91410 90, Email: erstling@interactive-instruments.de,
[3]*Momatec GmbH, Weiern 167, Aachen, D-52078, Germany*
Tel: +49 241 90075 11, Fax: +49 241 90075 20, Email: michael.feldges@momatec.de,
[4]*MVEL, Ministry of Transportation, Haroldstrasse 4, Düsseldorf, D-40190, Germany,*
Tel: +49 221 837 4420 , Fax: +49 221 837 4494, Email: manfred.schaefer@mvel.nrw.de ,
[5]*Comune di Genoa, Via Di Francia 1, Genoa, 16149, Italy*
Tel: +39 010 5577791, Fax: + 39 010 6026350, Email: dschenone@comune.genova.it

Abstract: Ensuring interoperability and integration of geospatial and traffic/transport related information is a key issue for a number of complex applications including traffic management, travel information provision, infrastructures management, land planning and use, etc. The rapid development of Internet and communication technologies, and particularly of web service technologies, will expand enormously the capabilities of different systems and services to exchange contents and become interoperable on-line. This paper describes the approach followed in the COSTE definition Phase project, part-funded by the EU under the eContent programme. Strongly oriented to European and world-wide standards, COSTE has defined and trialed an advanced, multi-service middleware architecture enabling on-line content access and integration from different Web Map Servers and Web Feature Servers, as well as the construction of Value Added Services to support operations in a number of different applications.

1. Introduction

The use of combined geographic, land and traffic related digital data has gained a great relevance in many service and application sectors, particularly in the realisation and operation of various type of Intelligent Transport Systems (ITS). The current market of transport telematics and ITS applications is characterised by a wide offer of products and systems. These encompass both base products and components – such as digital maps, data collection devices, location systems, etc. – as well as higher level systems addressing particular (complex) mobility and transport processes. These may include, for instance: traffic management systems, travel information dispatching systems and services, Location Based Services (for e.g. tourism, commerce, etc.), event management, emergency and risk management, land and resource planning, planning and operation of infrastructures, etc. The growth of global network infrastructures – the wired Internet and the expanding wireless environment (3G, WLAN, etc.) – together with the availability of advanced technologies and components such as web services, semantic and service grids, on-board

computers and smart phones are fundamental drivers which will expand enormously the capabilities of the different systems to exchange information and become interoperable.

In order to enable this, attention to open solutions, reference data models, architectures and standards has become a central issue. Efforts in this area are very active, with several organisations and initiatives addressing worldwide reference standards for e.g. information models, data exchange protocols, applications interfacing, etc. These include, among others, international consensus bodies such as the Open Geospatial Consortium (OGC, [1]) the ISO Technical Committee 211 on standardisation of Geographic Information/Geomatics [2], European initiatives such as INSPIRE (INfrastructure for SPatial InfoRmation in Europe, [3]) as well as several national or regional initiatives in various EU countries (e.g. GDI-NRW, the Geodata Infrastructure North-Rhine Westfalia Initiative [4]).

This paper reports on a view and approach addressing this strategic area of public content management developed within the European project COSTE (Combining Spatial and Traffic eContent for Regions in Europe; Contr. EDC 41030/28459) [5] aimed at defining and experimenting with a novel, multi-service distributed infrastructure to facilitate the access, integration and exploitation of geographical and traffic related information. The paper present the background objectives and motivations of the approach, the methodological view and technical approach developed as well as the experimental application of the infrastructure in two test cases in Europe.

2. Objectives

Financed under the EC eContent initiative, COSTE is a Definition Phase project carried out in the period January 2004 – March 2005 and aiming at facilitating the access to, the use and commercial exploitation of geographic and traffic digital contents available from Public Administrations in Europe. Our approach was to investigate and define suitable methods, operational procedures and a technological enabling infrastructure to:

- support on-line data access through standard methods and interfaces,
- enable interoperability among distributed data sources over the internet; i.e. different Web Map Servers (WMS) and Web Feature Servers (WFS),
- support the production and exploitation of digital maps and other enhanced “data products” combining elements from geographic and traffic digital contents sectors.

The ultimate goal of COSTE was to investigate the main problems related to on-line access and integration of geospatial and traffic contents, and define a general, standard-based and open middleware infrastructure to improve access to data and enhance their exploitation facilitating the implementation of Value Added Services (VAS) for a number of different users. In order to root the analysis and specification work to the typical European context of geographic and traffic digital contents, COSTE has involved a tight cooperation between IT solutions suppliers and Public Administrations acting as digital contents providers. Specifically, two reference sites have been included in the project:

- the North Rhine - Westphalia Region, in Germany
- the City of Genoa, in Italy

Both sites are largely representatives of the data, operational situations and common requirements that can be found in most land and transport systems in Europe, along the main interurban transport corridors and within mid and large size cities. The investigation, requirements analysis and specification work has been conducted in parallel in the two sites, where two demonstrators have been realised.

3. Methodology

Figure 1 introduces the reference service/value chain related to the integration of geospatial and traffic contents. COSTE addresses a key element in the chain – the content integration layer – providing a distributed, multi-service middleware infrastructure comprising of:

- *CosteServices*, a set of basic services enabling (1) publication of contents (services for content providers), (2) access to contents and generation of integrated information (services for content integrators), (3) generation and operation of specific value added service applications for different type of end-users (services for VAS providers),
- COSTE information products, to a great extent being integrated digital maps (*CosteMaps*) and data (*CosteProducts*) produced by the *CosteServices*.

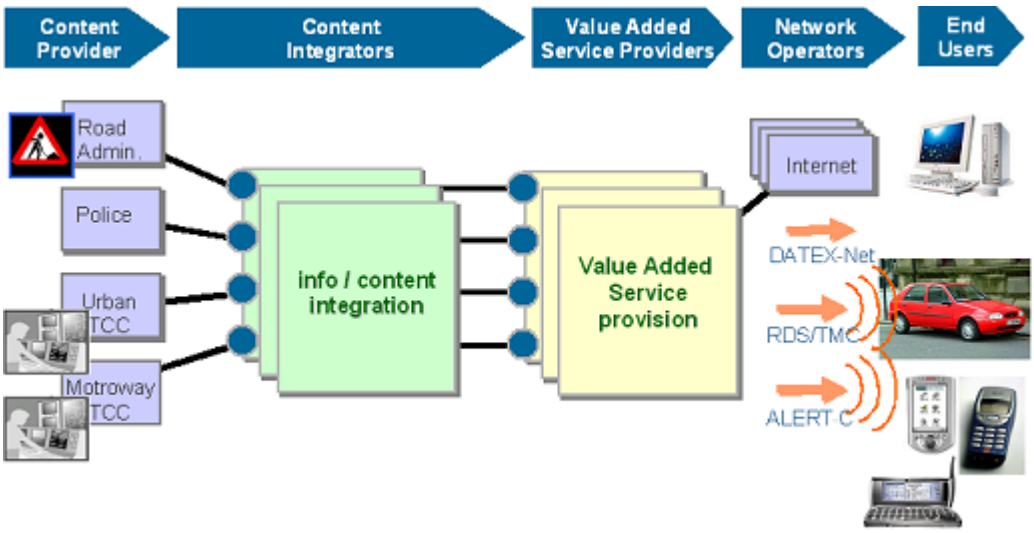


Figure 1: The COSTE Reference Value Chain

3.1 Target COSTE users

Interoperability and integration of geospatial and transport/traffic contents concern a number of different sectors of engineering and management of traffic, mobility, transport, land use and citizens oriented services. Within COSTE, several application areas have been analysed – ranging from transport and traffic management and information, to infrastructures information management, emergency and medical assistance – and a number of target end-users have been investigated.

Table 1 provides a list of all actors that are potentially involved in the use of COSTE infrastructure and its services, as well as the roles they are taking in the context of the above reference value chain. Generally, depending on the particular applications the actors may take more than one role. For example, many actors will be content providers as well as end users of their own or other contents. *CosteServices* enable provision and integration of the contents and are used by all actors in the infrastructure.

3.2 Standards and Enabling Technologies

A main methodological issue in COSTE is ensuring compliance of COSTE Infrastructure with the main technologies and standards in the Internet and web services world. To this end, COSTE incorporates recommendations from several major initiatives in the sector of geographic, spatial and traffic data, and web services architectures, including:

i. digital road map data model standards like GDF (Geographic Data File) [6];

ii. the OpenGIS Consortium (OGC) specifications for geodata interoperability computing standards; i.e. ISO 19xxx standards, like the ISO 19100 Geographic Information / Geomatics standards, including ISO 19119 "Geographic Information – Services" standard [7];
iii. the European initiative INSPIRE [3];
iv. the use of widely adopted languages for description of data semantics such as e.g. GML (Geography Markup Language) for road and traffic data [8].
v. the OGC's OWS Service Framework (OSF) [9] that identifies services, interfaces and exchange protocols that can be utilised by any OGC-compliant application.

Table 1: COSTE Target Users

User	Content provider	Content integrator	VAS provider	Network Operators	End-user
Cartographic, mapping service	✓	✓			✓
Traffic management and control centres	✓	✓	✓		✓
Traffic planning department	✓	✓	✓		✓
Private motorway companies	✓	✓			✓
Road/infrastructure planning/maintenance service companies	✓	✓	✓		✓
Public Transport services operator	✓	✓	✓		✓
Flexible transport operators	✓	✓	✓		✓
Flexible transport end-users					✓
Parking service companies	✓	✓	✓		✓
Service provider (radio, mobile, internet…)		✓	✓		✓
Tourism and Events agencies		✓	✓		✓
Cultural Agency, Event venue operators	✓	✓			✓
Police	✓	✓			✓
Statistics authorities	✓	✓			✓
Utility and Telecommunication companies	✓	✓	✓	✓	✓
Network Operators				✓	
Medical associations	✓	✓			✓
Environmental information administrations	✓	✓			✓
Weather Stations / Weather offices	✓	✓			✓
Road end-user, citizens, tourists					✓

4. Technology Description

The application environment assumed in COSTE is based on a context of distributed content and data, including digital maps and various types of spatial and traffic related data. Figure 2 provides a schematic view of the typical operational context for COSTE middleware infrastructure. Overall, one can distinguish the following conceptual elements:

- Web Map Servers (WMS) providing digital maps of various type, contents, scale, format, etc., made accessible to external applications through web services. The OpenGIS® Web Map Service specification is a reference standard to enable web mapping and supporting interoperability.
- Web Feature Servers (WFS) providing geographic and transport related contents that are generally referred to as "features"; (e.g., on-line traffic data, land use data). These contents can be integrated over maps (overlaid) and the OpenGIS® Web Feature Service specification provides a standard reference addressing this.
- Meta-Data Servers (MDS) offering meta-data about maps and contents. Provide various types of information about data themselves (e.g. source, validity, quality). Services Meta-data provide information about the services available within the global network environment. Meta-data are accessed through dedicated servers (catalogues, registries).

- COSTE Application Server(s) serve as interfaces of computational environments to the users and provide various COSTE services as well as integrated information available through the interconnected WMSs and WFSs.
- COSTE Enabled Applications. COSTE Application Servers enable implementation of specific value added applications for the end-users. These are delivered through standard global network channels (internet, wireless environment) and made accessible to the intended end-users via standard web client applications.

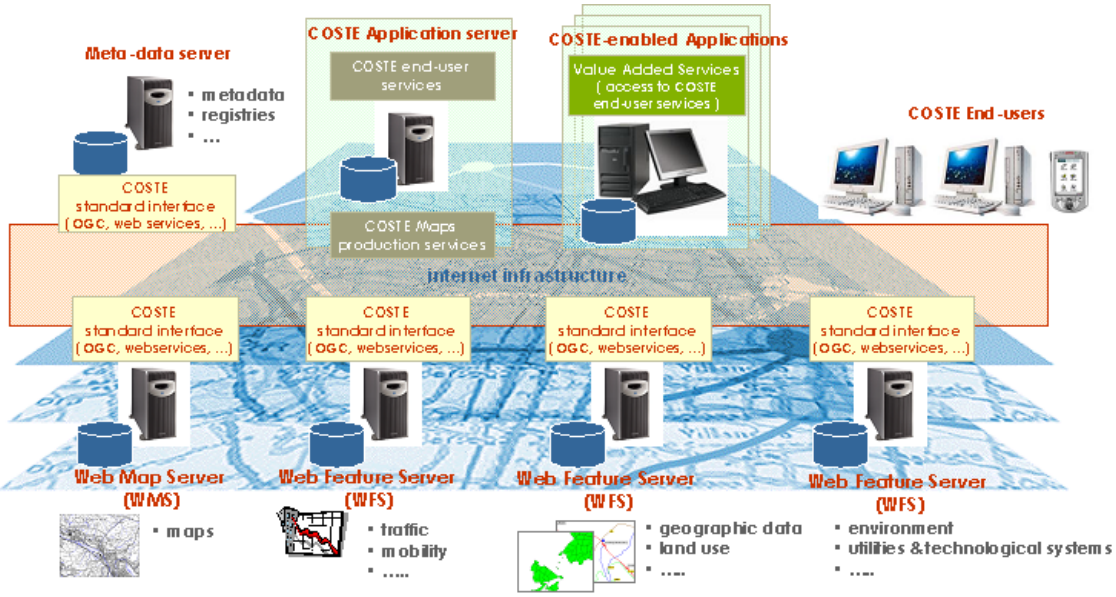


Figure 2: The COSTE Overall Architecture Context

4.1 The COSTE Services

The COSTE Infrastructure is a collection of services (*CosteServices*) oriented to the OGC Web Services model (e.g. [10]) and concrete web services definitions. It provides the base service infrastructure enabling the implementation and operation of COSTE supported applications. As a basis of most Spatial Data Infrastructures (SDIs) currently being set-up worldwide, the OGC Web Services Framework (OSF, [9]) has served as a reference model for specifying the *CosteServices*. Service implementation specifications from the following OSF categories are fundamental for COSTE: *Registry Services*, addressing the publish and find parts of the publish-find-bind interaction template typical for web services; *Data Services*, providing basic data source and flow management functionalities; *Portrayal Services*, supporting map generation and management functionalities; *Processing Services*, enabling implementation of a number of different capabilities (e.g. location referencing transformation, routing, etc.); *Digital Rights Management Services*, providing basic services to handle access to geospatial and traffic objects.

The complete specification of *CosteServices* is given in [11]. Table 2 provides an overview of the taxonomy of CosteServices that comprises the COSTE Infrastructure.

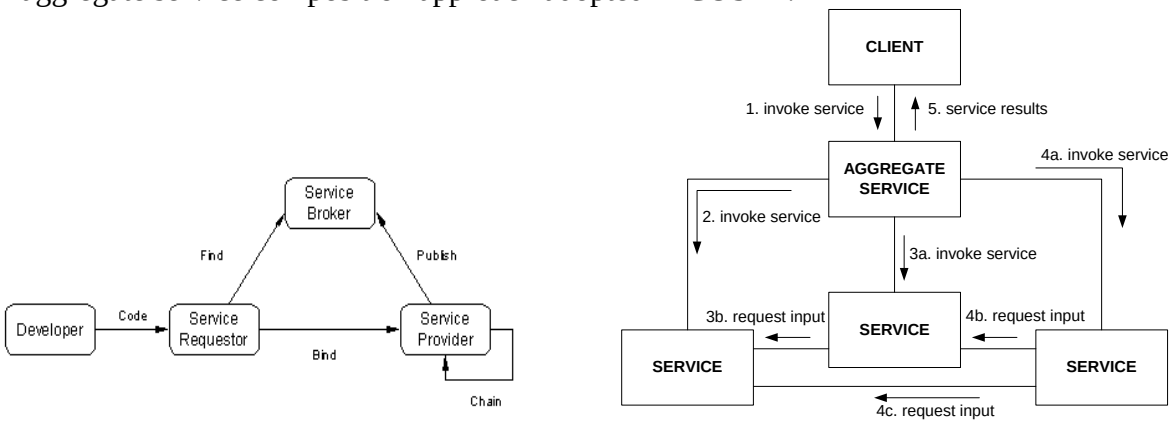
4.2 Service Operation and Chaining

One essential concept in COSTE is the well-known publish/find/bind pattern, which carries forward the general use of the World Wide Web to the world of web services (fig. 3-a). Furthermore, individual services maybe chained together, with several services successively working on the results of the previous service to generate the requested result.

Table 2: The Taxonomy of CosteServices

CosteService	OSF category	Comment
COSTE Catalogue Services	Catalogue Service	Implement read-type as well as write-type operations
COSTE Sensor Collection Services	Sensor Collection Service	Fully OGC compliant
COSTE Data Services	Data Service	Provide data access (data servers or DBs)
COSTE Portrayal Services	Portrayal Service	Map creation and manipulation. OGC and SLD compliant
COSTE Routing Services	Processing Service	Used on eg read network, public transport, …)
COSTE Watchdog Services	Processing Service	Notify event occurrence to users or other services
COSTE Location Referencing Transformation Services	Processing Service	Perform transformations between different road networks, coord. reference systems, etc.
COSTE Digital Rights Management Services	DRM Service	Authentication of users and services to access geoinfo objects. GeoDRM ongoing standard definition

According to this, *CosteServices* mostly constitute service chains or aggregate services (opaque-chaining). The user communicates with one interface service and doesn't recognise that there is more then one service involved. Figure 3-b provides a schematic view of the aggregate service composition approach adopted in COSTE.



(a) *(b)*

Figure 3: Service invocation through the publish/find/bind pattern (from the ORM)(a) & service chaining (b)

5. Developments and Results

In order to evaluate the viability of the specified COSTE Infrastructure and the basic mechanisms underlying the architecture and its *CosteServices*, a demonstrator has been built up involving three different transport/traffic applications in the two test sites North Rhine Westphalia (NRW) and Genoa. The applications involve different types of end-user services, and different kind of transactions – Administration-to-Administration (A2A), Administration-to-Consumers (A2C), Administration-to-Business (A2B), Business-to-Consumer (B2C). Particularly, the selected test application services include:

- Cooperative traffic strategy management: an A2A application enabling different traffic Authorities (e.g. urban traffic management centre, motorway operator, public transport service operator) sharing on-line information and management to respond to traffic events and achieve cooperative administration of traffic management strategies.
- Demand responsive transport service access, an A2C or B2C application allowing transport end-user accessing on-line information and booking/reservation services for demand-responsive transport (e.g. on-demand bus services).

- Road infrastructures information service, an A2A or A2B application allowing end-users (e.g. administration services, consultancies and business service providers) to access and use information about the physical characteristics of the road network (for e.g. infrastructure planning, maintenance, etc.)

All applications involve interoperation of several Web Map Servers and Web Feature Servers. These provide content accessed and integrated through a COSTE Primary Application Server (PAS), a generalised Web Mapping Application which makes WMS content visible in standard browsers, like e.g. Internet Explorer or Firefox. For example, the COSTE application in Germany involves the following servers and Internet resources:

1) The Web Map Servers of the NRW Public Surveying Agency (Landes-vermessungsamt), running in Düsseldorf and providing topographic maps of various scales from the NRW Spatial Data Infrastructure (GDI NRW)
2) The Access Point at the Traffic Information Center NRW (TIC NRW), also running in Düsseldorf and providing on-line updated information streams concerning traffic events on motorways (and other information)
3) A Strategy Manager Server and its interface services (WFS), running in Aachen
4) A COSTE Primary Application Server (PAS), running in Bonn

All contents provided by these WMS and WFS – i.e the digital map of NRW area, the traffic Levels of Service (LOS), traffic events (e.g. accident, roadworks), etc. – are integrated through the COSTE PAS. Figure 5 shows a sample screen of COSTE demonstrator in NRW.

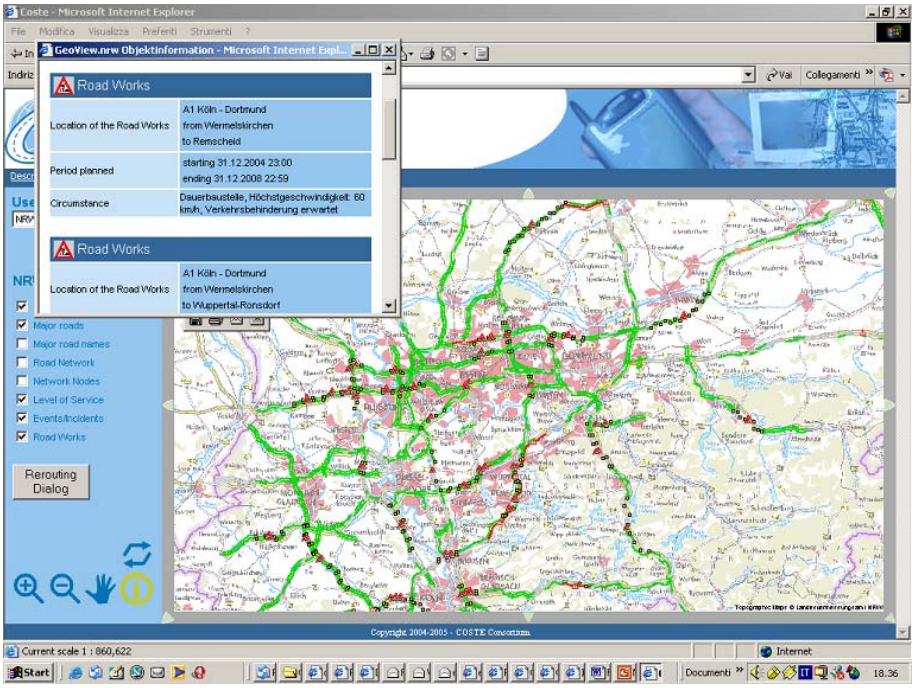


Figure 5: Sample screen from COSTE demonstrator in NRW: integration of digital map, traffic data (LOS), events information (accidents, roadworks)

6. Business Benefits

A better integration of geographic and various transport and traffic related contents is a key issue in today's Intelligent Transport Systems (ITS) as well as in many sectors related to transport, infrastructures and land planning and operations. With a large volume of geospatial information and transport/traffic/land/etc. related contents potentially accessible over the internet, and a number of standards which are becoming widely adopted, a clear need – and also an opportunity – is emerging for open, internet and web service based

middleware infrastructures that are able to facilitate the exchange of information, the interoperability of the different sources of contents and, ultimately, allow to realise the full potential and added value of integration. There is a potential wide market for such new systems, with many different actors and target customers as briefly introduced in chapter. 2.

The solutions achieved with COSTE offer important competitive advantages, including:

- An innovative approach to on-line contents integration, based on state-of-the-art WMS and WFS technologies.
- A modular and scalable architecture, including a number of base services (*CosteServices*) able to support implementation of a large variety of end-users applications and services.
- Provision of a comprehensive data and information model, encompassing a wide spectrum of geographic, traffic and transport related content domains (road network infrastructure, traffic information, parking information, public transport, event information, weather data, environment data, emergency services information…) and supporting generation of a number of value added integrated information products (*CosteMaps*, *CosteProducts*).
- Strong orientation and compliance to world-wide standards in web mapping, geo contents, web services, data encoding, etc. – OGC, ORM, ISO 19xxx series, GDF, GML, etc.

7. Conclusions

COSTE has addressed key issues and shown the feasibility of a novel middleware infrastructure to facilitate interoperability and on-line access and integration of different types of geospatial and transport/traffic related contents. The experiments conducted in the two sites and the feedbacks from the users have shown that there is a potentially very large number of applications that would benefit from the approach, and that the adopted standards are vital to enable the interoperability of contents and applications. On the other hand, harmonising the semantics of contents in such a huge domain as geospatial and traffic/transport information is a formidable endeavour and much has still to be explored in this area. Based on successful outcomes of this initial phase, the aim of COSTE is to support the take-up of piloted solutions in other European sites through larger-scale demonstrations and validations.

More information about COSTE, including on-line access to a proof-of-concept of COSTE Services accessing and using on-line real traffic data and digital maps, can be obtained from the COSTE website [5].

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