A new Approach to Collaborative Information Processing in Complex Environmental Management Problems

Gregor Pavlin

Thales Research & Technology, D-CIS Lab,
the Netherlands

DIADEM Project

- Full title: Distributed Information Aquisition and Processing for Environmental Management
  - FP7 (STREP)/ ICT2, start September 2008
- 9 Partners from B, D, DK, NL, RO, S
  - 2 environmental management organizations
  - 4 universities
  - 3 industrial partners.

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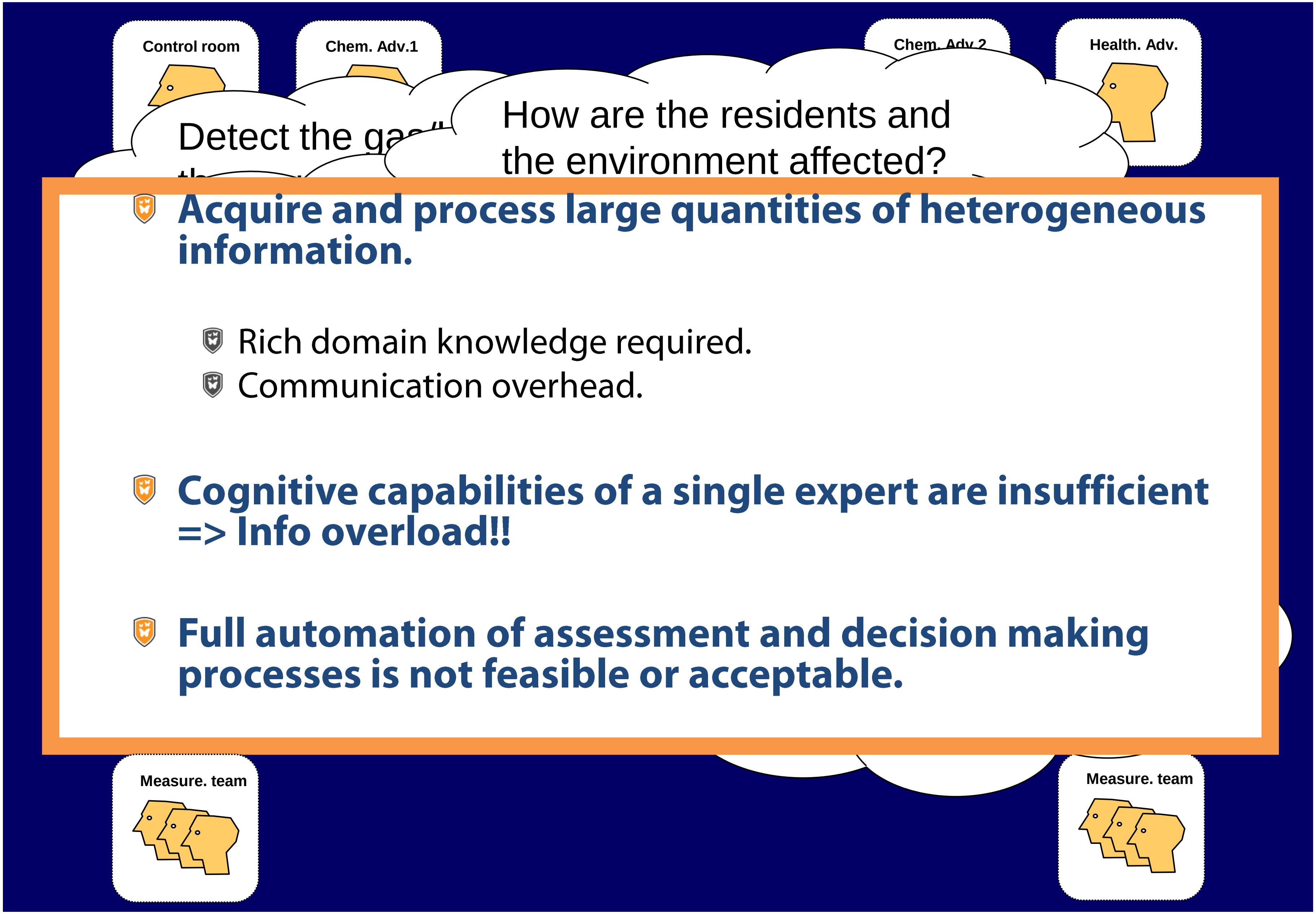
Objectives

- Create an ICT system for collaborative situation assessment and decision making that supports effective protection of the population and the environment against chemical hazards in industrial areas.
- Combine:
  - Advanced gas detection and monitoring approaches.
  - Methods and tools facilitating collaborative situation assessment and decision making involving many domain experts.
  - Advanced human machine interfaces.
  - A SOA bridging the gap between information sources, general public, domain experts and decision makers.

Overview

- Complex reasoning problems
  - Situation assessment.
  - Prediction.
  - Evaluation of decision alternatives.
- DIADEM solution:
  - SOA supporting collaborative reasoning in workflows => decompose the problem.
  - Tools and methods for collaborative construction of complex SO systems.

DIADEM use case



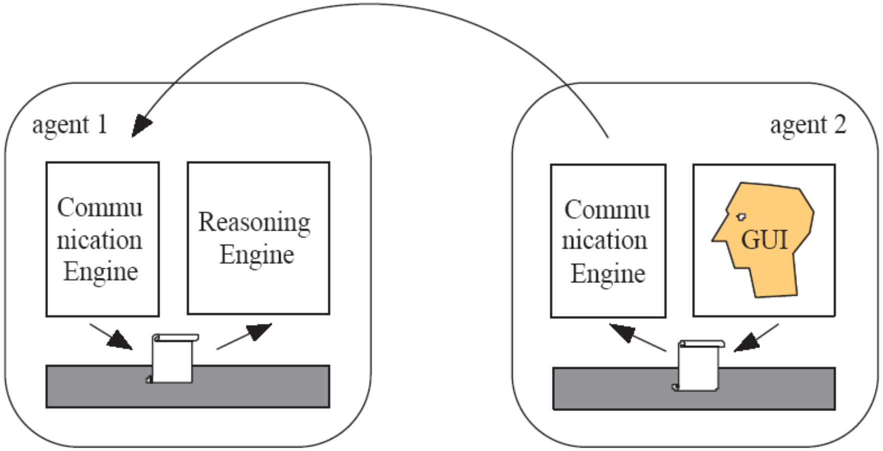
- **Acquire and process large quantities of heterogeneous information.**
  - Rich domain knowledge required.
  - Communication overhead.
- **Cognitive capabilities of a single expert are insufficient => Info overload!!**
- **Full automation of assessment and decision making processes is not feasible or acceptable.**

Organization Type

- Professional bureaucracy
  - Division of labor => heterogeneous services.
  - Decentralized control.
  - General domain knowledge is neither shared centrally nor standardized.
- State of the art approaches.
  - Phones/email => rich info cannot be efficiently used.
  - Communication overload.

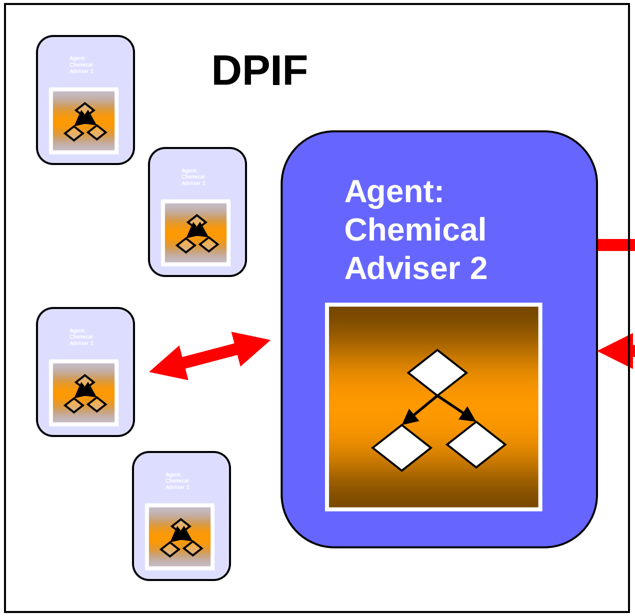
Dynamic Process Integration Framework (DPIF)

- Wrapper agents make resources "composable"
  - Asynchronous, data-driven processing in work-flows
- Communication engine
  - Uniform communication/collaboration mechanisms
  - Negotiation and maintenance of valid work-flows.
- Reasoning engine/Graphical user interface
  - Wrap arbitrary inference processes (domain models + algorithms).

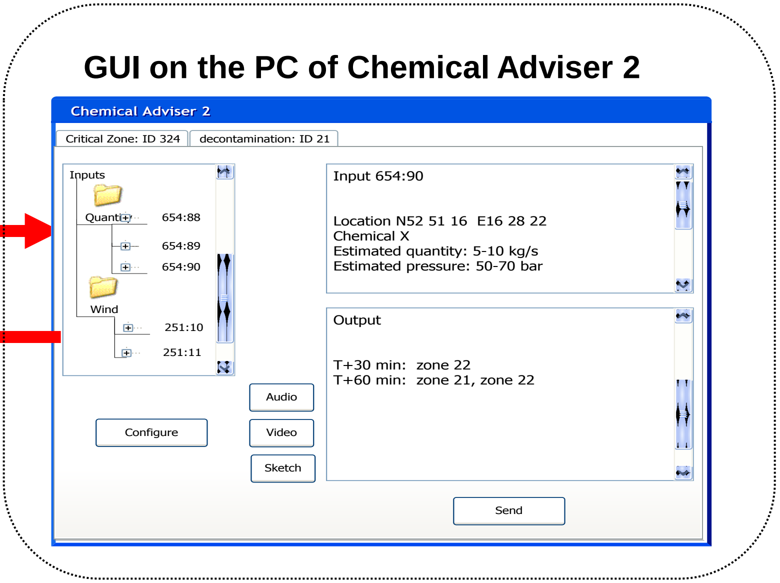


DPIF: A Software Assistant for Each Expert

- Each expert has a software agent that routes the information:
  - Collects all information relevant for the expert
  - Disseminate the expert opinion/estimates
  - Triggers expert’s attention
- Graphical user interface on local computers and PDA.



GUI on the PC of Chemical Adviser 2

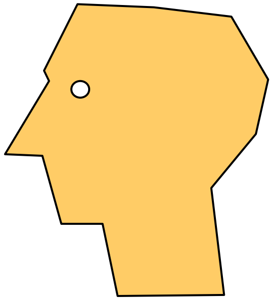


Input 654:90

Location N52 51 16 E16 28 22
Chemical X
Estimated quantity: 5-10 kg/s
Estimated pressure: 50-70 bar

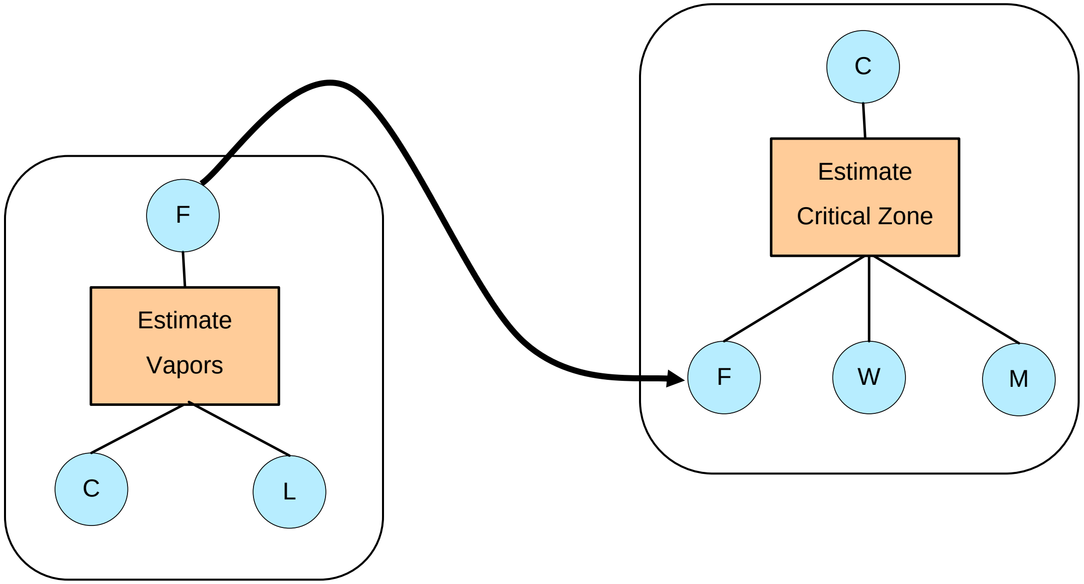
Output

T+30 min: zone 22
T+60 min: zone 21, zone 22

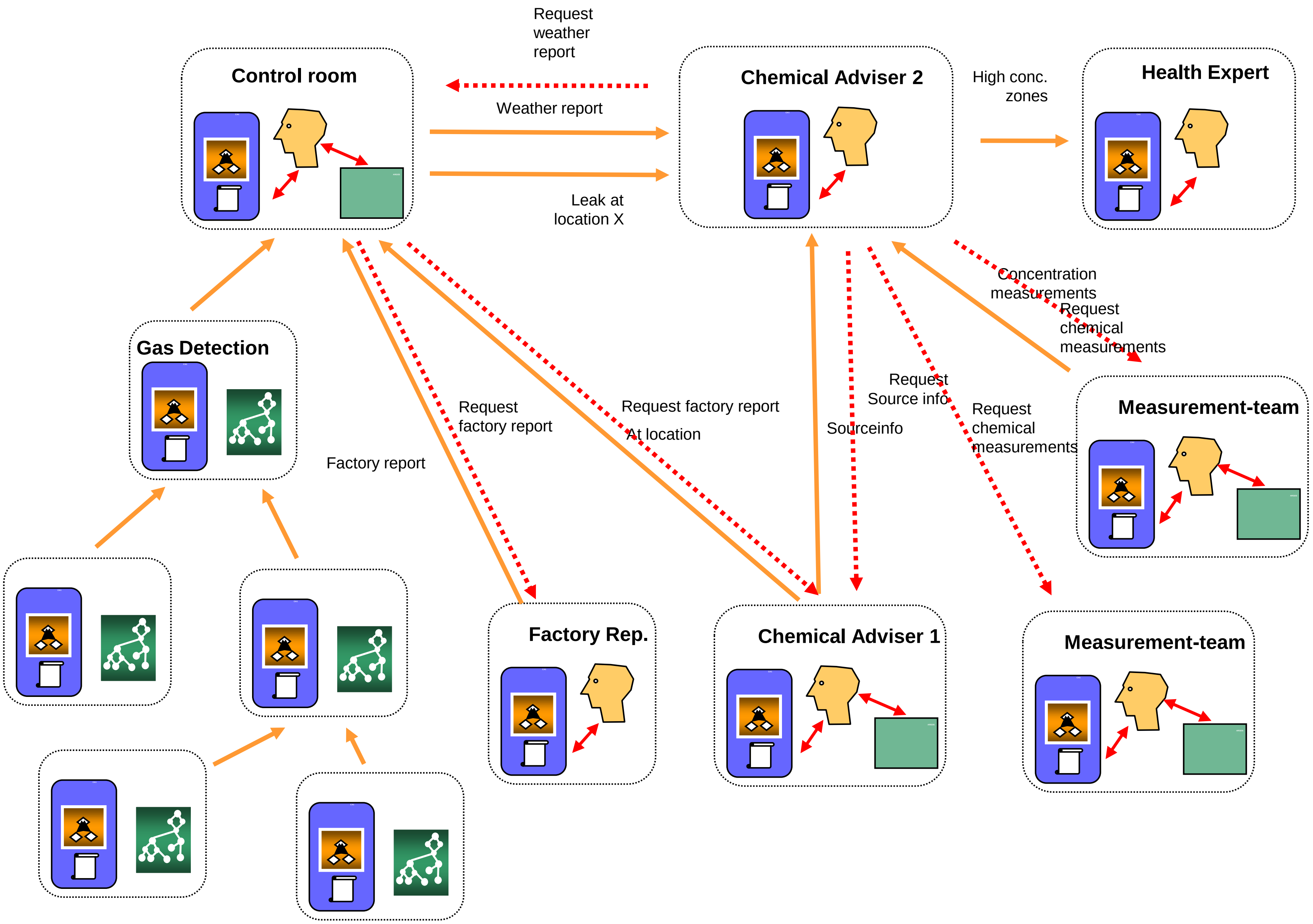


From Local Knowledge to Global Work-Flows

- Each expert knows what services she can provide and what services are needed for this.
- Search for services is initiated by the experts.
- Local domain knowledge captures relations between services.



Collaborative Reasoning in Workflows



Services: Challenges

- Very heterogeneous services.
- New services are added to the system continuously.
- We do not know which services will be added later prior to the operation .
- Centralized overview of service dependencies is not practical (likely to be intractable).

Solution

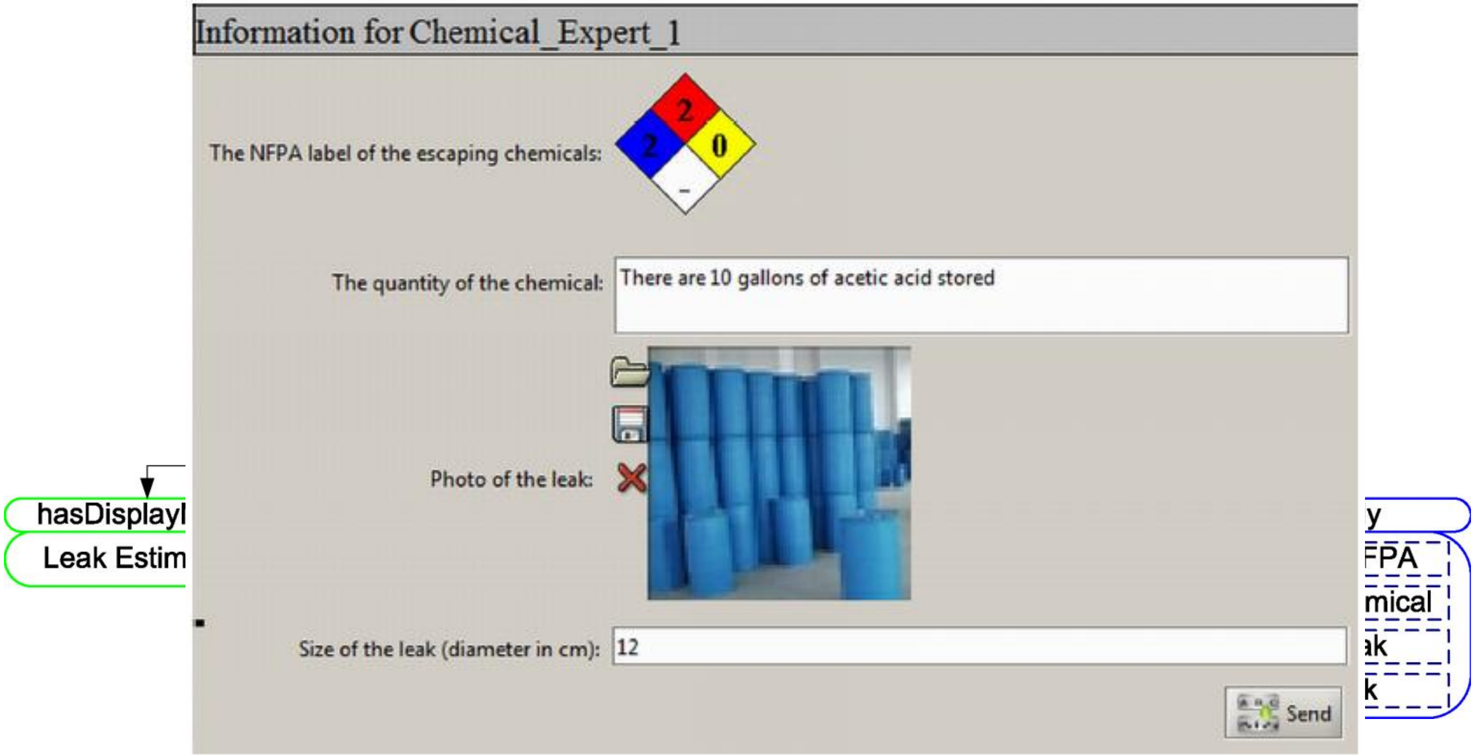
- **Consider the properties of the organizations using the system.**
    - Professional bureaucracy.
    - Keep the domain knowledge distributed (private).
- **Delegate creation of the service ontologies to the service providers.**
    - Tool supporting specification of rigorous ontologies.
    - No training in formal ontology techniques required.
- **Minimize ontological commitments.**

Solution

- **A set of light-weight ontologies.**
  - Service ontologies.
  - Information model; basic elements
  - Local task ontologies.
- **Construction procedures.**
- **Tools supporting construction of ontologies without extra training.**

Global Service Ontology

- A service description consists of three main components:
  - (i) a verbal description and keywords
  - (ii) a description of the service invocation conditions => Query Form
  - (iii) a description of the service outputs => Reply Form



Information for Chemical_Expert_1

The NFPA label of the escaping chemicals:

The quantity of the chemical: There are 10 gallons of acetic acid stored

Photo of the leak:

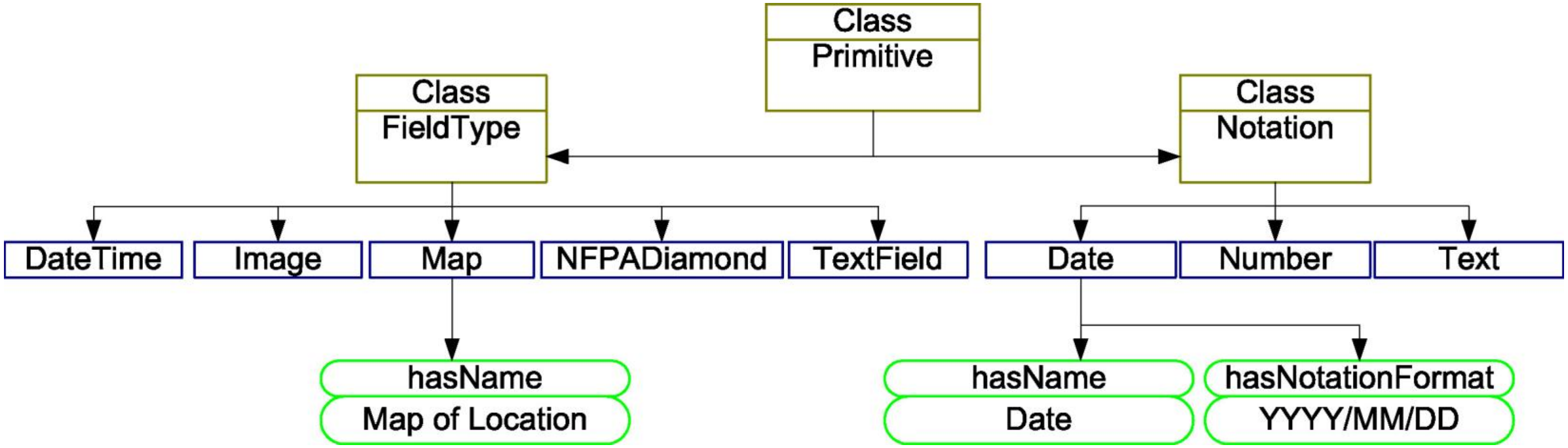
Size of the leak (diameter in cm): 12

Global Service Ontology

- The global service ontology describes only capabilities of different types of experts.
- The global service ontology DOES NOT describe the domain.
  - The experts possess domain knowledge.
- The global service ontology DOES NOT describe relations between services.
  - The experts know for each of their roles the associated capabilities and the needs.

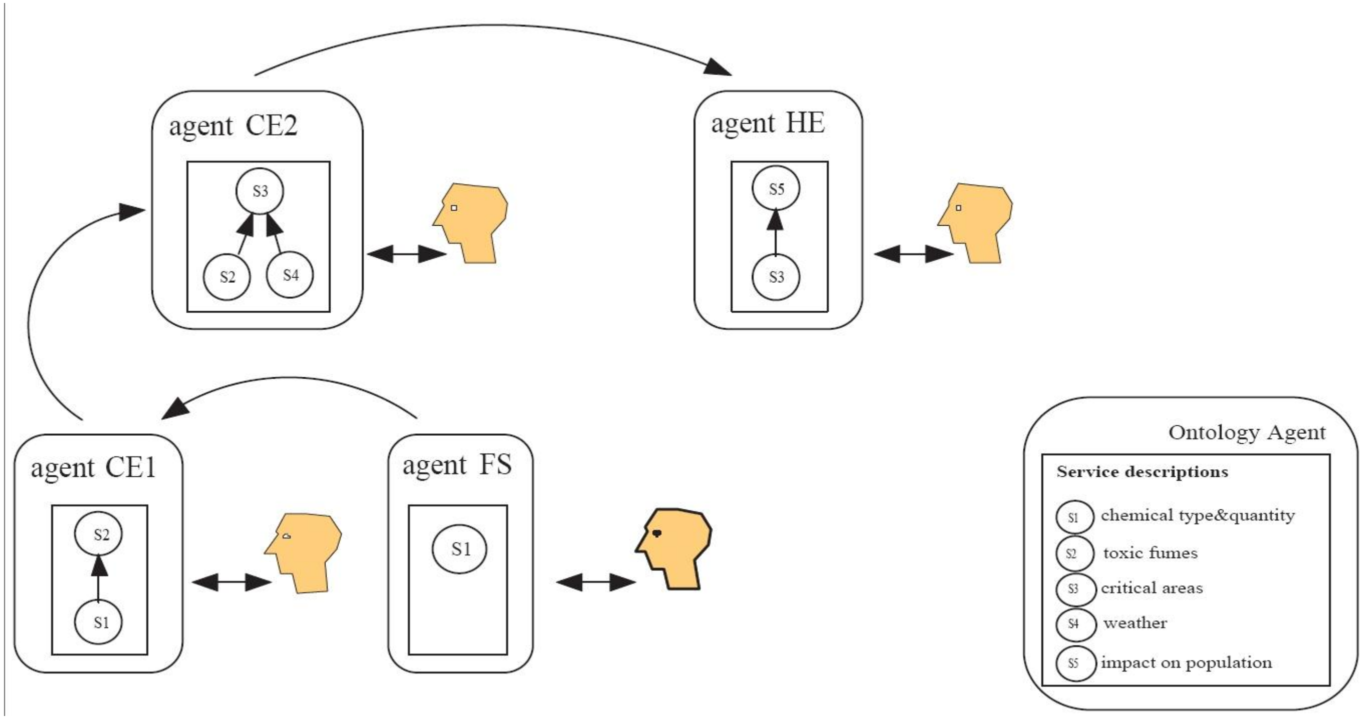
Information Model

- Basic information types are used to describe the services.
  - Time, Location, Text, Date, Time, a Map, etc.
- Query and Reply forms are an arbitrary combination of a limited set of objects of basic information types.
- Each information type has clear semantics and format.



Task Ontology: Local Knowledge

- Each assistant is associated with a specific task ontology
  - **Specified by the expert => reflect the expert's domain knowledge.**
- Local task ontologies capture relations between the services => critical for service composition.



OntoWizzard Tool

- Enforce a specific construction procedure:
  - Guide the user through a sequence of steps.
- By using the OntoWizzard tool the experts:
  - Contribute to the global service ontology.
  - Build local task ontologies.
  - No formal language skills required.
- Service ontologies are rigorously encoded in OWL.

OntoWizzard Tool

- Experts align their service descriptions with the services known to the organization their are part of.

- Create service descriptions that comply with internal standards.

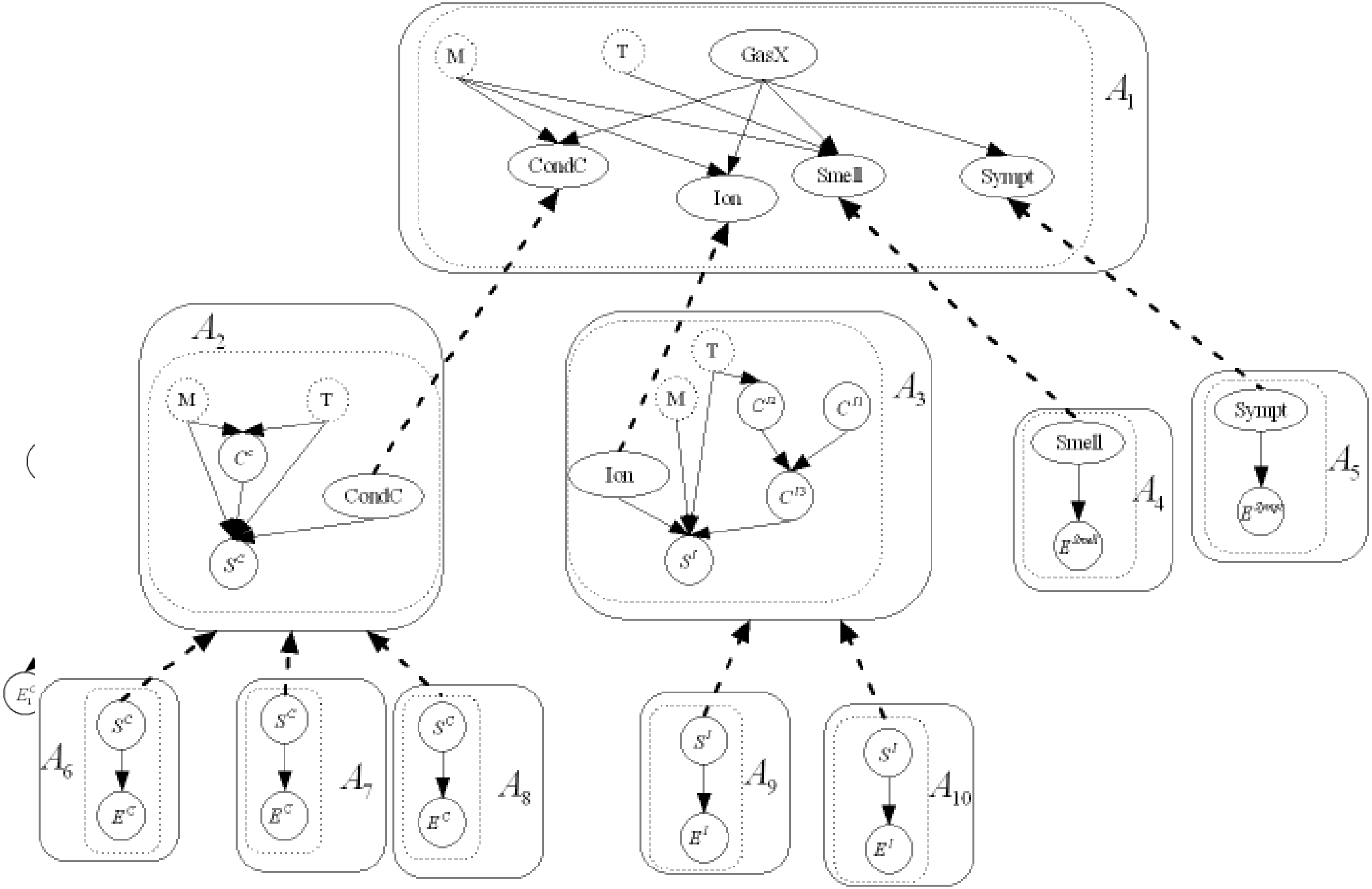
- The standards for composite service descriptions evolve as more expertise is introduced into the system.

Summary

- Application type: situation assessment, prediction, decision analysis
- SOA that makes heterogeneous resources "composable".
- Exploit the local domain knowledge to relate the services.
  - **No heavy weight service ontologies**
  - **Key to efficient construction and maintenance**
- Prototypes have been evaluated.
  - **Demonstration at the NATO ASI summer school (hands on work)**
  - **November 23, 2010 a large scale demonstration and evaluation involving chemical experts will take place in the serious gaming environment at the DECIS lab in Delft.**
- The emphasis is on advanced solutions which are economically feasible and maximally exploit the existing resources, such as public communication networks as well as dedicated processing, communication and sensing systems.

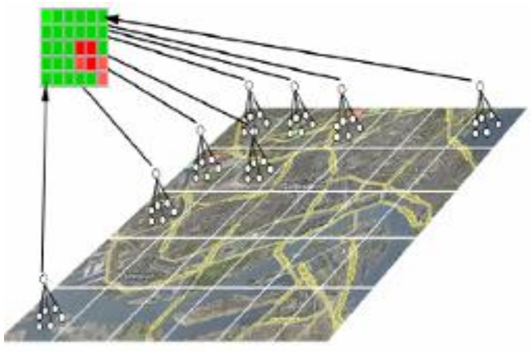
Thank you!

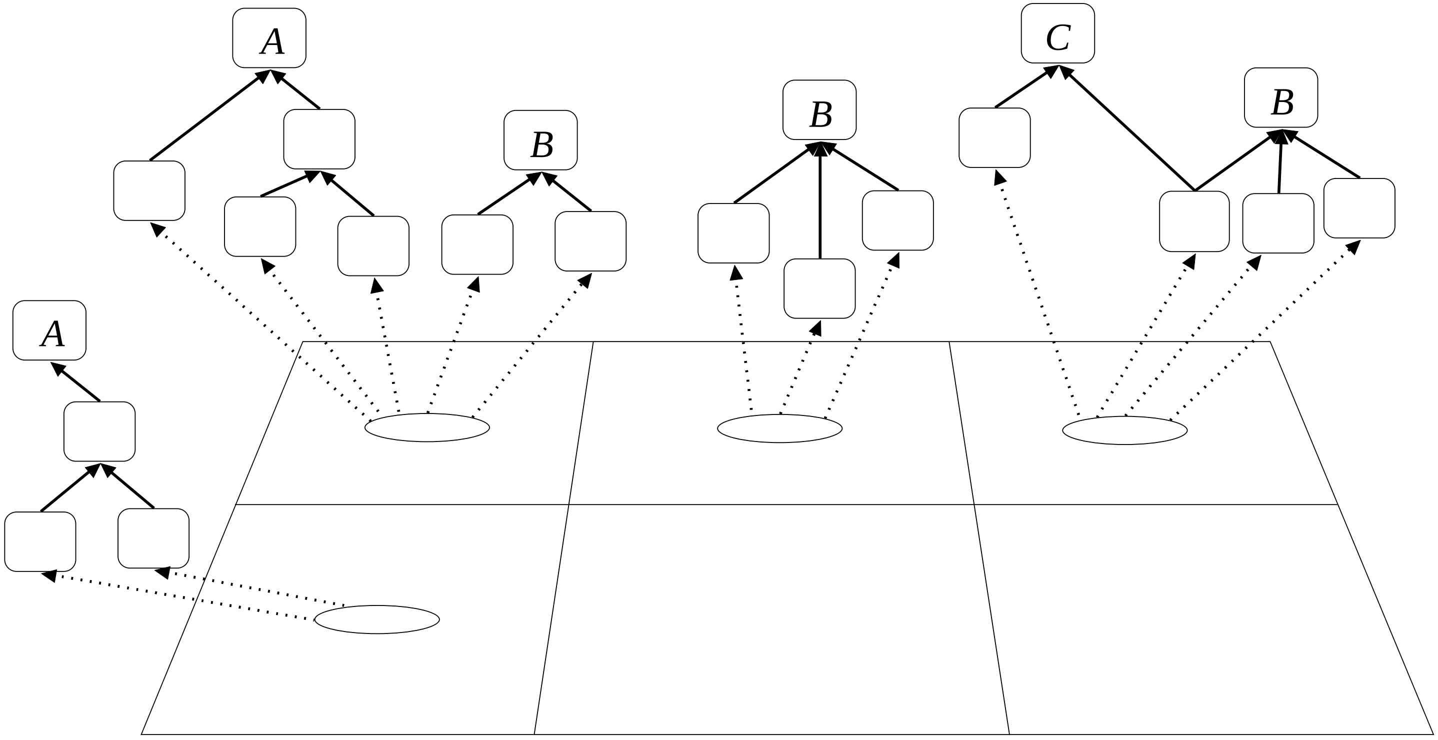
Distributed Perception Networks (DPN)



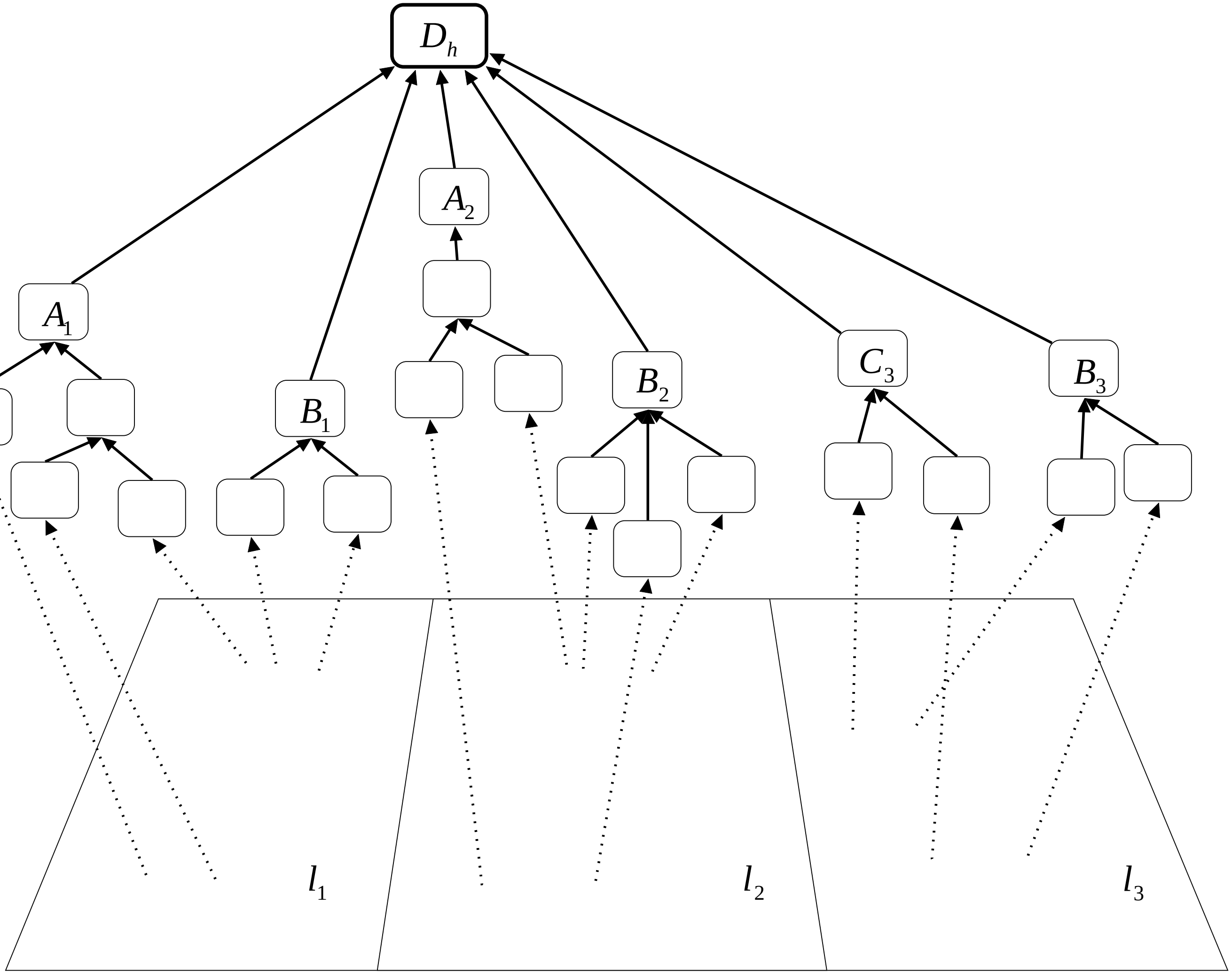
Distributed Detection Systems

- Compound observation models:

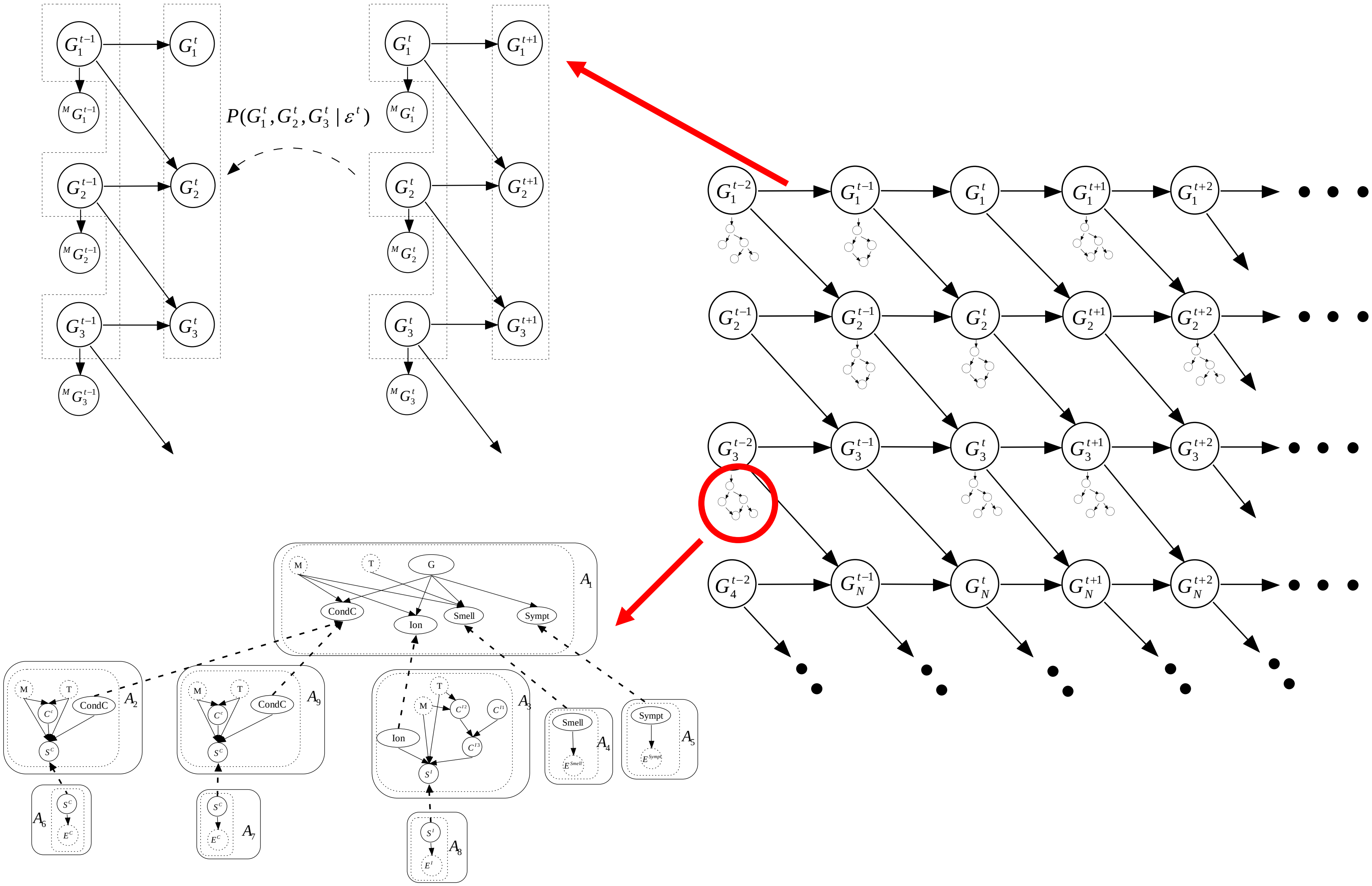




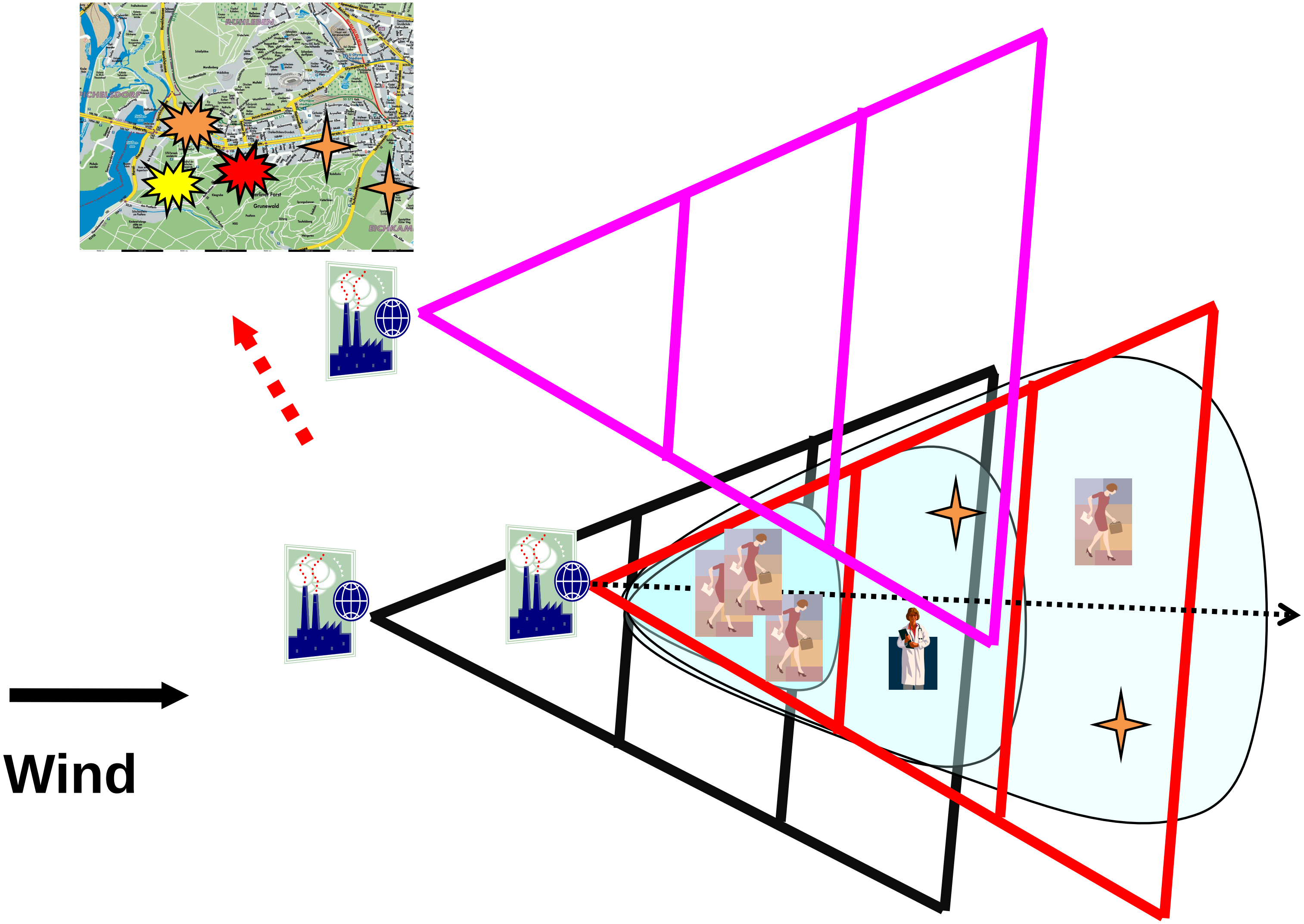
Dynamic Models



Dynamic Models



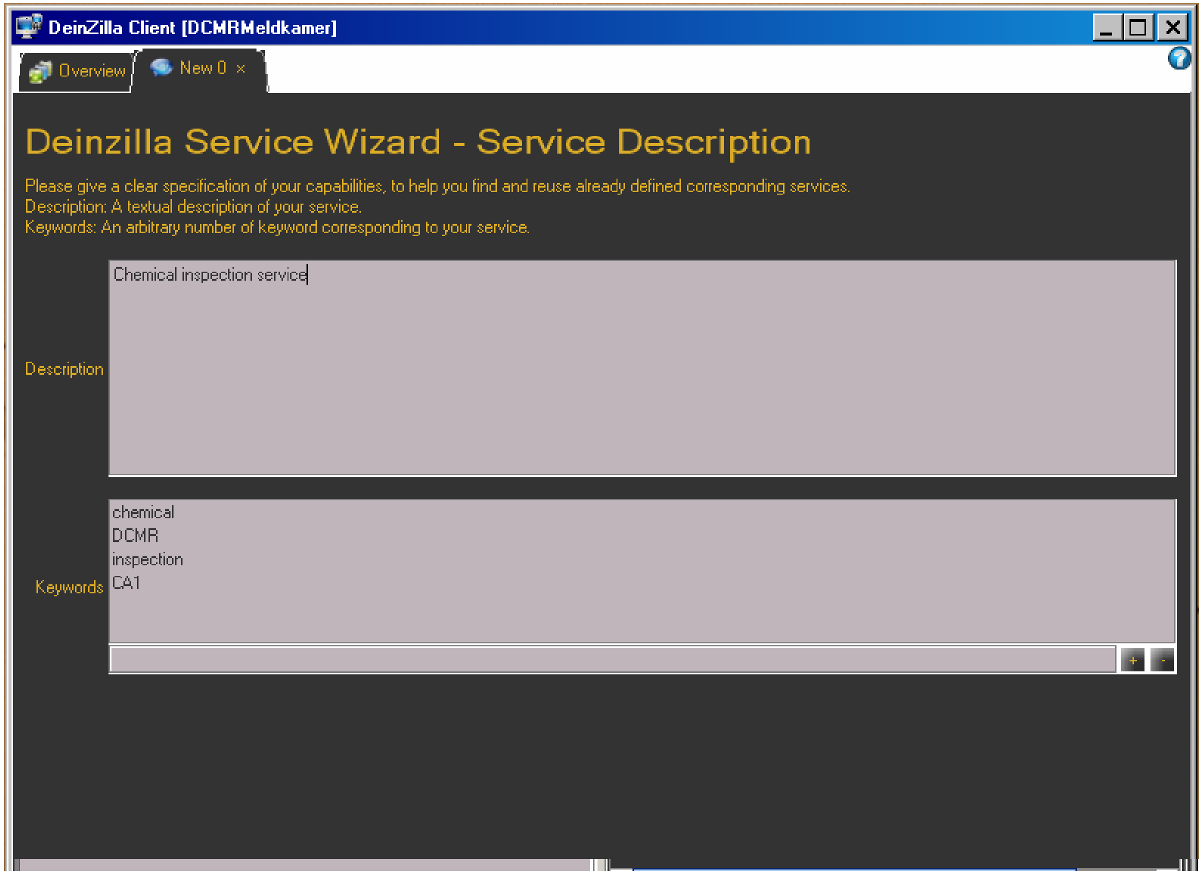
Example: Source Detection



Wind

OntoWizzard: Inspect Existing Services

- Use keywords and natural language to search the global service ontology.
- A dedicated ontology agent returns a ranked list of service descriptions.



Deinzilla Service Wizard - Service Description

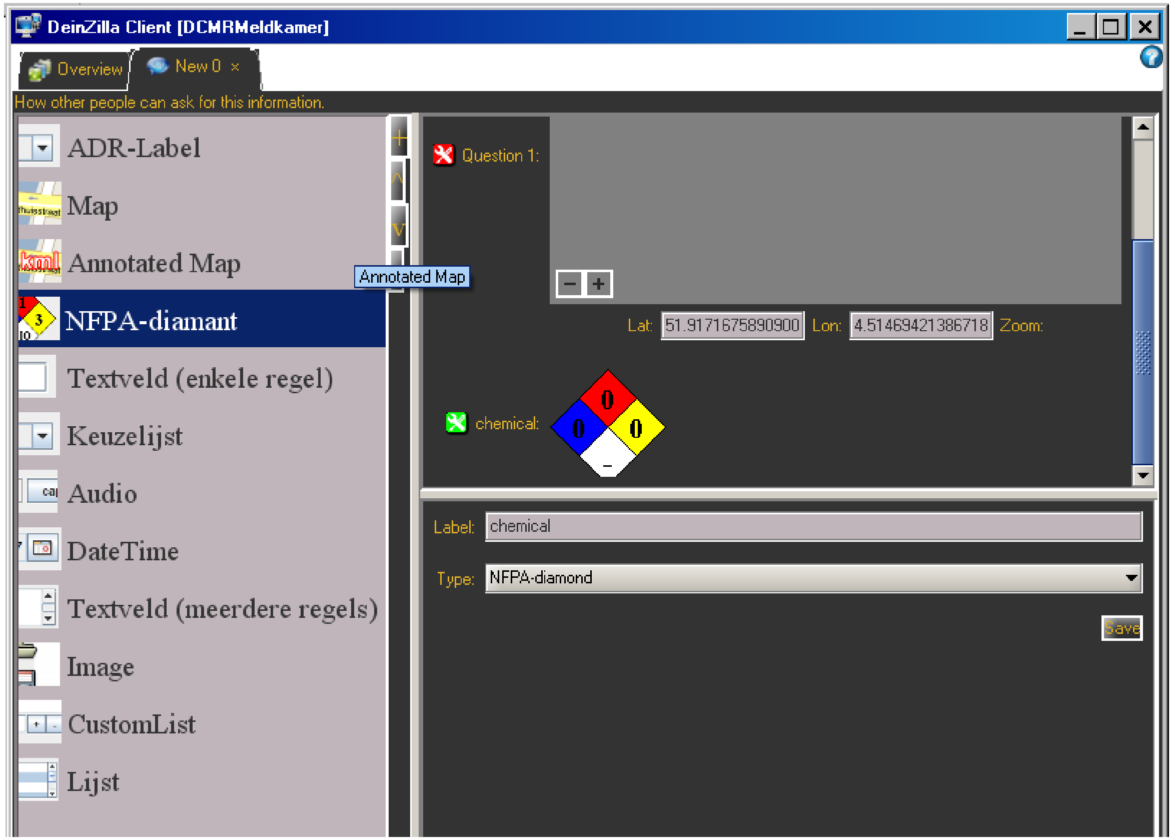
Please give a clear specification of your capabilities, to help you find and reuse already defined corresponding services.
Description: A textual description of your service.
Keywords: An arbitrary number of keyword corresponding to your service.

Description: Chemical inspection service

Keywords:
chemical
DCMR
inspection
CA1

OntoWizzard: Define New Services

- Define query and reply forms.
- Use standard basic elements/information types



How other people can ask for this information.

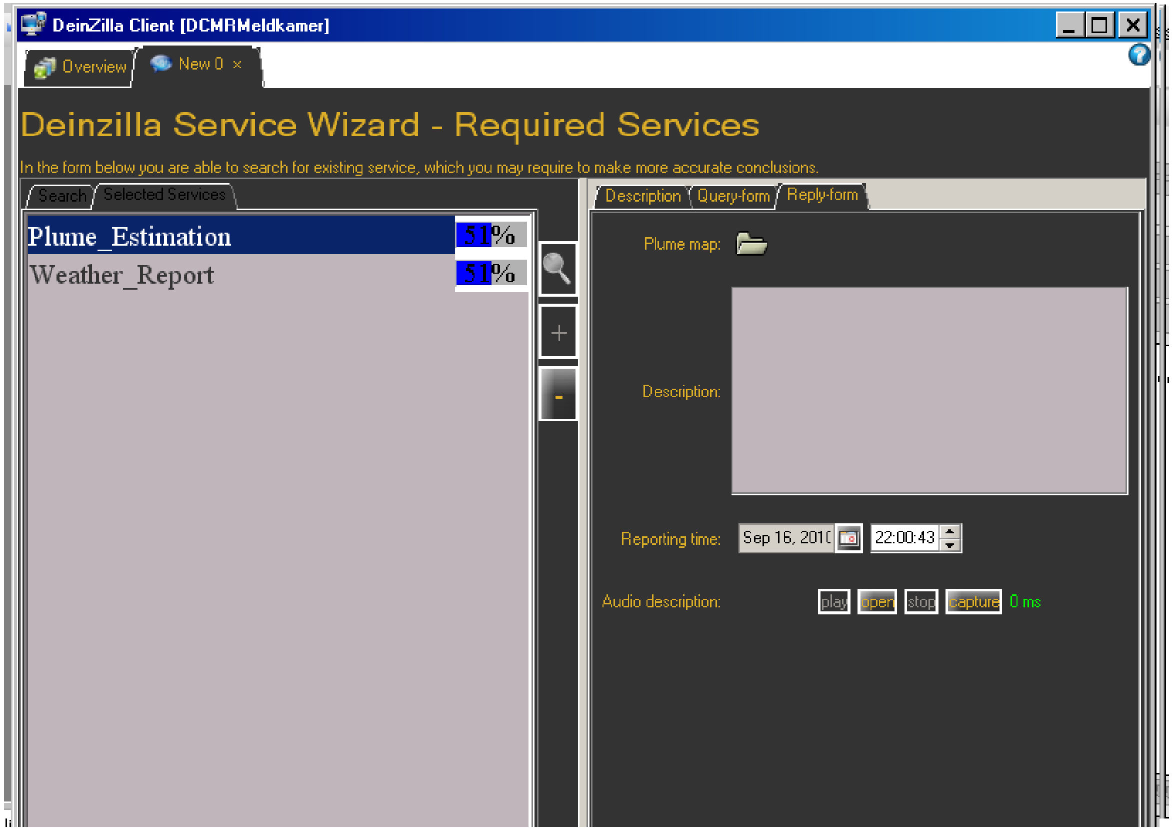
Lat: 51.9171675890900 Lon: 4.51469421386718 Zoom:

Label: chemical

Type: NFPA-diamond

OntoWizzard: Couple Services

- Allow the definition of service relations => internally create local task ontologies.
- Local task ontology is associated with a particular expert.



DeinZilla Client [DCMRMeldkamer]

Deinzilla Service Wizard - Required Services

In the form below you are able to search for existing service, which you may require to make more accurate conclusions.

Plume_Estimation 51%

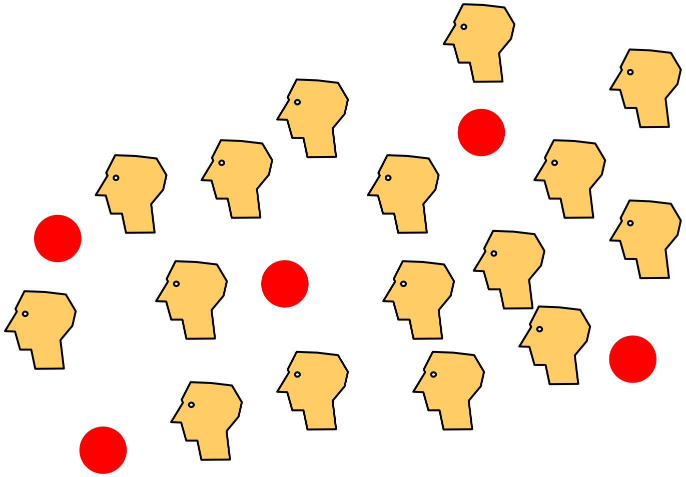
Weather_Report 51%

Reporting time: Sep 16, 201(22:00:43

Conclusions (2)

- A new collaborative approach to construction of large scale service oriented systems.
- A combination of light weight service ontologies, efficient construction procedures and tools.
- Machine understandable service descriptions with well defined syntax and semantics.
    - Created by multiple designers.
    - No complex coordination of collaborative design processes needed.
    - No knowledge of formal ontology techniques required.

Environmental Management



- Estimate current situation.
- Predict the evolution of critical processes/events.
- Evaluate impact of different options.

Reasoning as Function Composition

1. No explicit function composition takes place in any of the agents.

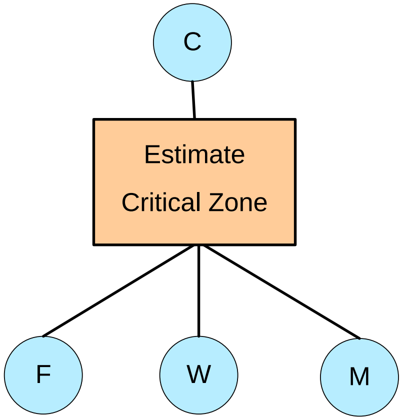
2. A work flow corresponds to a composite (globally emergent) function.

3. The function is implemented via sharing of function outputs in the workflow.

From Local Relations to Global Work-Flows

- Experts are “processing nodes”.
  - Implement a transformation between different types of information.
  - Each expert solves a limited set of problems => specific services.
- Local functions capture relations between service types.

$$C = f_c(F, W, M)$$


C
Estimate
Critical Zone
F
W
M