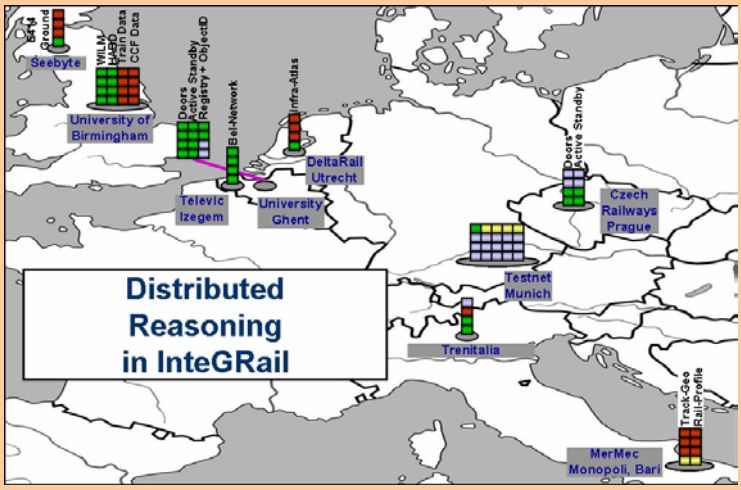

Integration

Distributed Reasoning

Seamless integration and processing of distributed knowledge

Integration of information is key for further growth of railway transport volume. Decision makers will be able to make better decisions once they have the right information at hand about their own processes and about the processes of their partners in business. InteGRail is the project that developed an enabling technology to allow universal access to existing information systems, be it databases, monitoring systems or existing user applications. For this purpose InteGRail defined a standard approach for architecture and communication. Using this standard approach a number of example applications were developed. Distributed reasoning plays a central role for supporting those applications that need to process integrated railway domain data. This sophisticated technology forms an active part of data integration - especially for relating data acquired by rolling stock with information only available on the ground side.

As part of the **Distributed Intelligent System,** the technology for **Distributed Reasoning** offers:

- efficient use of available information systems for better decision making
- logical combination of information (which is automated and machine-interpretable)
- adaptability and flexibility (in the face of new business partners across Europe)
- extensibility (concerning new partners and large-scale distributions of data pools and distributed reasoning components)
- consistent extensibility of information content (automatic consistency check)
- customized views to information (supports the need-to-know principle and even allows for stakeholder-specific - yet consistent - interpretations)
- getting more out of your data by deriving additional information by exploiting logical relationships such as symmetry, transitivity, inversion, disjointness, etc.
- handling incomplete information in a logical consistent way (OWA)

What is Distributed Reasoning?

Distributed reasoning is a leading/modern IT technology that has been implemented for intelligent Monitoring by the InteGRail partners and lead by Siemens AG. As software components to serve different InteGRail applications, it combines complex queries and consistency checks of distributed data but allows interpreting information in order to make implicit knowledge explicit. This so-called reasoning process leverages the Railway Domain Ontology together with description logics as a formal logic foundation to dynamically create different integrated views on spatially distributed information. Hence, applications are no more restricted to isolated information of single stakeholders in the railway context but now can utilize an added value by commonly understanding distributed railway domain data from different customizable points of view. For instance, door faults of multiple trains can be aggregated and interpreted together with timetable data in order to reason about possible maintenance schedules.

Who can benefit?
The encapsulation of stakeholder privacy allows to implement the "who needs to know" principle. Since distributed reasoning represents a highly flexible way to combine Railway condition monitoring data with maintenance optimisation by the use of IT/Internet-Technology it can be applied to all sectors of the railway domain. This technology helps to seamlessly integrate and interpret distributed information for rolling stock and infrastructure management, as well as for operations and traffic management. For this, the Railway Domain Ontology represents a common interface and supports a common understanding of shared data**. The key benefit of distributed reasoning** is a gain of performance compared to centralized reasoning since lower-level data interpretation can already be started locally and pre-interpreted in parallel. This additionally allows communicating less information – the local reasoning results – to subsequent higher-level reasoning nodes for further processing This approach also supports **means for data and process abstraction** and **only discloses** data to authorised partners. In addition, other partners can be provided with customized integrated views to access inter-enterprise information if requested. For instance, an independent partner can use a custom view on distributed data and interpretation results to create monthly reports about cross-company fleet performance. Using distributed reasoning makes it easy to implement the required **integrated views on distributed shared data** for all railway domain stakeholders.

How is the benefit realised?
Example: Remote-Condition-Monitoring of Rolling Stock status for **predictive** Maintenance with landside Depot-Information logically combined (=reasoning). Based on a common terminology spatially distributed data can be seamlessly related to each other and interpreted no matter what kind of information it represents and where it is acquired. For instance, on-board sensor information such as train status and observation data can be easily integrated and interpreted in combination with landside information such as data about depots. This **terminology** is available in the form of the **InteGRail Railway Domain Ontology**, which can be extended easily to incorporate additional data sources and support applications – even at runtime.
In contrast to relational databases distributed reasoning also enables to interpret incomplete data based on the open world assumption. For example, even in case of information source unavailability e.g. when the train is in the tunnel the best possible reasoning result will be returned to the railway domain application. Distributed reasoning also allows for **efficient data consistency checks and root cause analysis** of failures. Finally, this technology supports **facilitated extension** by adding additional data repositories including relational databases that may manage heterogeneous railway domain information.

Present status, availability and future possibilities
The distributed reasoning technology has been implemented in the context of the InteGRail project as a set of software modules based on available reasoning components. In InteGRail, these **modules provide data integration and reasoning functionality** to different applications. These are the Network Statement Checker and the demonstration scenarios (e.g. door maintenance, wheel impact load measurement, hot axle box integration).

Other results of InteGRail

Architecture definition of integrated information systems: IGRIS

Semantic data structure of the railway domain, the InteGRail ontology

Example user applications: ODSS fo r on-line operational decision support, IAC for on-line infrastructure availability, IDT for on-line vehicle maintenance information

Description of interdependence of performance of railway processes: the railway KPI tree, and a tool to assess and visualise performance

InteGRail - Facts and Figures

InteGRail started on 1/1/2005 and ends on 31/12/2008

Total project budget:
20 million Euros

EC funding : 11 million Euros

Total effort over 125 person-years

39 partners from 11 countries

Partners of InteGRail:
UNIFE • Alstom Transport • AnsaldoBreda • Bombardier Transportation • Siemens Mobility • UIC • Trenitalia • D'Appolonia • TSB-FAV • DeltaRail • ATSF • CAF • Nortel Networks • Laboratori Guglielmo Marconi • FAR Systems • MER MEC • Italcertifer • ATOC • České dráhy • MAV • UNICONTROLS • Strukton Railinfra • Deuta-Werke • Heriot-Watt University • IMEC • OFFIS • Televic • Seebyte • Kontron • University of Chile • INRETS • Wireless Future • University of Birmingham • ADiF • RFF • ARGE Corridor X • Network Rail • ProRail • SNCF

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