Towards a Single Information Space for Environmental Management through Self-Configuration of Distributed Information Processing Systems

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DIADEM (FP7/STREP)

- Distributed Information Aquisition and Processing for Environmental Management
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  - Duration 3 years, start September 1, 2008
  - **www.ist-diadem.eu**

- Consortium
  - Thales-NL (Coordinator)
  - **DCMR Milieudienst Rijnmond** (NL)
  - **Danish Emergency Management Agency** (DK)
  - University of Karlsruhe (D)
  - University of Orebro (S)
  - University of Amsterdam (NL)
  - University of Craiova (RO)
  - Prolog Development Center (DK)
  - Space Applications & Systems (B)

The prime objective

- An ICT system for **collaborative** decision making that effectively supports protection of the population and the environment against chemical hazards in industrial areas.

DIADEM Process Integration Framework

- Facilitate collaborative problem solving in complex environmental management processes.
- Hybrid information processing carried out by automated services and experts from multiple, geographically distributed organizations.
- Simple implementation/evolutionary approach to automation.

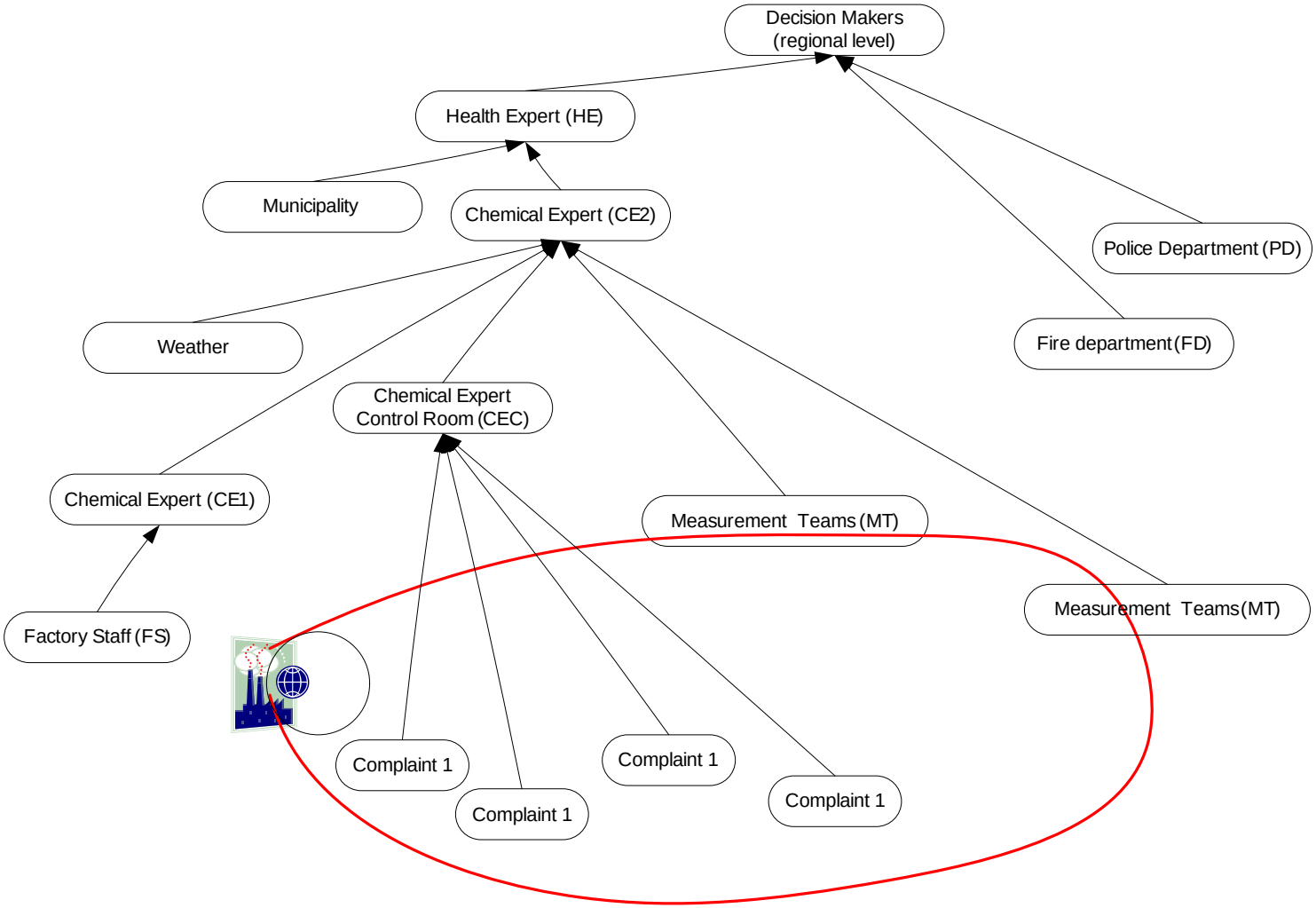
Environmental Management: Example

- A chemical incident in Rotterdam: 1.2 million residents, high density of petrochemical and waste management industry
- Decision making: evacuation/shelter/stay indoors

Environmental Management: Challenges

- Inherently complex information processing
  - Situation assessment.
  - Prediction.
  - Evaluate impact of different options.
- Acquire and process large quantities of information.
  - Cognitive capabilities of a single expert are exceeded.
  - Full automation of decision making is not feasible/acceptable.
- Crisis management
  - Systems of systems
  - Ad-hoc organization of organizations

Environmental Management: Collaboration



State of the art

- A lot of useful information and expertise is not exploited
  - Often it is not known who has the relevant expertise or the person cannot be reached in a given situation.
  - The experts are exposed to irrelevant information.
- All relevant information cannot be used due to cognitive limitations and time pressure. **Information flood!**
- A great variety of data formats, communication protocols, processing methods, etc. **Information inaccessibility!**

A Uniform Information Space

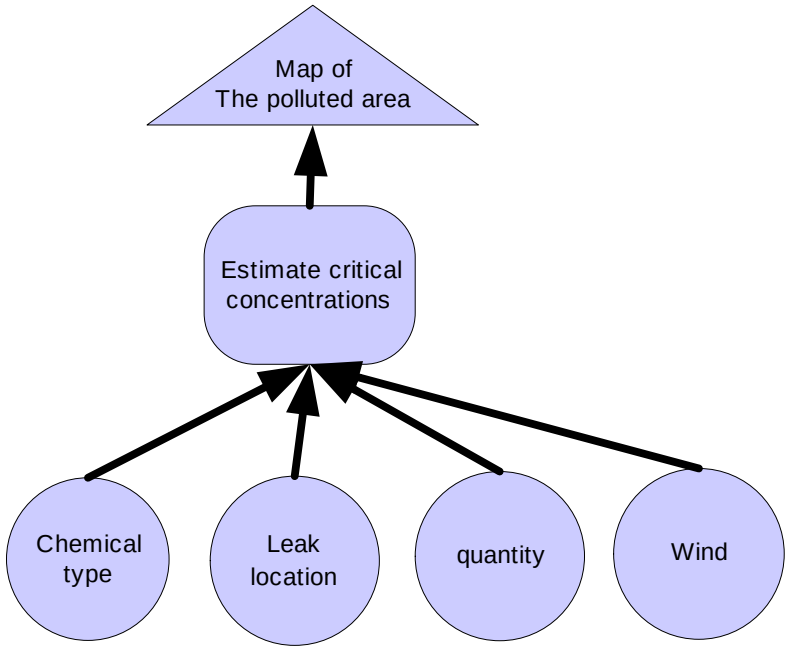
- Standardized formats/protocols
  - Facilitate data/information exchange
- Information processing services
  - Transform heterogeneous data/info to more abstract information types.
  - Deliver the interpretation results to the experts that can use them.
  - Draw attention of experts in case of relevant data/information => rapid response via direction of attention.

Hybrid collaborative processing

- Multiple experts
  - Contribute specific expertise and processing capabilities
- Automated reasoning processes
  - Implemented by software agents
  - Speed up certain types of information processing
- Humans and agents are processing nodes
  - Note: humans are NOT mere users of a system.
  - Humans and agents contribute processing services needed for solving a particular problem.

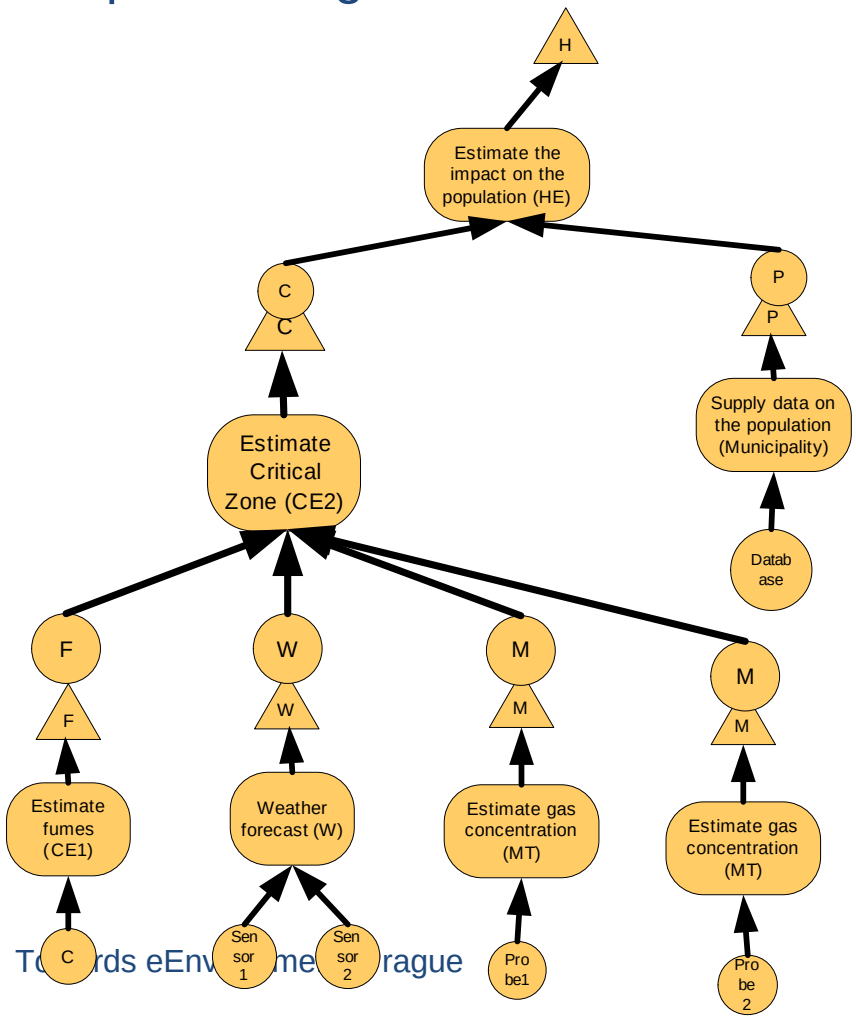
Processes

- Each expert/agent provides a particular service for certain inputs.
  - Implement a particular transformation process.
- Decentralized description of provided services and inputs
  - Each expert/organization or designer defines a local ontology.
  - OntoWizzard tool supports decentralized creation of coherent service descriptions.

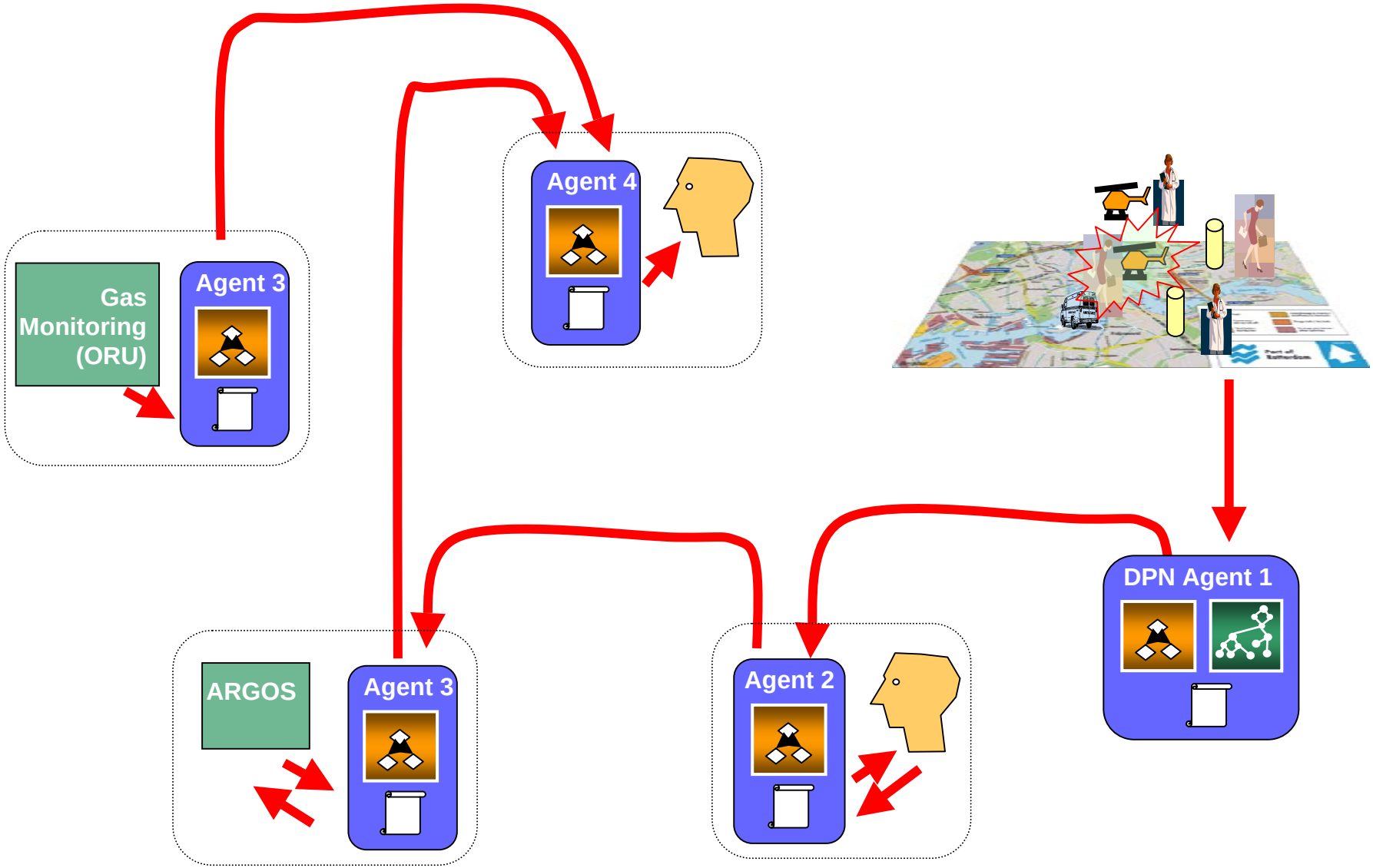


Processing in workflows

- Locally defined services are registered (e.g. yellow pages)
- Through service discovery configure workflows between experts and machines supporting hybrid processing.



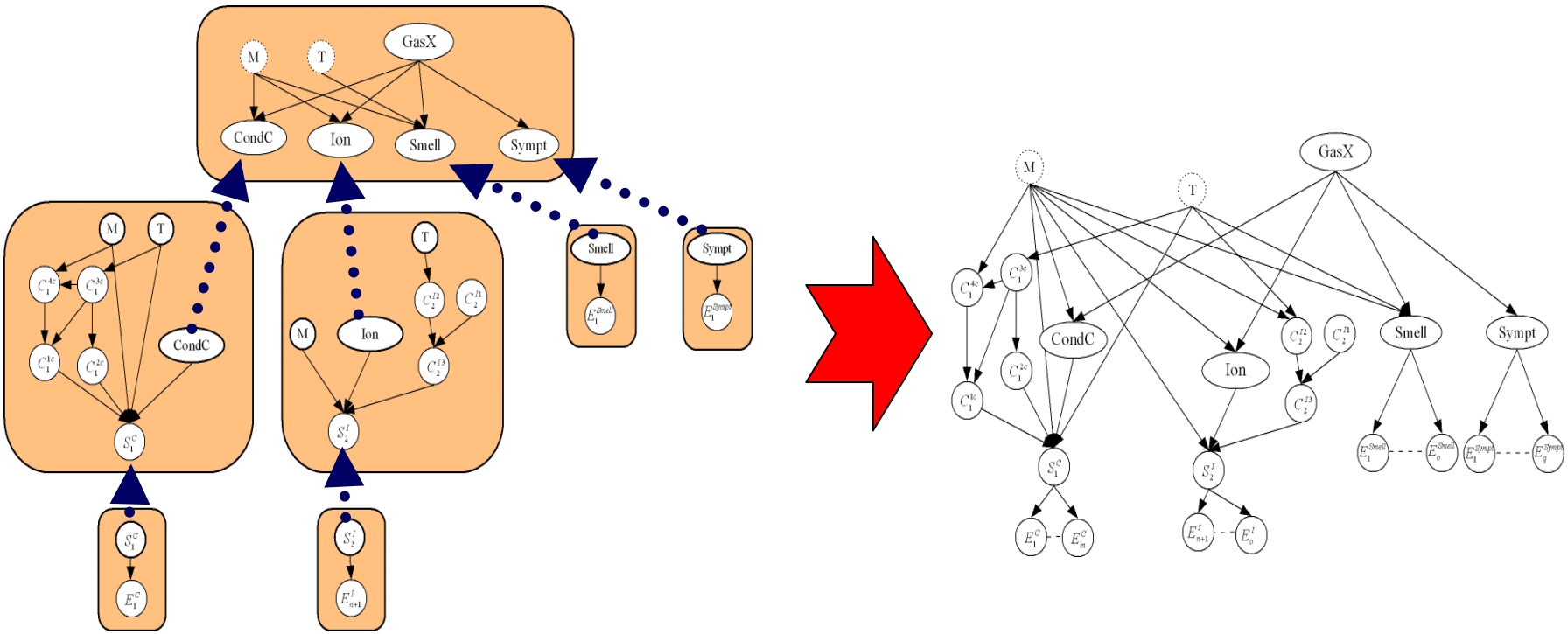
Agents: Basic Building Blocks



Distributed Bayesian Inference

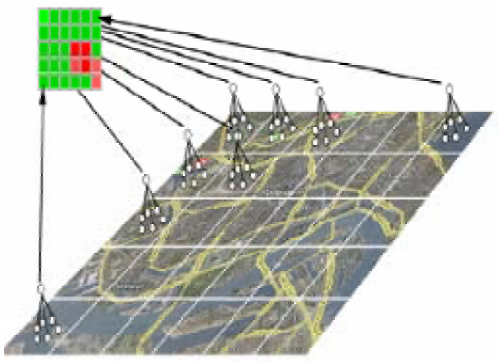
- Agents support Bayesian information fusion.
- Complex fusion systems obtained by combining local Bayesian models; decentralized, globally coherent inference

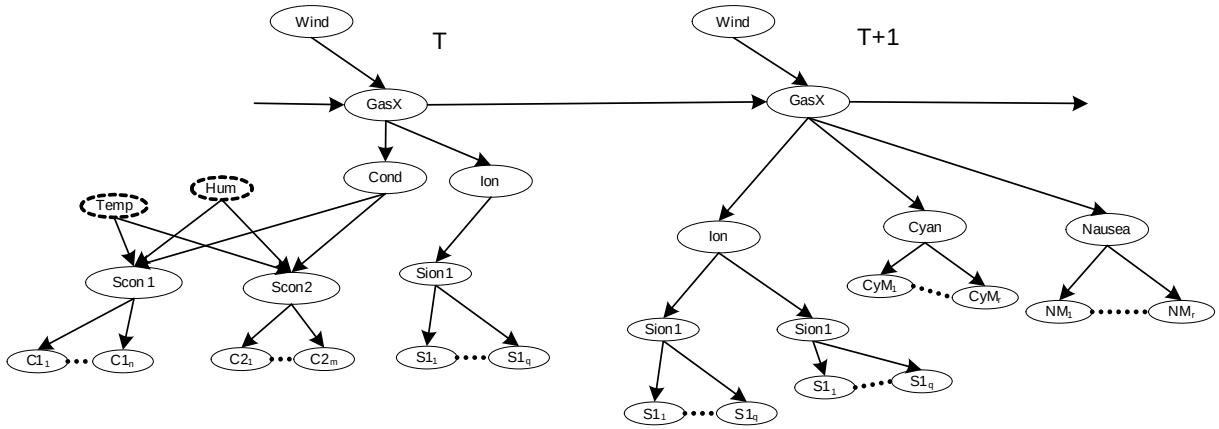
(de Oude&Pavlin, Fusion 2007; Pavlin et. Al, Information Fusion Journal 2008).



Gas Detection/Source Estimation

- Complex sensor models



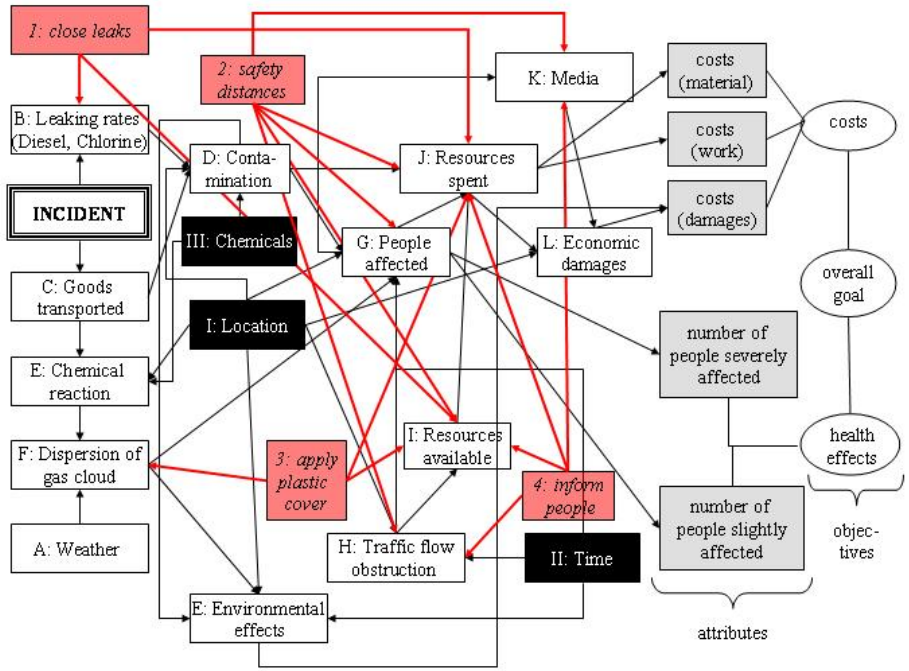


- Integrate humans as “sensors”
  - Generate queries answered with yes/no: “Do you observe a yellow haze?”
  - Use the existing infrastructure: **GSM and Internet.**

- Integrate mobile sensor platforms on the fly

Streamlining Human Based Processing

- Multi-criteria decision making
  - Transparent resolution of complex decision problems with conflicting objectives
- Scenario-based reasoning
  - Plausible future developments
- Integration
  - decision making in dynamic environments

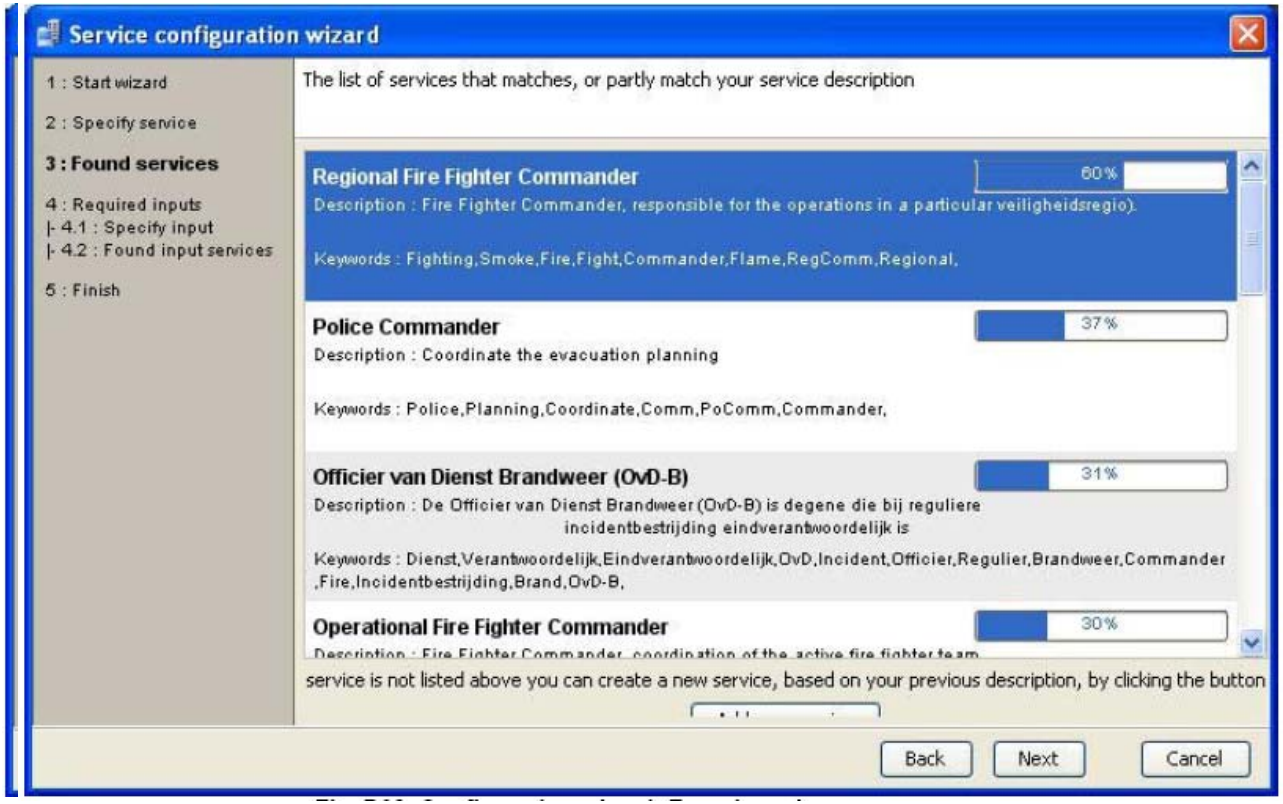


Conclusions

- A service oriented framework facilitating collaborative problem solving.
  - Seamlessly combine experts, citizens and automated services into collaborative processing systems.
  - Acquire relevant information and harness the expertise.
  - Expertise-driven information dissemination.
  - Initial implementation **DIADEM Process Integration** framework.
- Hybrid information processing integrating
  - Arbitrary automated reasoning processes.
  - Advanced methods for human based reasoning.
- Methods and tools facilitating implementation
  - Development of modules which “wrap” heterogeneous services
  - OntoWizzard Tool for decentralized and coherent definition of services.

OntoWizzard

- A tool for collaborative definition of services.
- The system assists a user with the specification of services such that other modules can understand them.



Environmental Management (2)

- Unpredictable domains
  - Each incident is a unique combination of events/phenomena of *known* types.
  - General knowledge about event/phenomena types is available.
  - Mapping between experts and event types can be made a priori.
- Professional bureaucracy
  - Division of labor between experts: experts are “processing nodes”.
  - Each expert implements a particular transformation between different types of information.