

Intelligent Framework for Risk Management

GMES OPERATIONAL CAPACITY WORKSHOP

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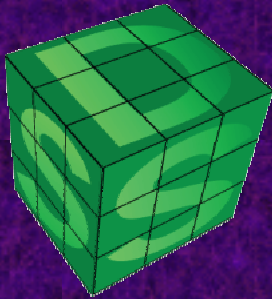
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1.1. Decision Support System, DSS (in emergency context)

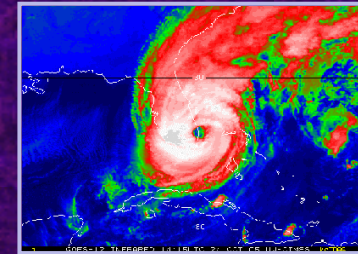
Very generic term,
many definitions:



- A computer system providing both problemsolving and communications capabilities for semistructured / unstructured problems
- e.g. DSS helps persons to detect risks and to make decisions to manage them in an emergency context - Risk Detection System (RDS)

The goal of the RDS is to provide an evaluation of the current situation by comparing it with past experimented situations stored in a database.

1.1. Decision Support System, DSS (in emergency context) (2)

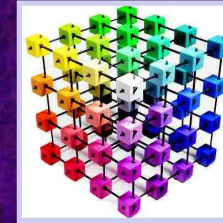


The **roles** of a RDS are:

- Supporting the **preparation for emergency situations** (e.g. the system watches permanently over the environment state by assessing continually the current situation and alerting the organizations when it detects a hazard or a risk of disaster)
- Insuring efficient **responses during a crisis situation** (e.g. the system helps the rescue units by providing them emergency action plans).

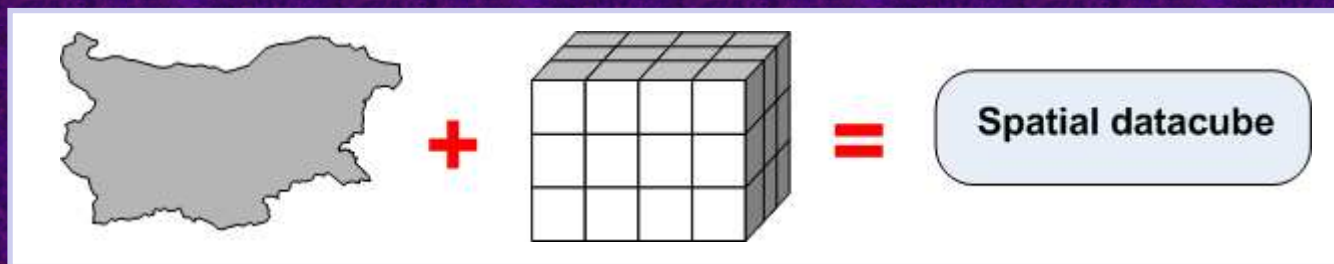
1.2. Spatial Data Warehouse/OLAP (SDW/SOLAP)

Data Warehouses (DW) have become the core technology for DSSs offering the large amounts of integrated, consistent, and historical data for decisionmaking.

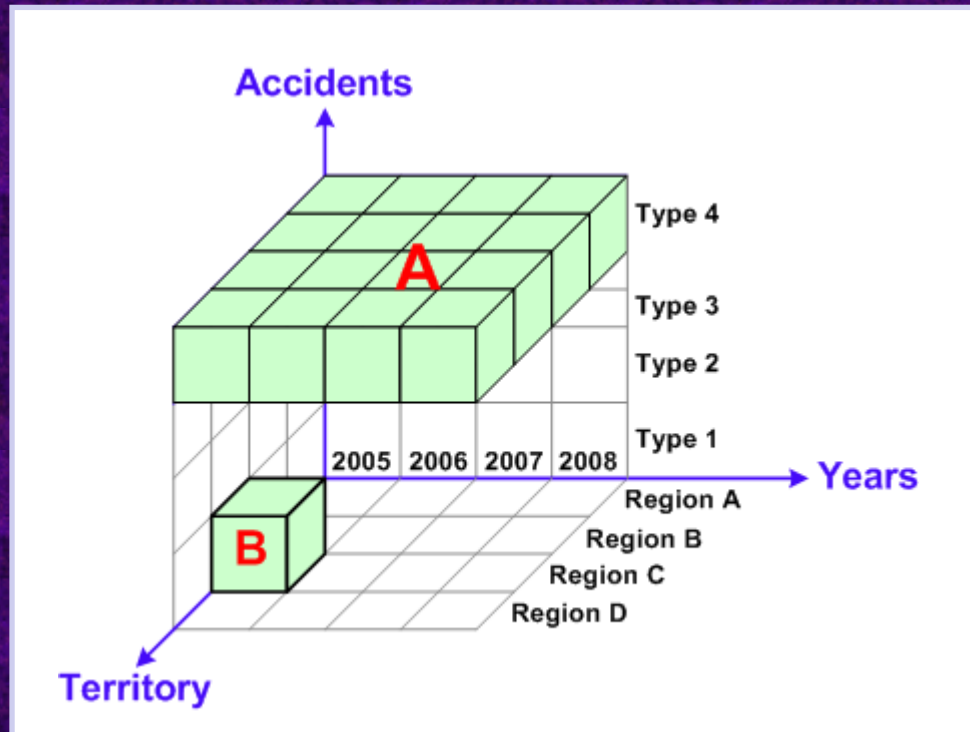
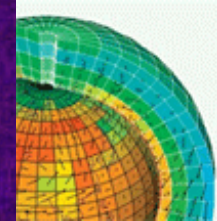


They are usually structured as **datacubes**, i.e. according to the multidimensional paradigm defined in the field of **Business Intelligence (BI)**.

Multidimensional databases (datacubes) are widely used in the geographic field.



1.2. Spatial Data Warehouse/OLAP (SDW/SOLAP) (2)



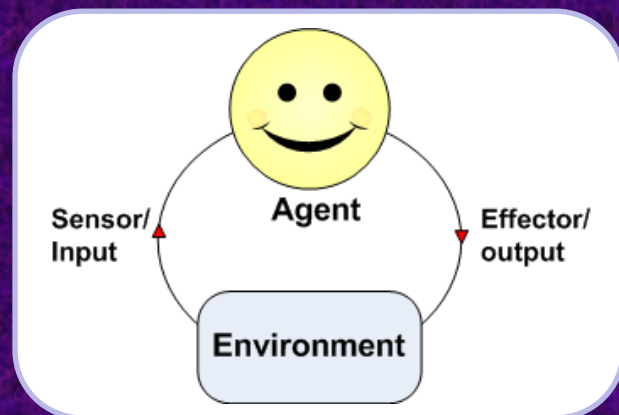
Example. Multidimensional cube: number of accidents based on territory, time and accidents type.
Data segment (A) represents the accidents Type 4 for all years and for all regions.
Data cell (B) represents the accidents Type 1 for the year 2005 for Region C.

1.3. Multi-Agent Systems (MAS)

Intelligent agents and **Multi-Agent Systems (MAS)** technologies are considered to be a promising method to construct the scalable, robust, reusable high quality software system thanks to agents characteristics that can be summarized as follows: **proactivity, reactivity, social ability, intelligence and purpose.**

MAS is a system composed of multiple interacting Intelligent Agents.

Examples of problems which are appropriate to multi-agent systems research include **disaster response, online trading, modelling social structures...**



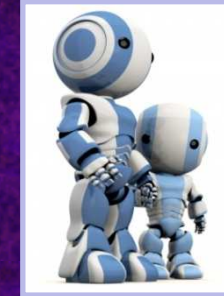
Agent Definition:

"An agent is anything that can be viewed as perceiving its **environment** through **sensors** and acting upon that environment through **effectors**".

1.3. Multi-Agent Systems (MAS) (2)

Intelligent agents

An **intelligent agent** is an autonomous entity which observes and acts upon an environment (i.e. it is an agent) and directs its activity towards achieving goals (i.e. it is rational).



Data mining agents:

- This agent uses information technology to **find trends and patterns** in an abundance of information from many different sources
- A data mining agent operates in a data warehouse **discovering spatial information**
- '**Classification**' is one of the most common types of data mining, which finds patterns in information and categorizes them into different classes.

2. UNIRISK Project

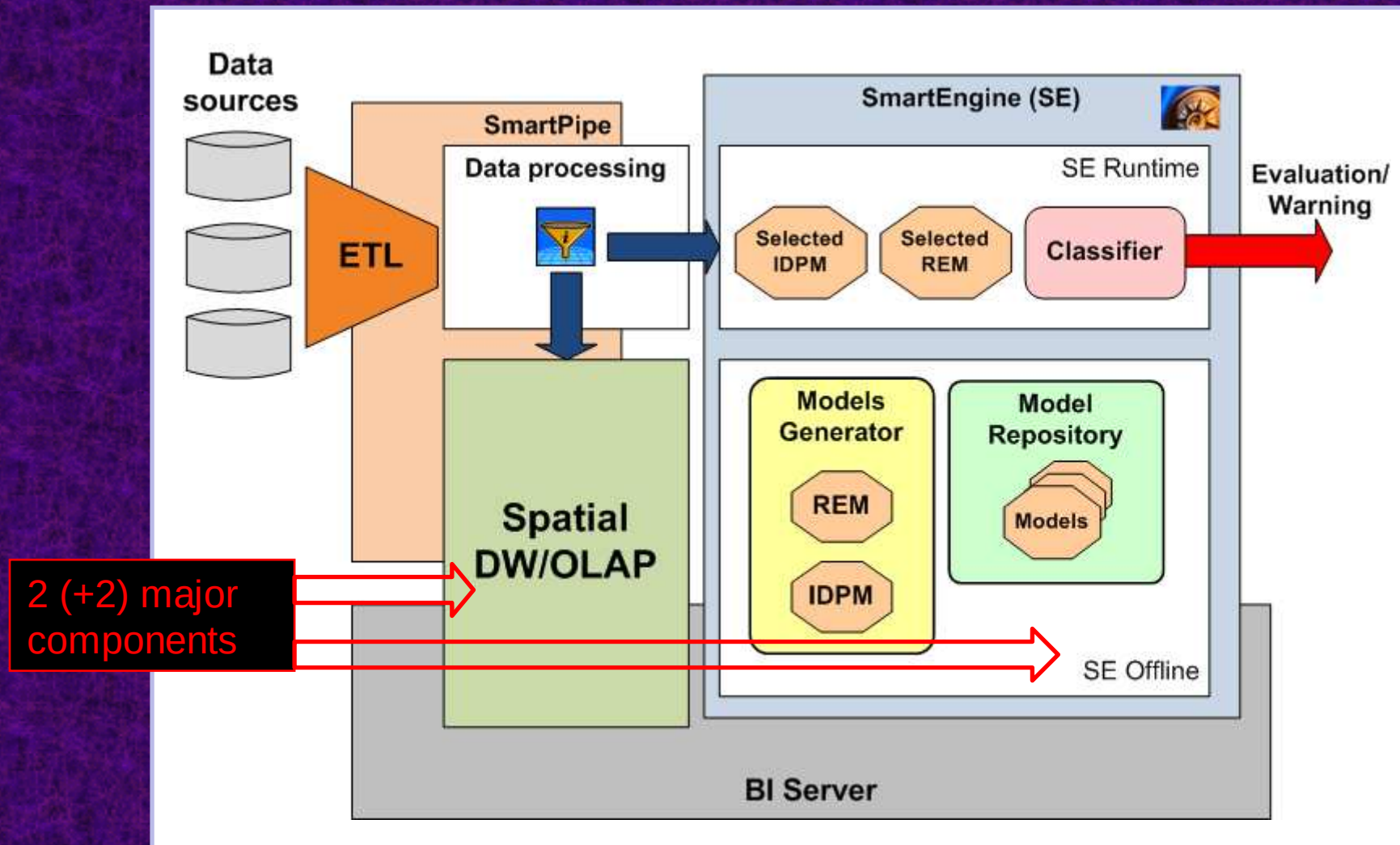


UniRisk is a long term project.
System components are at different phases of development.
Our objective is to develop a system as generic as possible.

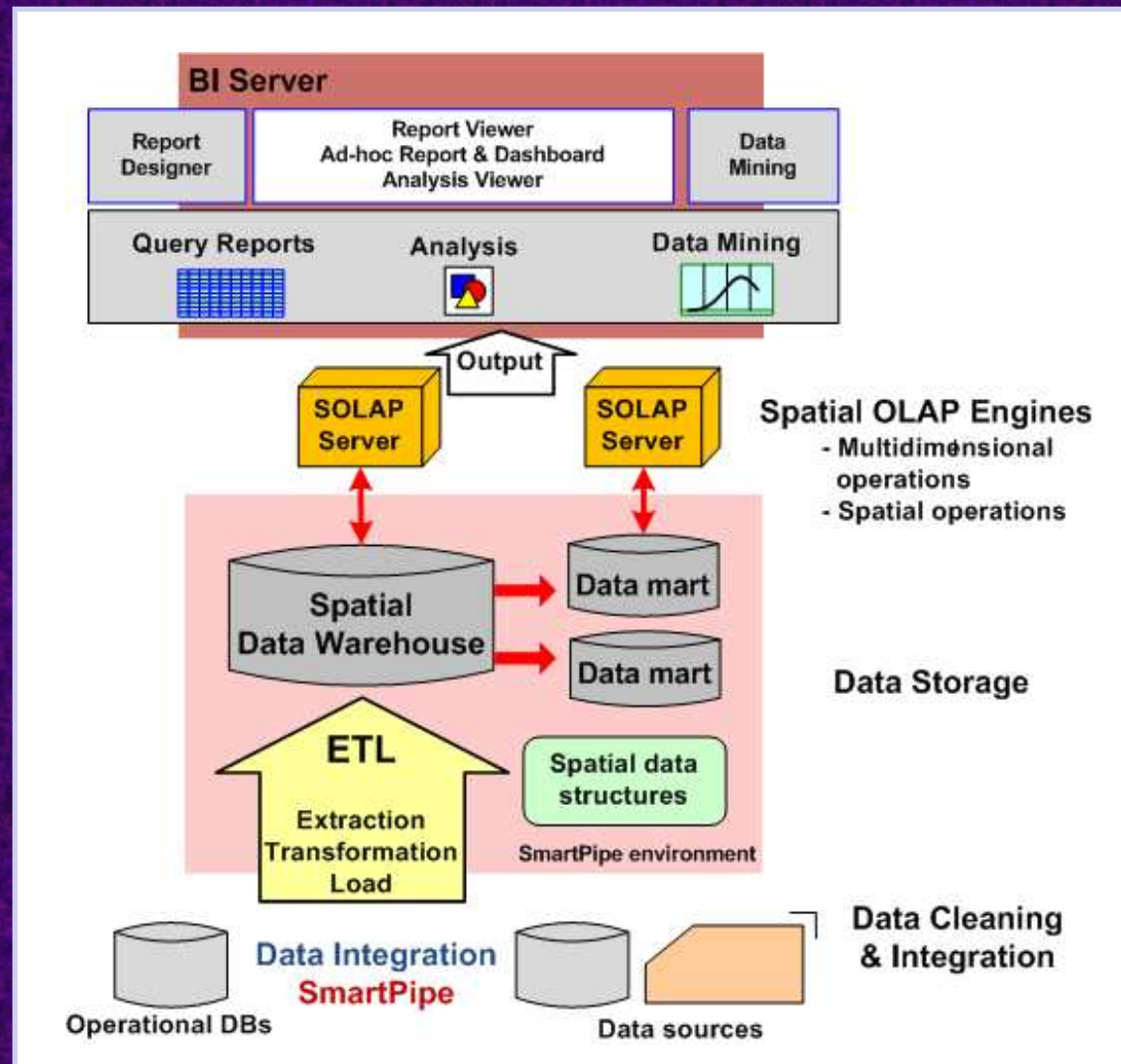
2.1. Key Features

- UniRisk automates processes for **identification**, **assessment** as well as for **overall risk management**
- UniRisk is an **intelligent system**. Its knowledge base (including models) is being regularly 'improved'
- Based on **Spatial Data Warehouse/OLAP**
- System Architecture contributes to its effective application in different domains (**multi-hazards**)
- Flexibility and adaptability. Adapting the model to the **specifics of the domain**
- **Integrated risk** evaluation
- **Machine Learning**, Inductive and Deductive models support
- **Open architecture**, integration with existing systems and environments.

2.2. UNIRISK Architecture



2.3. UNIRISK Spatial DW/OLAP



2.4. SmartEngine (DATACOM)



The main concept of SmartEngine is based on **Machine Learning** (inductive approach).

The system applies **several algorithms** (Model Trees – M5P, etc.) for the generation of **Inductive Models**.

The system consists of **two basic pillars**:

Learning Module

- Provides functions for analysis of already registered data and knowledge acquisition from them
- The extracted knowledge is the fundament of the **Risk Evaluation Model (REM)** which is used for future evaluation/prediction.

Evaluation (Prediction) Module

Provides functions for **evaluation (prediction)** of newly arrived data in real time using the actual **REM**.

2.4. SmartEngine (2)



Construction of REM

- The construction of Risk Evaluation Models (**REMs**) is a complex, heuristic process
- A lot of different methods are used for **scaling and discretisation of the input data** which adjust it for the optimal performance of the **inductive learning algorithm**. The transformation rules are stored as metadata (Input Data Preparation Model, **IDPM**)
- Large number of alternative models can be generated based on 2 main variations:
 - ✓ Different inductive learning algorithms
 - ✓ Different type and preparation of input data
- The generated models are only candidates for use. The system chooses the **optimal REM** for a given domain
- The models are stored in **ModelRepository**.

2.4. SmartEngine (3)



Inductive Learning Algorithms (алгоритми за индуктивно обучение)

- Regression (Регресионни алгоритми)
 - ✓ Linear Regression (Линейна регресия)
 - ✓ Logistic Regression (Логистична регресия)
- Discriminant Analysis (Дискриминантен анализ)
- Naive Bayesian Networks (Наивни Байезиански мрежи)
- Decision Trees (Дървета на решенията)
 - ✓ C4.5
 - ✓ M5 - Model Tree (Моделиращи дървета)
 - ✓ Random Forest (Случайна гора)
- Decision Rules (Правила)
- Neural Networks (Невронни мрежи)
- Support Vector Machines (Векторни машини)
- Instance-based learning (Алгоритми за отложено обучение)
 - ✓ K-Nearest Neighbors (Алгоритъм на 'най-близките K съседа')
 - ✓ Locally Weighted Regression (Локално претеглена регресия)
- Genetic Algorithms (Генетични алгоритми)
- Meta Techniques (Мета Техники) - Bagging (Опаковане), Boosting (Повишаване), etc.

2.4. SmartEngine (4)



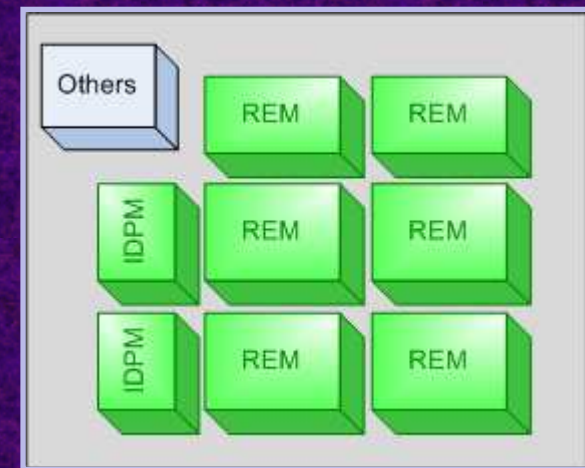
SmartEngine features:

- Innovative framework for data mining for the needs of Risk Management
- Universality - did not depend on the type of the domain
- Provides flexible tools for models elaboration
- Iterative procedure for optimization of generated models.
'Calibration' of objects (structure, scaling, weights, etc.) that build the inductive models
- Supports inductive and deductive models
- Interface with external systems.

2.5. Model Repository

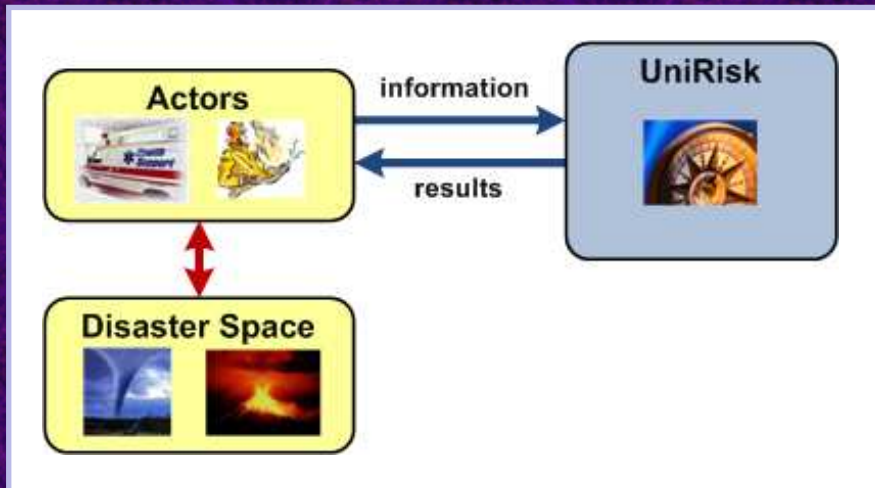
Model Repository (MR):

- The system generates multiple models, MR stores all of them
- Models are dynamic and can be improved within the automated learning procedures
- MR supports metadata about generated models as well as an estimation for their effectiveness.



3. Future Development

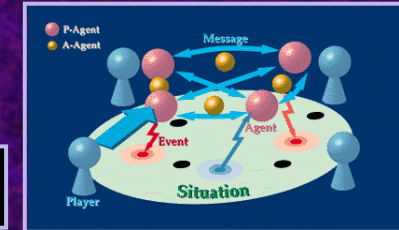
3.1. UNIRISK - part of a Disaster Management System based on MAS paradigm



- The system is fed permanently by information sent by **actors** and which describe the current state of the environment – **disaster space**
- Information is processed thereafter by UniRisk **agents**
- **Outcomes** provided by the system include an evaluation of the situation, an emergency management plan, etc.

3.2. Distributed eLearning Center (DeLC) – InfoStation-based MAS.

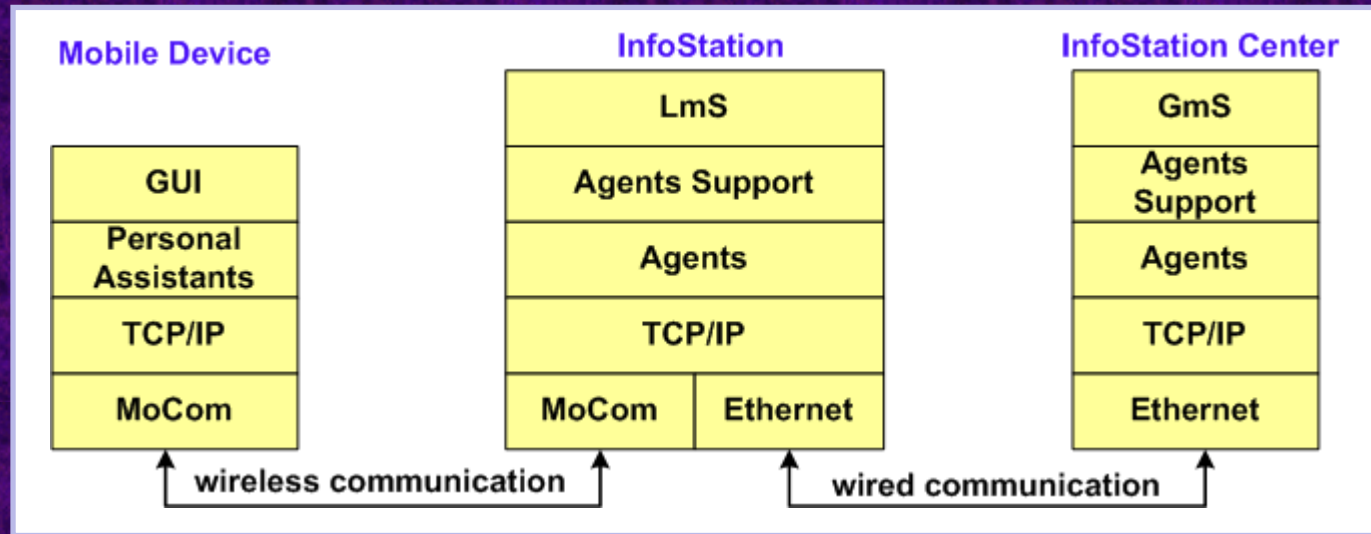
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- The InfoStation-based multi-agent system provides access to a variety of mobile eLearning (mLearning) services
- The efficient mobile user access to services and resources is supported via intelligent wireless access points (called InfoStations) deployed at key locations.
- In the standard InfoStation architecture, mobile devices use InfoStations only as mediators for accessing the services offered by the InfoStation Center.
- In DeLC project InfoStations act as hosts:
 - ✓ for the local mLearning services (LmS)
 - ✓ and for preparation, adaptation, and conclusive operations of global mLearning services (GmS).
- This way the service provision is distributed across the whole architecture in an efficient way.
- Services related to disaster management are under development. These services use the same infrastructure and architecture as DeLC (e.g. DeMC). The distributed architecture is very convenient for the efficient implementation of disaster management services.

3.2. Distributed eLearning Center (DeLC) - InfoStation-based MAS (2)

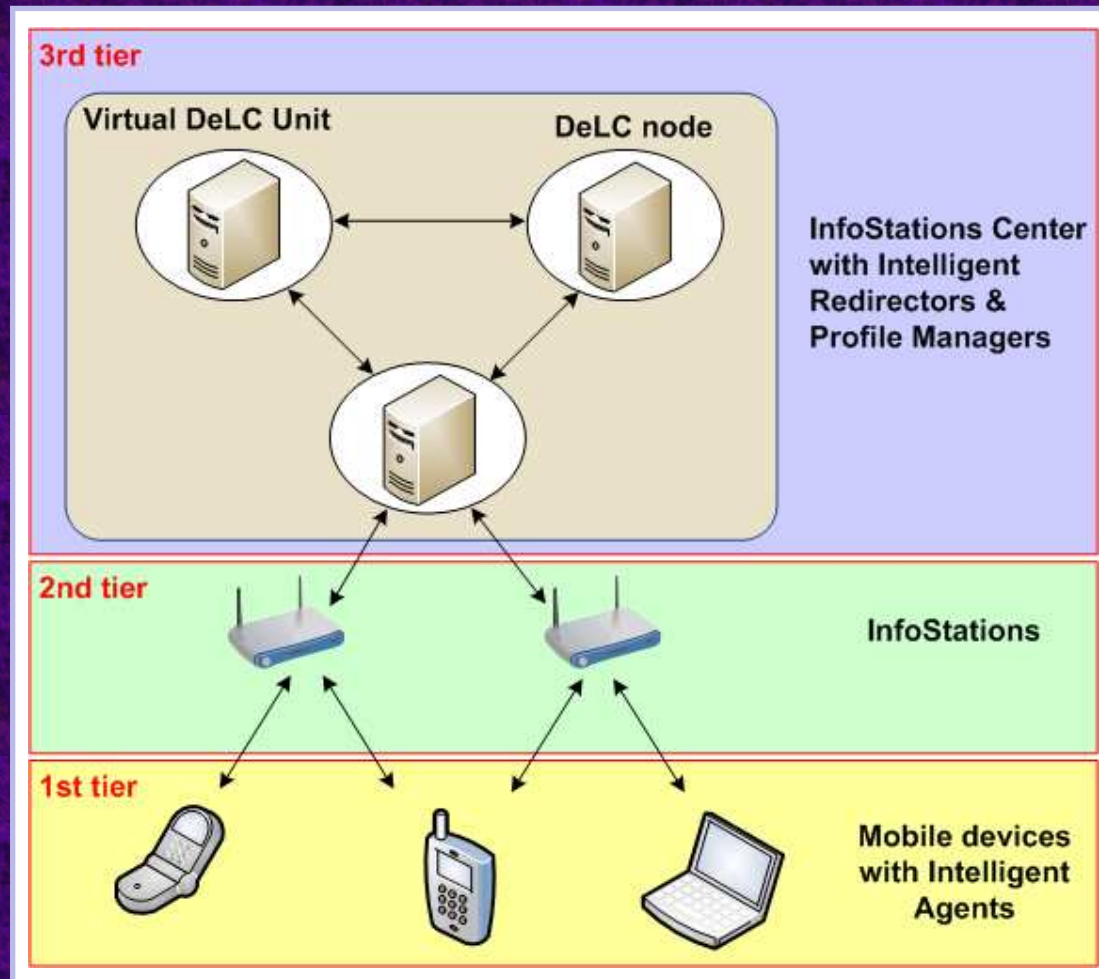
Multi-Layered Software Architecture



- A set of mLearning service prototypes use the resources distributed across the system in an efficient manner
- A middleware software with specific functions is being developed and used to ensure sufficient flexibility, adaptability, and autonomy of the system architecture's nodes
- The autonomic software components are able to communicate at a higher semantic level with regard to the context, business logic of the provided service, and the individual characteristics of users. The chosen agent-oriented implementation approach greatly facilitates this.

3.2. Distributed eLearning Center (DeLC) - InfoStation-based MAS (3)

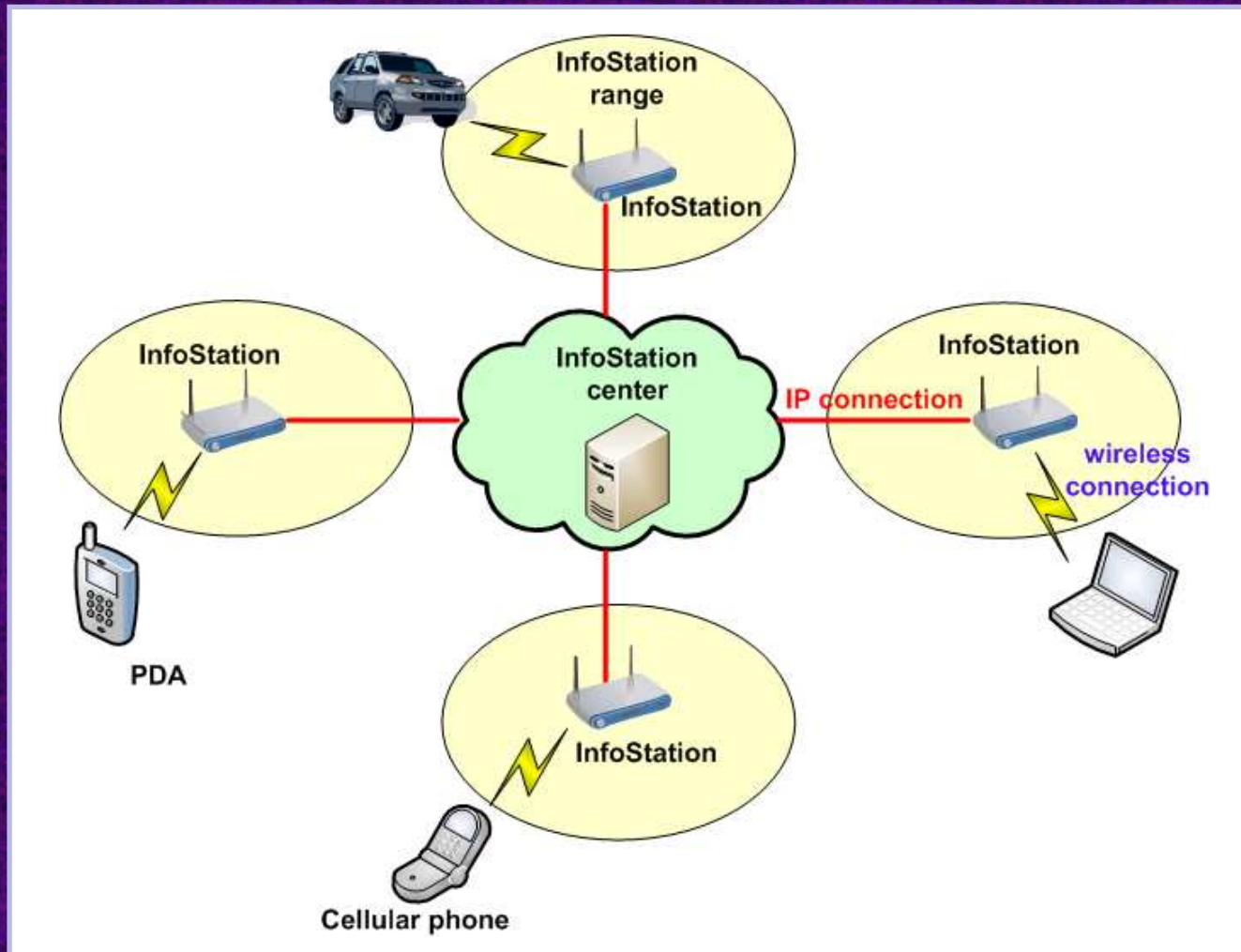
DeLC Network Model: Tiers



- **InfoStations Center (ISC):** controls all InfoStations, provides updates and synchronization of information
- **InfoStations (ISs):** intelligent access points deployed at the key information points throughout the University Campus and providing wireless network access/connectivity for users with mobile devices
- **Mobile Devices (MDs):** e.g. cellular phones, PDAs, laptops, which house intelligent agents which act as personal assistants (PAs) for mobile users.

3.2. Distributed eLearning Center (DeLC) - InfoStation-based MAS (4)

DeLC Network Model: Vertical View



4. CONCLUSIONS



What we have:

- 1) UniRisk Framework with generic architecture – flexible and expandable
- 2) SmartEngine (designed and implemented by DataCom) - an intelligent system based on adaptive framework with a focus on risk management
- 3) Successfully realized projects using SmartEngine framework
- 4) DeLC – InfoStation based MAS infrastructure
- 5) A Team with proven experience in a broad spectrum of IT.

UniRisk future directions:

- 1) Implementation of components of the 'standard' UniRisk architecture:
 - Core (UniRiskCore) - 'universal', domain independent
 - Vertical applications - UniRiskSeismic, UniRiskFlood, UniRiskFire, etc.
 - Implementation of Spatial DW / OLAP
 - BI infrastructure
- 2) Evaluation of integrated risk (multi-hazards)
- 3) Using the multi-agent approach - the most suitable technology to endow the system with adaptability and flexibility abilities:
 - Expanding UniRisk as a part of a Disaster Management System (DMS)
 - Implementation of a Simulator for disaster scenarios
 - Use InfoStation-based infrastructure for DMS needs.

**THANK YOU FOR YOUR
ATTENTION**