The Intelligent Cargo Concept in the European Project EURIDICE

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The project

EURIDICE: European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics

FP7 ICT Integrated Project
Budget > 14 M€
Duration 3 years since Feb. 2008

Objective: to make cargo “intelligent”, i.e.: self-aware, context-aware and connected in order to support a wide range of information services such as:

- Monitor, trace and safely handle moving goods at the required level of detail, from full shipments to individual packages or items.
- Increase efficiency of transportation networks, by improving synchronization between logistic users, operators and control authorities.
- Improve sustainability of logistic systems, by reducing their impact on local communities in terms of traffic congestion and pollution.
The challenge - The logistics industry

- Extreme fragmentation
  - Majority of SMEs, average turnover in EU: 430 k€ (src. EC DG TREN)
  - The world leader DHL controls 5% of total traffic
  - Large players subcontracting most low-value activities (e.g., DHL subcontracts over 70% transport).

- Labour intensive, low margins
  - 2.6 million workers in road freight transport (src. EC DG ENT)
  - Value-added per employee in EU: 33 k€ (src. EC DG TREN)

- Commodity vs. value-added service
  - Advanced services (3PL, intermodal) have yet to take off
  - SCM process and information mostly in the customer hands, i.e., the “cargo owner” (industry, distribution).

- Sustainability challenges
  - Trucks absorbing 35% of total road-fuel production with an expected increase to over 40% by 2030 (source “World Energy Outlook 2006”).
  - Transport-related CO2 emissions at 23% and rising.

- Regulatory pressures
  - The community pays for infrastructures (trucks account for 50% of motorway traffic)
  - Citizens suffer pressures on fuel prices, congestion in cities and road safety problems.
EU response

EC ICT for Mobility Strategic Research Agenda - Mobility Services for Goods

→ ICT innovation for the logistics industry:
  ● Creating a seamless efficient (goods) mobility service system using ICT as an enabler.
  ● Exploiting RFID and ICT platforms as critical component and architecture.
  ● Urban logistics supported by network management.
  ● High level of liable security and of adequate tracking and tracing.

All of this is technologically possible. Why isn’t it happening already?
EURIDICE intends to fill the existing gap between technical feasibility and adoption of ICT services platforms for goods mobility, by coordinating S/T research in two directions:

- **Structured approach** to technology innovation, harmonizing and filling gaps between existing technologies and aiming at the **intelligent cargo** as unifying concept.

- **Holistic perspective on the business models**, that considers both traditional and innovative logistic models, while looking explicitly at the cargo communities operating at the local and global levels.
EURIDICE Intelligent Cargo vision

“In five years time, most of the goods flowing through European freight corridors will be ‘intelligent’, i.e.: self-aware, context-aware and connected through a global telecommunication network to support a wide range of information services for logistic operators, industrial users and public authorities.”
ICT for goods mobility today: Cutting-edge technologies for top \textbf{demanding customers}

Target: high value goods, with special requirements (precious, dangerous, perishable, needed just-in-time, …)

What about goods that are neither precious nor special?
What services are needed by the majority of logistic users and operators?

- A qualified answer: “nothing, thank you!”
- “Governments should stop wasting money in goods traceability projects: no one cares about that”
  
  President of Assologistica (Italian Association of Logistic companies)
  23/4/08, speech at Politecnico of Milano convention on Logistics in Port

- Why:
  - “Because operators already have all the data they really need.”
  - “Traceability across operators would force us to link our information system into a ‘system of systems’.. costly and hardly achievable.”

Missing or misdirected value proposition

Faulty architectural approach

Overshooting: offer focused on top-demanding customers

Adoption barriers: unjustified cost and complexity for average users
The product

• Euridice goal is to build a cargo centric information chain that provides automated end-to-end information about the logistic supply chain based on existing technologies and standards combined with intermediating trusted third parties.

• Information infrastructure / platform? (too vague)
• Hardware / software tools / systems? (too limited)
• Another (?) process / data integration platform? (not true)

“We provide cargo information services ..”
The customers: Who cares about the cargo being intelligent? ➔ Who is target of our value proposition?
Approach to the market

- Bring about a paradigm shift by promoting the Intelligent Cargo approach across the widest audience of users.
- There is not an “intelligent cargo” product.
- Different intelligent cargo capabilities require different implementation models:
  - Basic capabilities should be available as public domain services for all the intelligent cargo users.
  - Specialized capabilities should be developed for specific purposes by individual users or groups of users to fulfill specific application requirements.
- There is not a single “intelligent cargo” user:
  - Need to carefully analyze value produced across the transport chain (“Who cares”?).
  - Need a convincing value proposition for all the involved actors.
Value proposition pitfalls

- Some apparently good targets are hostile or neutral at best
  - Shipping agencies, terminal operators, carriers.
  - Misdirected value propositions can be found behind some past failures.
- Aiming at individual targets is not enough
  - The intelligent cargo concept, like other similar approaches, builds on cooperation between different actors.
  - Among the necessary actors some will find no value in the interchange, at least at the beginning (e.g., small carriers).
  - Other motivations/levers can be attempted to convince them, but a good business architecture should work by itself (frictionless).
- Importance of finding the right architectural approach
  - Maximize the value for those who care.
  - Minimize the burden for those who don’t care.
The customers

- **Our customers:**
  - Logistic companies
  - Cargo owners / shippers
  - Authorities / infrastructures? (not customers, more providers / users)

“We provide cargo information services for logistic and industrial companies ..”
The benefits

- What is our value proposition?
  - Cargo-centric
  - Open (not proprietary), based on existing technologies and standards combined with intermediating trusted third parties
  - End-to-end information train
  - Option to use the EURIDICE architecture gradually, depending on the needs and available resources
  - …
- Need to translate this into user value
Application ideas

- Ubiquitous track & trace functionality, based on events communicated bottom-up by moving freight items.
- Cargo-initiated, completely automated transit verification and authorization procedures.
- Supply chain event management based on thing-to-thing interaction and embedded intelligence, where cargo itself has the primary responsibility to detect and handle unexpected events and to escalate to a human operator if needed.

- ...

- ... and many more applications that Euridice S/T research will make possible.
The EURIDICE message

“We provide cargo information services for logistic and industrial companies that can be activated at low cost and work with any logistic partner along any transport route.”

Our mission:
“Providing cargo information services for all”
Our market
(go for the biggest catchment!)

All users

Basic cargo services
● Identification
● Positioning
● Monitoring
● ...

Tagged goods + Mobile / Fixed Terminals

Integration services + Application services

Services authoring & delivery

Large enterprise users

Service Providers
ICT for goods mobility tomorrow

Ad-hoc services combination

Basic services
- Identification
- Positioning
- Std. processes (bill of lading, proof of deliv.,...)

Advanced services
- Integration
- Authoring
- Orchestration

Enterprise Services / Third Party Services

Users

Goods

Object Recognition and Positioning
Hosted European Service
ORPHEUS

Intelligent cargo = self-identifying, easy to interact and communicate with
What does “Intelligent Cargo” mean?

- The **technological innovation** dimension is not sufficient to define Intelligent Cargo.
  - Smart tags, sensor networks, distributed intelligent agents, ...
- Defining Intelligent Cargo requires a second dimension of **architectural innovation**, to highlight changes from the users perspective.
- EURIDICE list of **intelligent cargo capabilities**:
  - Cargo capable of autonomous decisions (intelligent agent),
  - Cargo capable to start processes (independent behavior),
  - Cargo capable to monitor and register its status,
  - Cargo capable to grant access to services (authorization, ETA estimation, data read/write, ..),
  - Cargo capable to detect its context (location, user, infrastructure, ..),
  - Cargo capable to identify itself.
## Intelligent vs. “dumb” cargo, basic capabilities

<table>
<thead>
<tr>
<th>Capability</th>
<th>Dumb Cargo (state of the art)</th>
<th>Intelligent Cargo</th>
</tr>
</thead>
</table>
| Self-identification  | ● Local identification based on proprietary systems of each actor.  
● Shared IDs through ad-hoc connection between back-office systems.  
● Pre-fixed level of detail throughout the supply chain. | ● Global identification provided by public domain services.  
● Cargo is able to self-identify through a common infrastructure, accessible to field users, vehicles and back-office.  
● Dynamically selected level of detail (package, pallet, container, ..). |
| Context detection     | ● No self-standing context detection capability.  
● Context is extrapolated by back-office systems accessing other information sources (e.g., local ID repository). | ● Context determination provided by public domain services.  
● Common infrastructure, providing context data (identification details, location, time) to authorized users. |
| Access to services    | ● No direct access to services from the cargo itself.  
● Services managed by proprietary systems of each actor or by generic (not cargo related) platforms.  | ● Common infrastructure, providing access to services to authorized users or systems interacting with the cargo. |
# Intelligent vs. “dumb” cargo, specialized capabilities

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<th>Intelligent Cargo</th>
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</table>
| Status monitoring and registering | ● Sensing and data storing at a specific cargo level (e.g. container).  
● To go beyond raw data, ad hoc back-office elaboration is needed.                                                                                                   | ● Status data are available in real time through the service infrastructure.  
● Status data are contextualized and integrated with the other cargo information services.                                                                                                                |
| Independent behavior              | ● No such capability.                                                                                                                                                                                                       | ● Cargo is able to invoke services and start processes autonomously in response to predefined events.                                                                                                              |
| Autonomous decisions (Intelligent agent) | ● No such capability.                                                                                                                                                                                                  | ● Cargo has decisions making capabilities and is able to choose services to invoke according to circumstances.                                                                                                    |
Intelligent Cargo in practice

Cargo

Self-identification

I am container (or package, or trailer, or..) X, I belong to Y

Context detection

I have been moving from here to there, I have been opened, my temperature has changed..

Owner service: content info, 3PL service: shipping info, Authority service: clearance info..

Services access

I am presently at location L, being handled by Z

What’s this?

Status monitoring

Where are our goods, who is dealing with them?

What's happening to our cargo?


Act independently

I am not where I was supposed to be, please take action

I am not where I was supposed to be, pick me up

Autonomous decisions

User
EURIDICE vision translated into an architecture

“In five years time, most of the goods flowing through European freight corridors will be ‘intelligent’, i.e.: self-aware, context-aware and connected through a global telecommunication network to support a wide range of information services for logistic operators, industrial users and public authorities.”

- What does this mean from an architectural perspective?

“Connect cargo objects with each other, to provide intelligent services for logistics stakeholders.”

- We aim to realize the “internet of cargo”
Internet of Cargo vs. Internet of Things

The internet of cargo
Connect cargo objects with each other, to provide intelligent services for logistics stakeholders

The internet of things
Connect objects with each other, to provide intelligent services for any individual user
# Expected paradigm shift

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<tr>
<th></th>
<th>Current paradigm</th>
<th>Intelligent Cargo</th>
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</thead>
<tbody>
<tr>
<td><strong>Data origin</strong></td>
<td>User or back-office generated.</td>
<td>Item/sensor generated.</td>
</tr>
<tr>
<td><strong>Interaction paradigm</strong></td>
<td>Organization-to-organization</td>
<td>Thing-to-thing.</td>
</tr>
<tr>
<td><strong>Data processing</strong></td>
<td>Centralized at organization level.</td>
<td>Distributed, may start at object level.</td>
</tr>
<tr>
<td><strong>Communication support</strong></td>
<td>Predefined communication channels.</td>
<td>Self-configuring combination of local and global communication resources.</td>
</tr>
<tr>
<td><strong>Data interchange semantics</strong></td>
<td>Mutually agreed with each partner or between trade community members.</td>
<td>Globally established, for any-to-any ad hoc exchanges.</td>
</tr>
<tr>
<td><strong>Decisions support</strong></td>
<td>Top-down decision making, based on periodic data revision.</td>
<td>Event-triggered, decentralized and (partially) automated exception resolution.</td>
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</tbody>
</table>
# Cargo objects and logistics stakeholders

<table>
<thead>
<tr>
<th>Cargo Objects</th>
<th>Cargo owner</th>
<th>Carrier</th>
<th>Logistic service provider</th>
<th>Infrastructure manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>Needs data / provides data</td>
<td>Needs data / provides data</td>
<td>Owns</td>
<td>--</td>
</tr>
<tr>
<td>Warehouse</td>
<td>Needs data</td>
<td>Needs data / provides data</td>
<td>Owns</td>
<td>--</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Needs data</td>
<td>Owns</td>
<td>Manages</td>
<td>Needs data / provides data</td>
</tr>
<tr>
<td>Item</td>
<td>Owns</td>
<td>Needs data / provides data</td>
<td>Manages</td>
<td>Needs data / provides data</td>
</tr>
</tbody>
</table>

**Stakeholders**
Thing-to-thing vs. organization-to-organization

**Thing-to-thing**
- Connect via cargo objects interaction.
- Decentralized data processing.
- Owner systems may not be involved (only to access owner services).

**Organization-to-organization**
- Connect via pre-existing links between organizations.
- Cargo objects may not be involved (disconnected physical / information flows).
Any-to-any communication and data interchange

- DNS\(^1\)-like system for cargo objects and related services.
- Globally shared semantics.
- On demand configuration of communication resources.

\(^1\) = Domain Name System, used to make computers and sites accessible via the internet.
Event-triggered, decentralized decisions support

Intelligent cargo
- Automated event detection and context determination.
- Bottom-up exception resolution (escalation, consolidation of decisions).

Traditional approach
- Data consolidation from back-office systems.
- Top-down centralized monitoring, revision and communication.
IC implementation

- Legacy system
- Secure WS
- Pilot Application
- IC implementation
  - Secure WS
  - Reasoning (External applications)
  - External data providers

- Business Specific functionalities
- Euridice horizontal Component/infrastructure

- Fixed SOA based
- ACL
- Mobile Agent based JADE
Cargo Intelligence solution

GLOBAL INTELLIGENCE

- Context generation
- Trend detection
- Prediction
- Anomaly detection
- Data processing (fusion, cleaning)
- Knowledge discovery
- Background knowledge
- Information extraction
- Reasoning

LOCAL INTELLIGENCE

- Local data analysis
- Cargo control
- Cargo sensors
- Cargo
- External information

Pattern tag

GUI applications for decision support, visualisations,…

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Intelligent Cargo & the Agent Paradigm

- Agents ... [by definition]
  - ... sense their environment

Agents use **sensors**

They interpret their environment and react **appropriately**
Architecture

- The Intelligent cargo is implemented decoupling the fixed and mobile components
- **Different intelligent cargo capabilities (different user needs) require different implementation models:**
  - Basic capabilities are available as public services (horizontal components) for all the intelligent cargo users.
  - Specialized capabilities are developed for specific purposes by individual users or groups of users to fulfill specific application requirements.
- **A User Application** in Euridice is the combination of Platform horizontal components and user specific components
Euridice “basic capabilities”

- Connection between fixed and mobile (ACL protocol)
- Identification
- Positioning
- Context detection
- Communication
- Sensor monitoring (cargo monitoring)
- Work flow management
- Orchestration/choreography
There is not a single “intelligent cargo” user: 8 Pilot Scenarios

<table>
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<tr>
<th>Scenario</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Connected manufacturing and transport execution</td>
</tr>
<tr>
<td>S2</td>
<td>Active cold-chain control</td>
</tr>
<tr>
<td>S3</td>
<td>Cargo interacting with operators across hubs</td>
</tr>
<tr>
<td>S4</td>
<td>Real-time information to consignor and consignee</td>
</tr>
<tr>
<td>S5</td>
<td>Self-returning empty pallets and boxes</td>
</tr>
<tr>
<td>S6</td>
<td>Cargo-assisted inter-modal transport planning</td>
</tr>
<tr>
<td>S7</td>
<td>Intelligent routing through cargo-infrastructure cooperation</td>
</tr>
<tr>
<td>S8</td>
<td>Automated clearance and billing of transiting goods</td>
</tr>
</tbody>
</table>
Example: Scenario S7
Intelligent routing through cargo-infrastructure cooperation

Objective:
To avoid congestion and accidents and optimize utilization of road and parking infrastructures, through:

- automated re-routing performed by the cargo itself based on its planned and actual status, traffic and weather conditions, availability of parking areas;
- cooperation between cargo and infrastructure operator to acquire authorization and reserve parking space;
- self-diagnosis of anomalous events on the cargo (e.g., non-authorized movements in parking area) and automated triggering of the infrastructure security systems.
Objective:
To speed up the transit of goods at international borders and to increase security levels, through:

- security information self-generated by the cargo interacting with vector, agent and customs authority;
- event-triggered clearance and authorization procedures, with the cargo activating the involved authorities based on its present location, status and applying regulations;
- automated billing system based on prepaid tokens, allowing the cargo to pay for itself customs and shipping duties.
Results (so far)

- High level architecture
- Pilot application requirements

- First release of the **Euridice integrated platform** (beta version).
  - Services library, Context Model and cargo-related information sources identification.

- 8 pilot applications (beta version)
Issues

- Economic sustainability
- Stakeholders preparedness
  - User do not understand how technical capabilities could improve their business
  - User are not willing to pay for technology (hardware/services)
- Security & data ownership
- Technical limitations
  - Cost (devices/tags)
  - GPS
  - Performances
  - Sensors availability
  - Appropriate device (java enabled)
- Implementation – high level skills
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The true sign of intelligence is not knowledge but imagination.
Albert Einstein