ANFAS

CROSSGRID

Information Society Technologies

MEDIgRID

K-Wf Grid

eGee Enabling Grids for E-sciencE

Knowledge-based Platform for Environmental Risk Management

6th International Symposium on
Parallel and Distributed Computing

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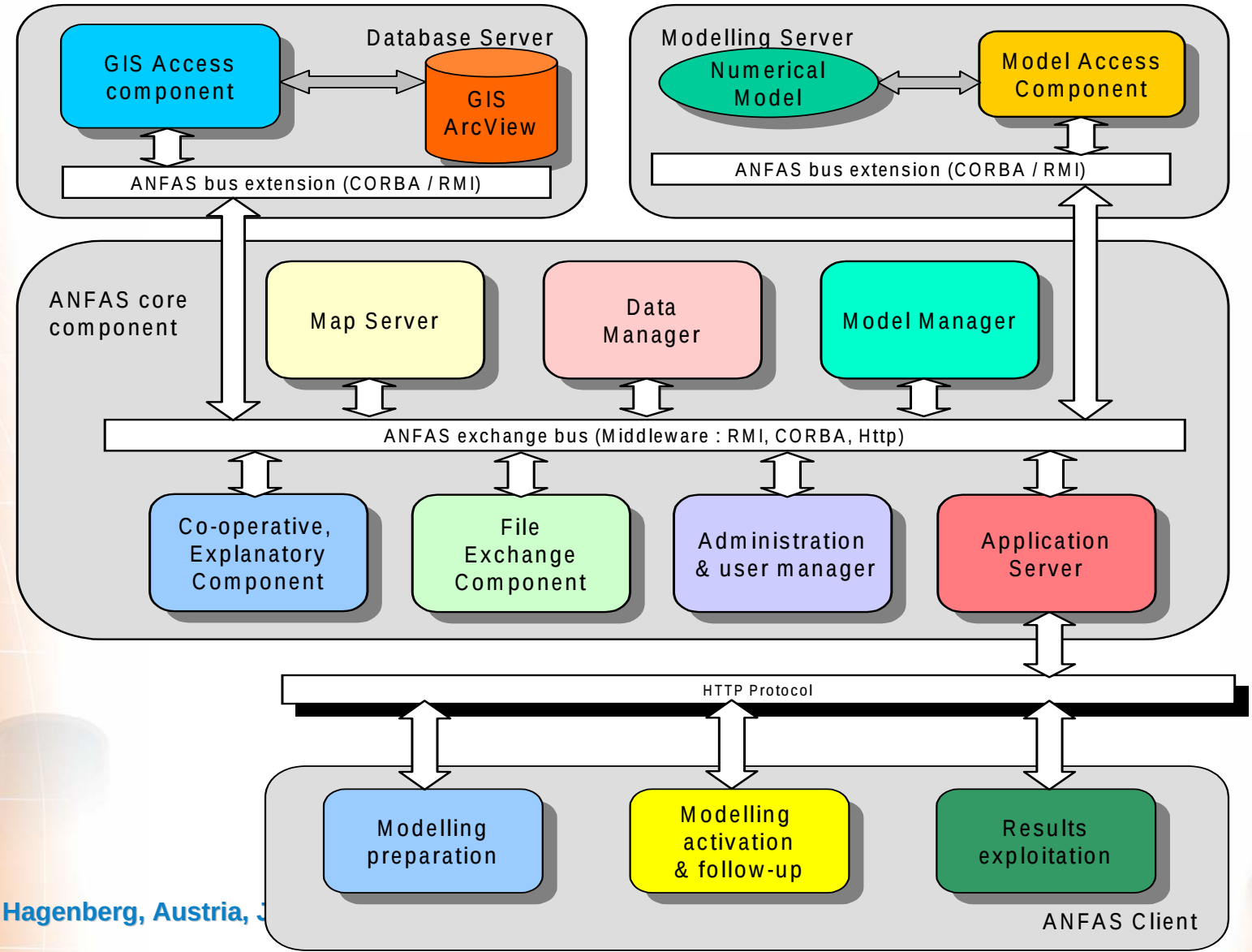
History of Flood application

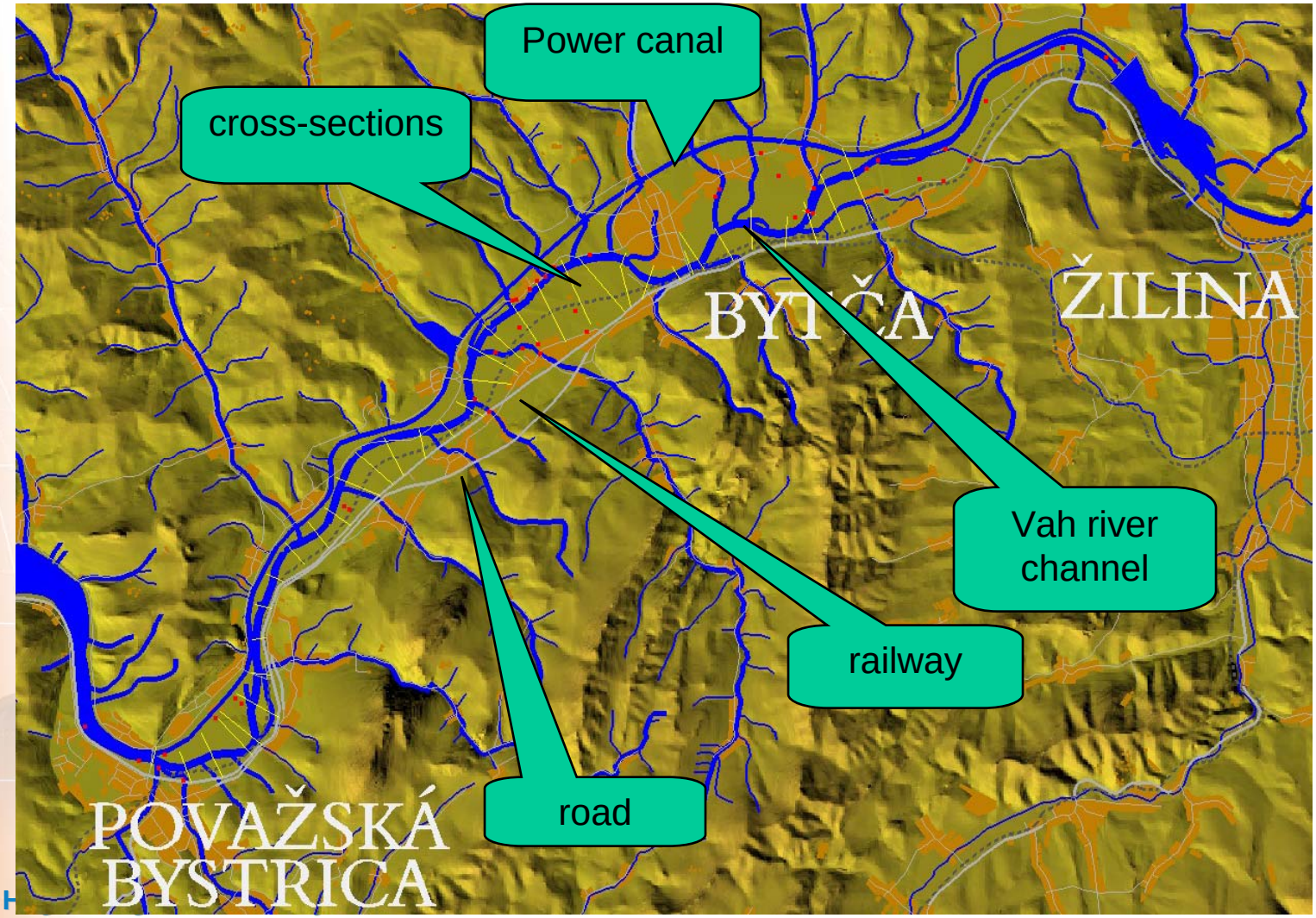
- **Flood application is continually developed in**
  - ANFAS: datA fusioN for Flood Analysis and decision Support,(2000-03) IST-1999-11676
    - Data fusion, hydraulic modeling
    - Cluster computing
    - Remote processing
  - CrossGrid: Development of Grid Environment for Interactive Applications (2002-05) IST-2001-32243
    - More models (meteorology, hydrology)
    - Grid computing
    - Metadata catalog
    - Portal
  - EGEE: Enabling Grids for E-sciencE (2004-2006) INFSO-RI-508833
    - Porting to gLite
    - Working in Earth Science Research Virtual Organization (ESR VO)
  - K-Wf Grid: Knowledge-based Workflow System for Grid Applications(2005-2007) IST 511385
    - Added workflow management and semantic support
    - Actually a SOKU implementation, with Grid infrastructure almost invisible
- **Collaboration with Slovak Hydro-meteorological Institute (SHMI) and Slovak Water Research Institute (WRI)**

Cave-based Flood Visualization

ANFAS Architecture



Layout of the Vah river pilot site



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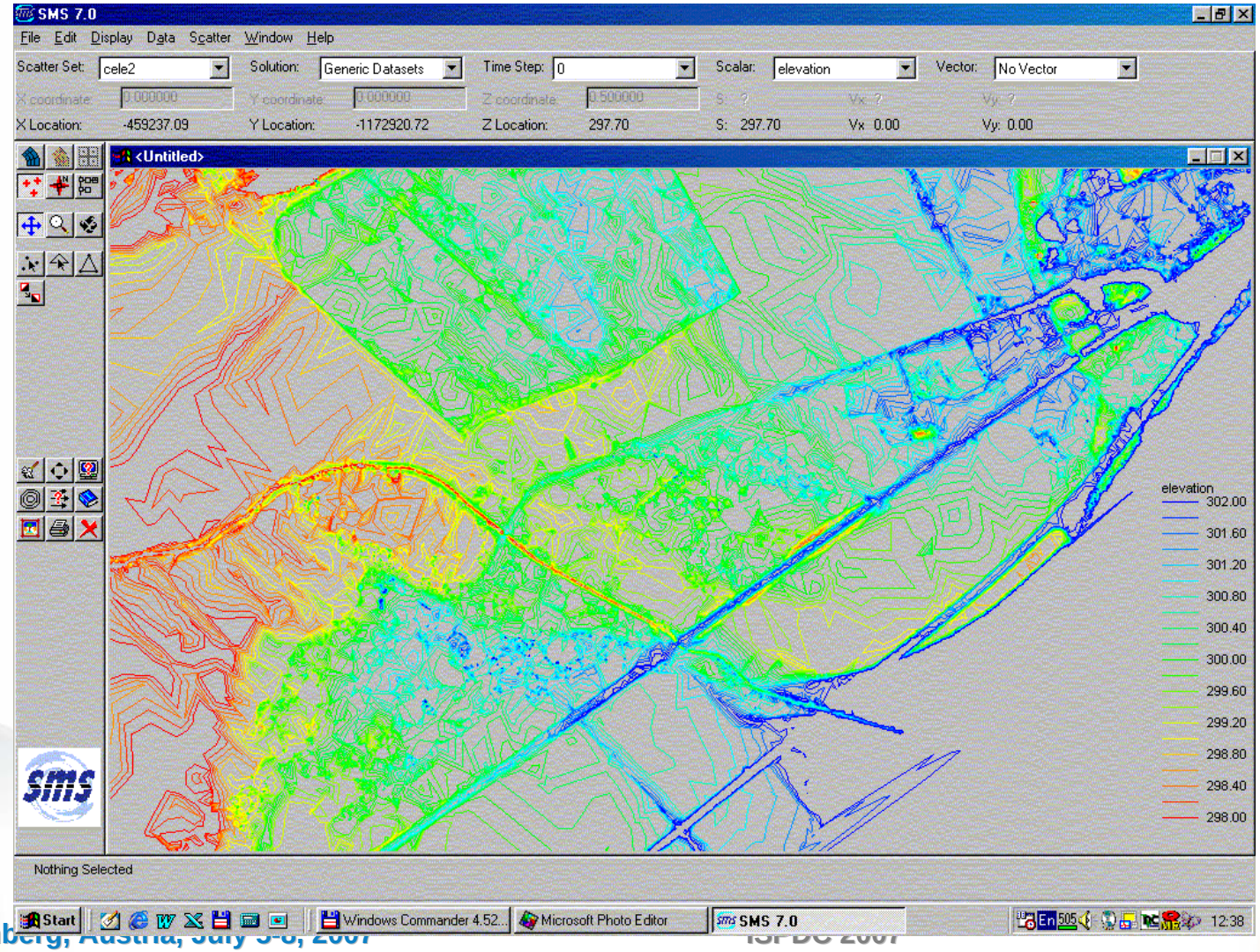
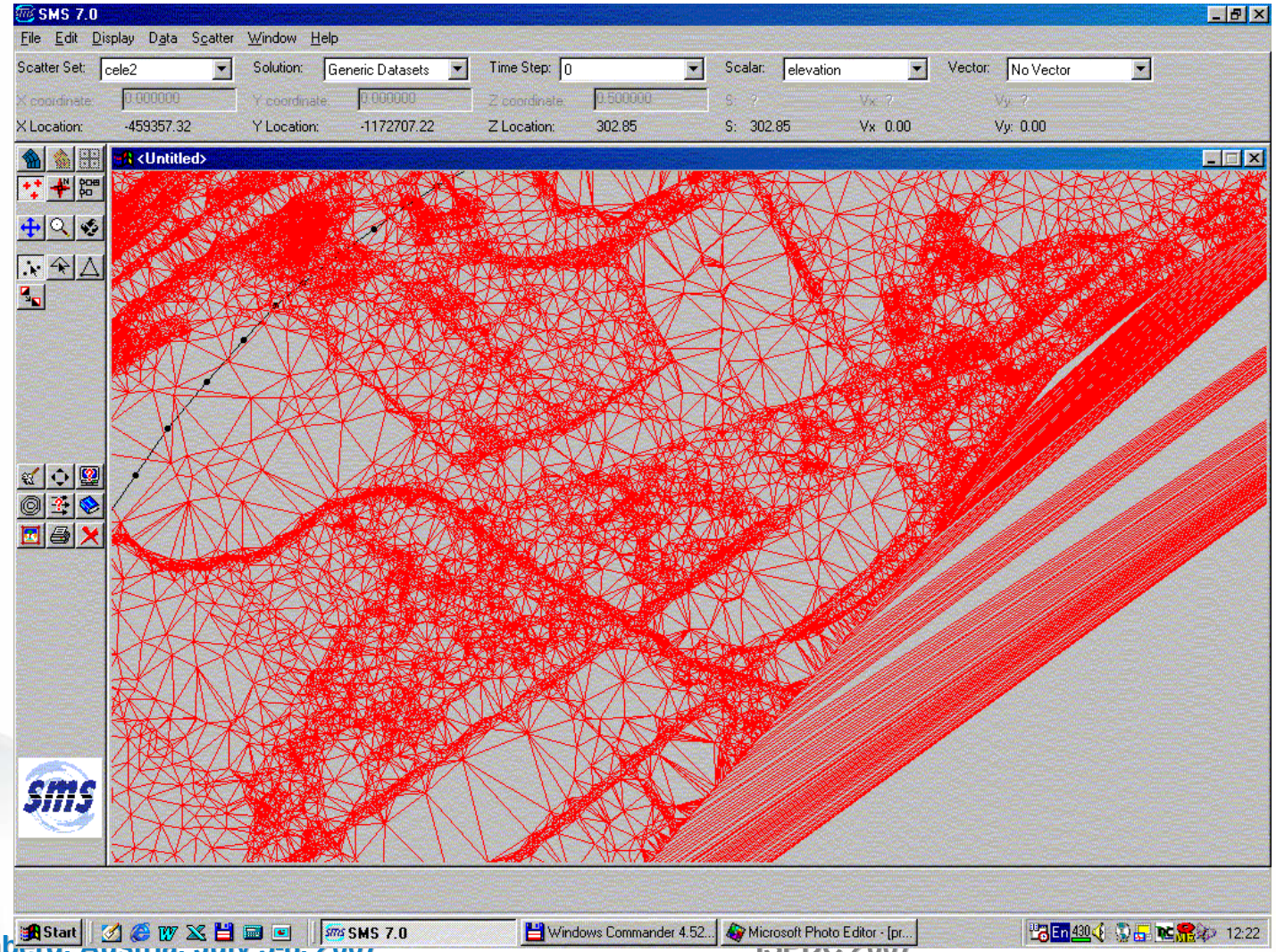
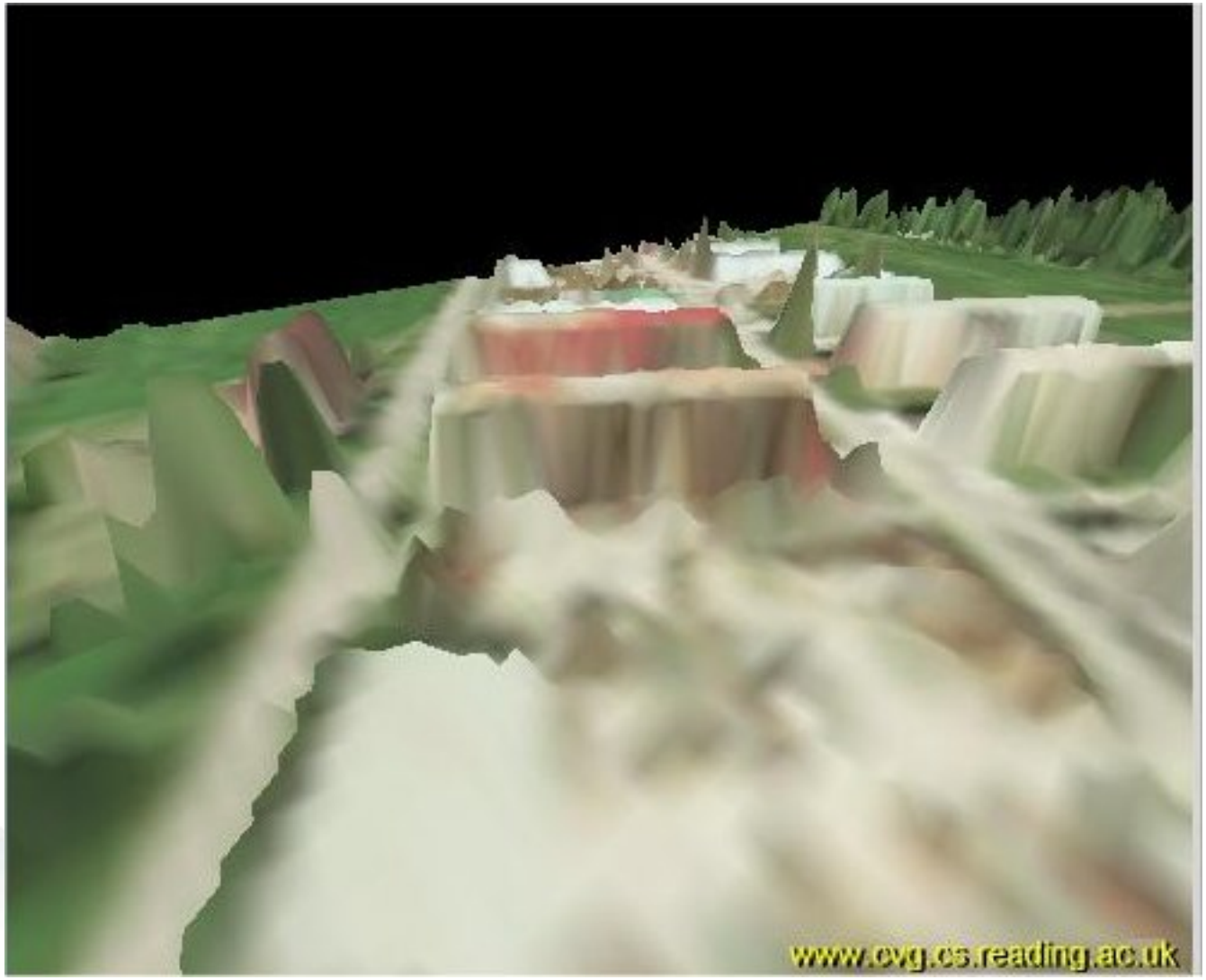
Predmier village in LIDAR



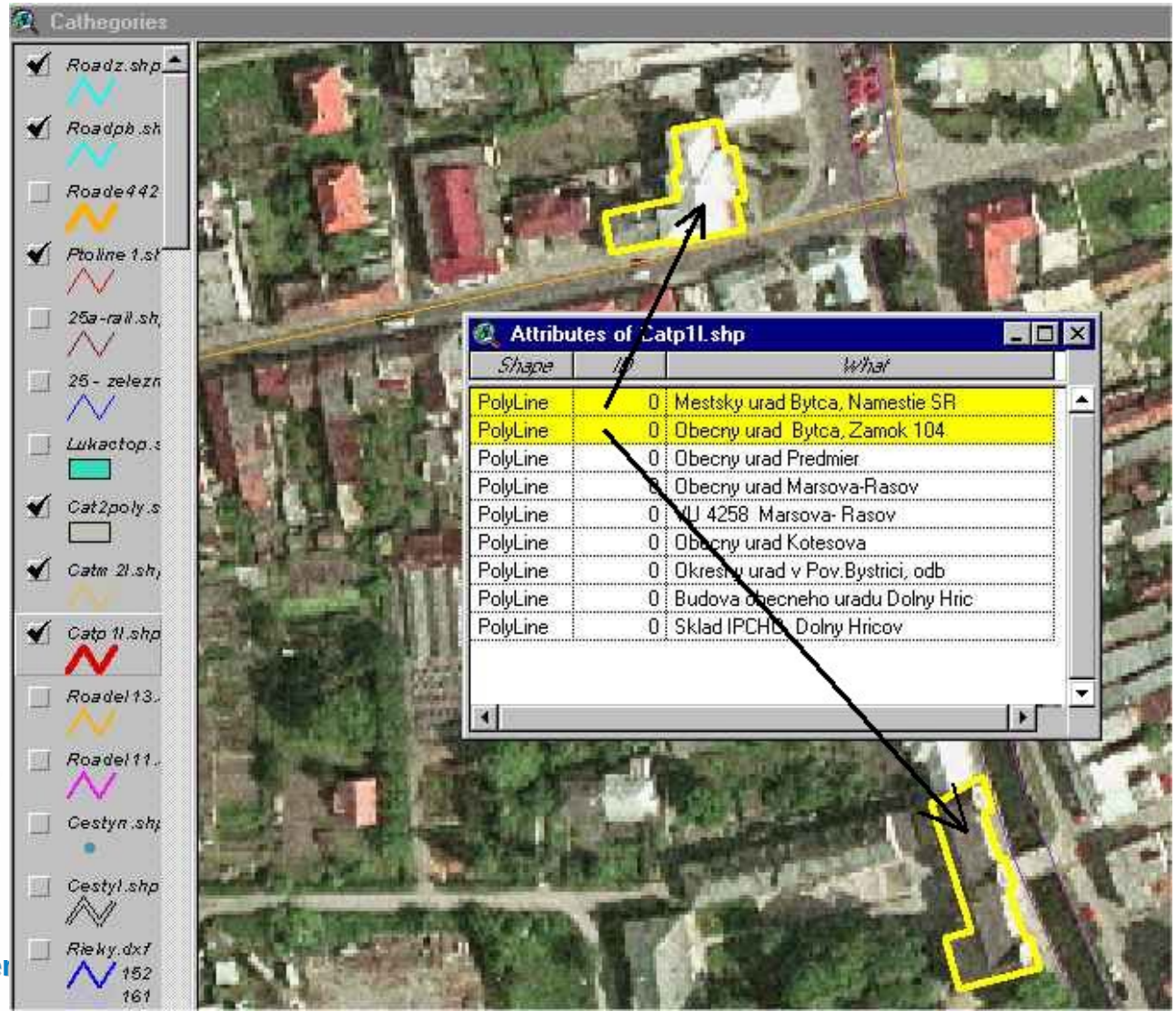
TIN network at Predmier



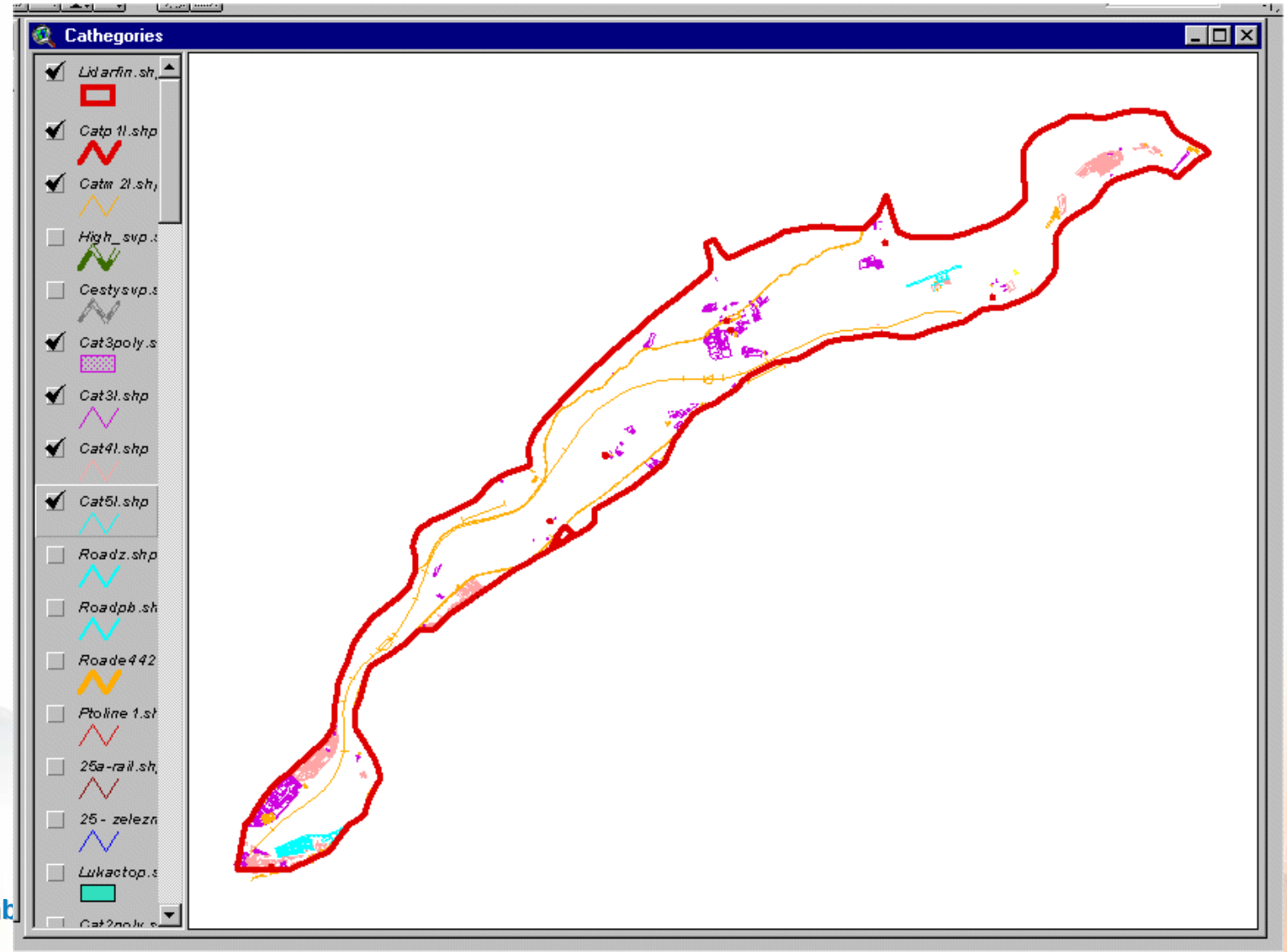
Computer Vision



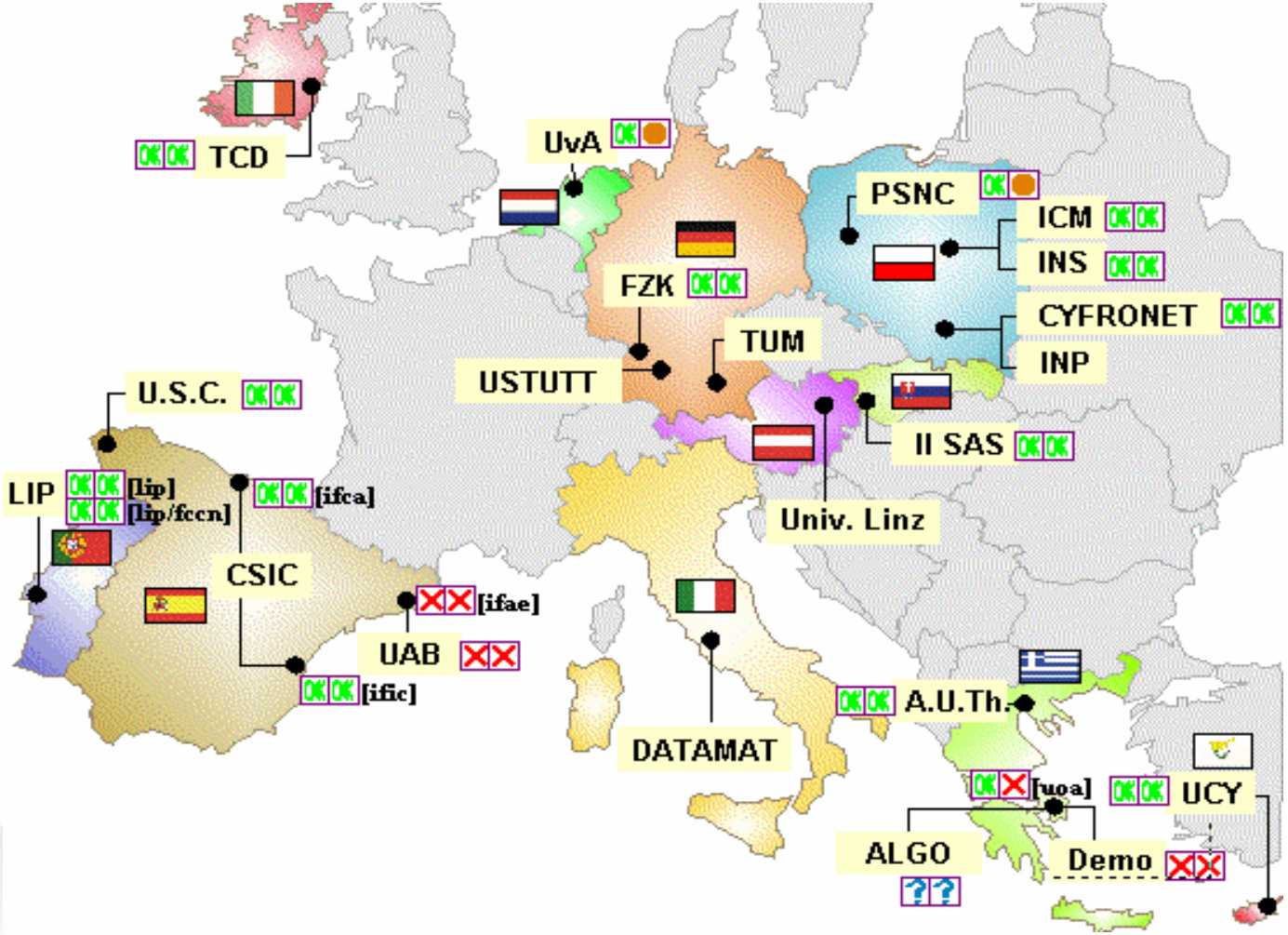
Impact assessment



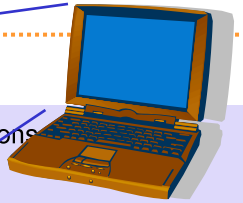
Categories of vulnerability



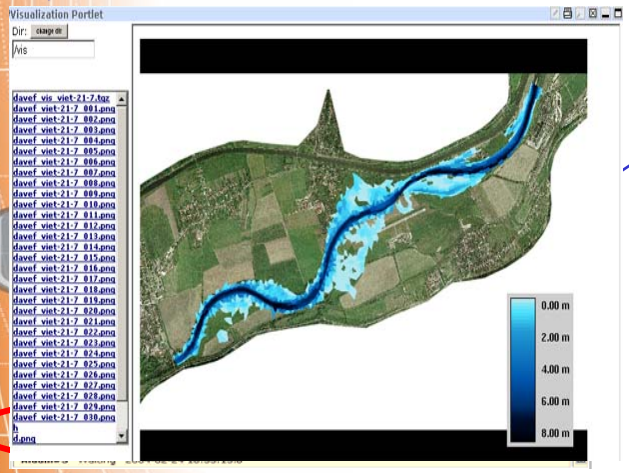
CrossGrid testbed



Application Portal

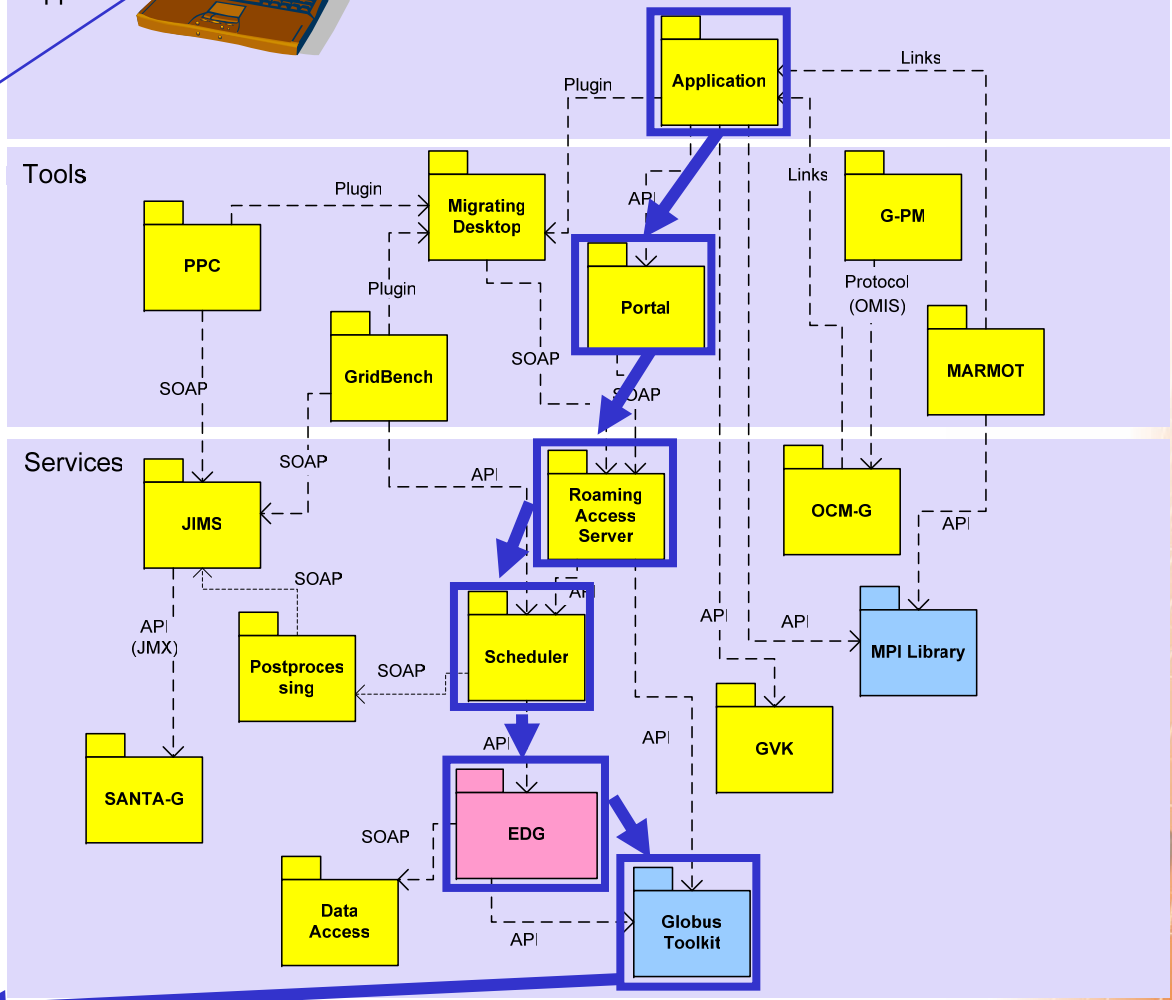


Applications

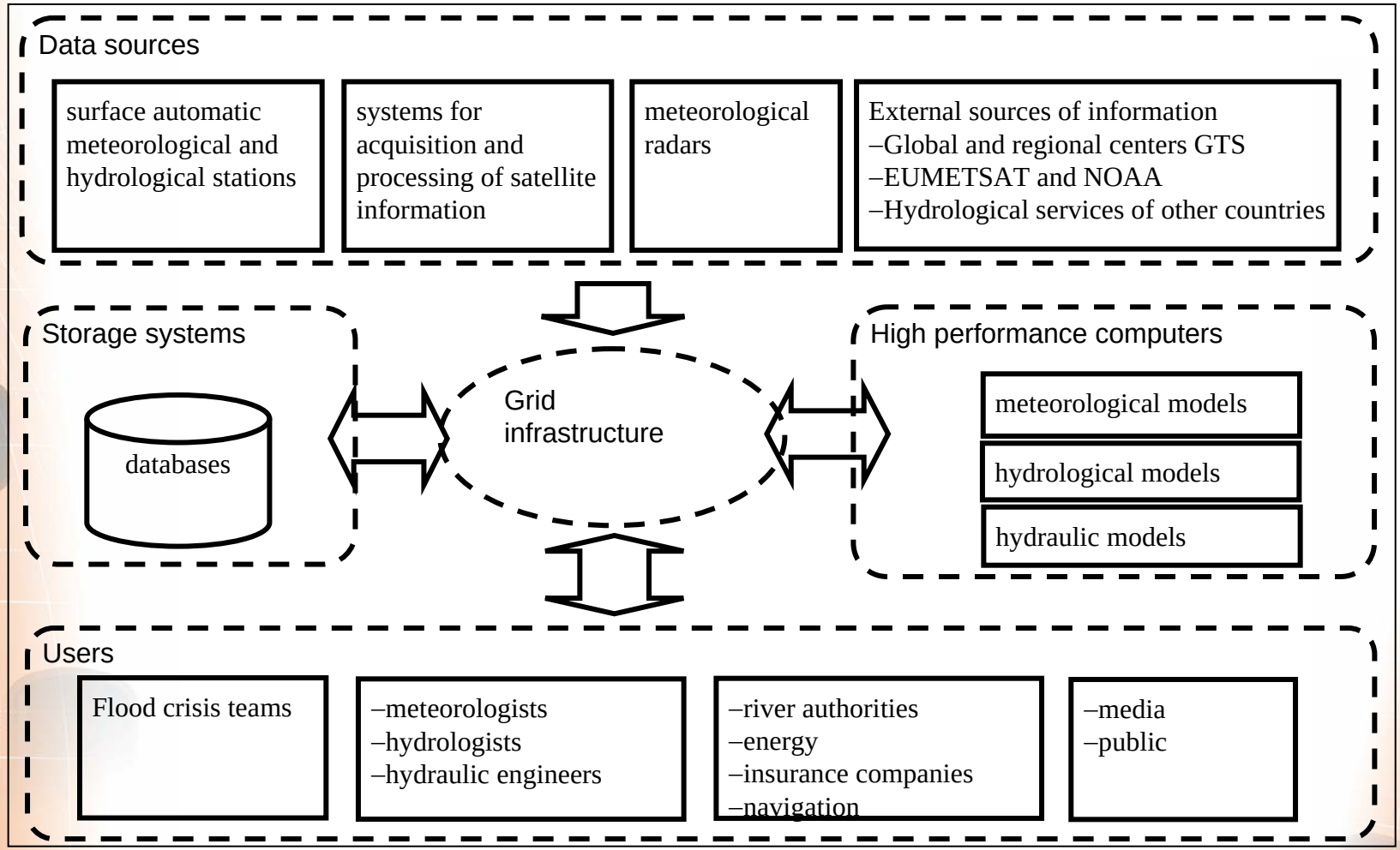


Simulation Output

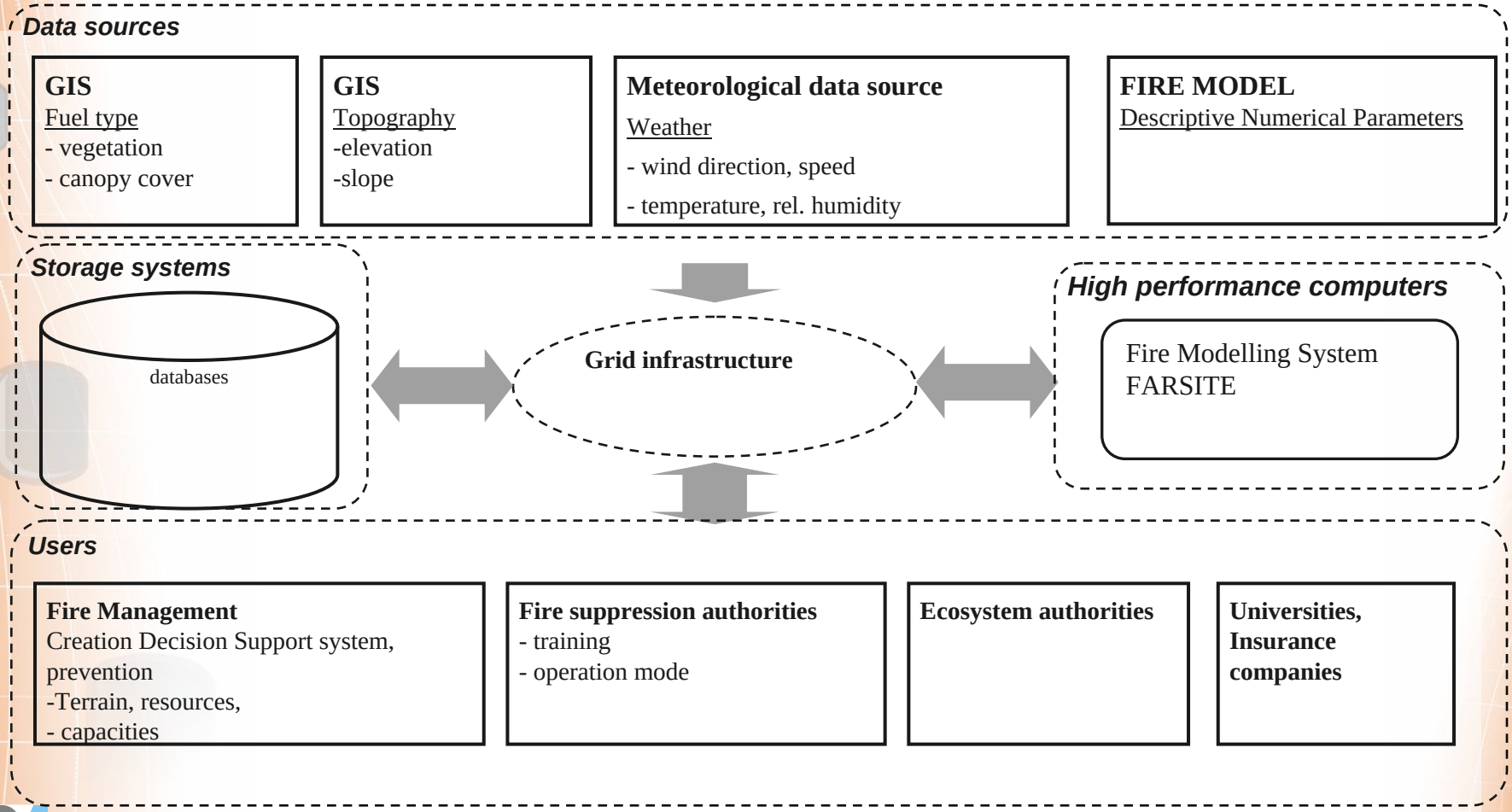
Testbed



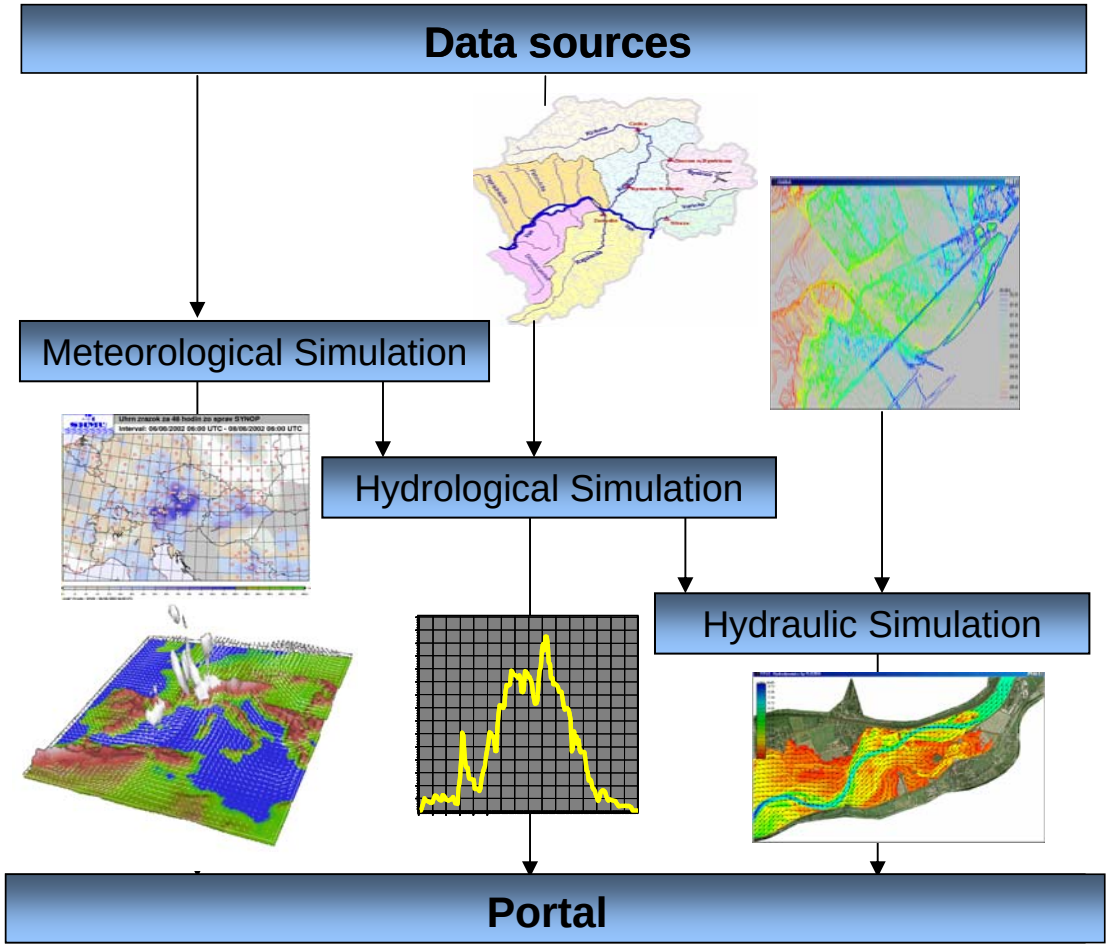
Flood Forecasting VO



Virtual Organization for Fire Simulation



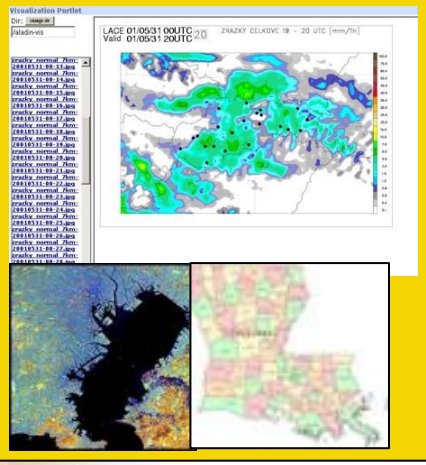
Flood forecasting problem



MEDIGRID

Mediterranean Grid of
Multi-risk data and Models

Web portal



DATA
Locate (find) input data
Access data
Get data
Transfer data to the PN

PROCESSES
Locate process
Execute process

Visualization of maps and tables

Testbed

- Meteorological data
- Soil properties

Data warehouse

Erosion

Proccess node

- Fire station
- Flood

Proccess node

- Hydrological data
- Fire Maps

Data warehouse

- TempSim
- RHSim
- NUATMOS
- Fire propagation-1

Proccess node

Objectives

MEDIGRID - Mediterranean Grid of Multi-risk data and Models

- Create a distributed framework for multi-risk assessment of natural disasters
- Make the models and data accessible via internet in a secure manner for all partners
- Create a distributed repository with earth observation data, combined with field measurements
- Models for:
  - simulation of forest fire behavior and effects
  - flood modeling and forecasting
  - landslides and soil erosion simulations

Partners

- **Algosystems SA,** Greece - ***coordinator***
- **Associação para o Desenvolvimento da Aerodinâmica (ADAI),** Portugal
- **Entente Interdépartementale en vue de la Protection de la Forêt et de l'Environnement contre l'Incendie (EIPFEI/CEREN),** France
- **Tecnoma SA,** Spain
- **Institute of Informatics, Slovak Academy of Sciences (II SAS),** Slovakia
- **University of Newcastle Upon Tyne,** United Kingdom

MeteoDataRes

meteo_1
meteo_2

TerainDataRes

soil_1
soil_2

Hydraulics

Hydrology

Information Society Technologies

Meteo

Hydrology

FloodDataRes

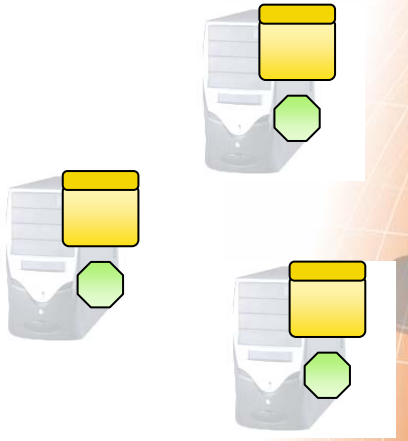
soil_type_4
terrain_5

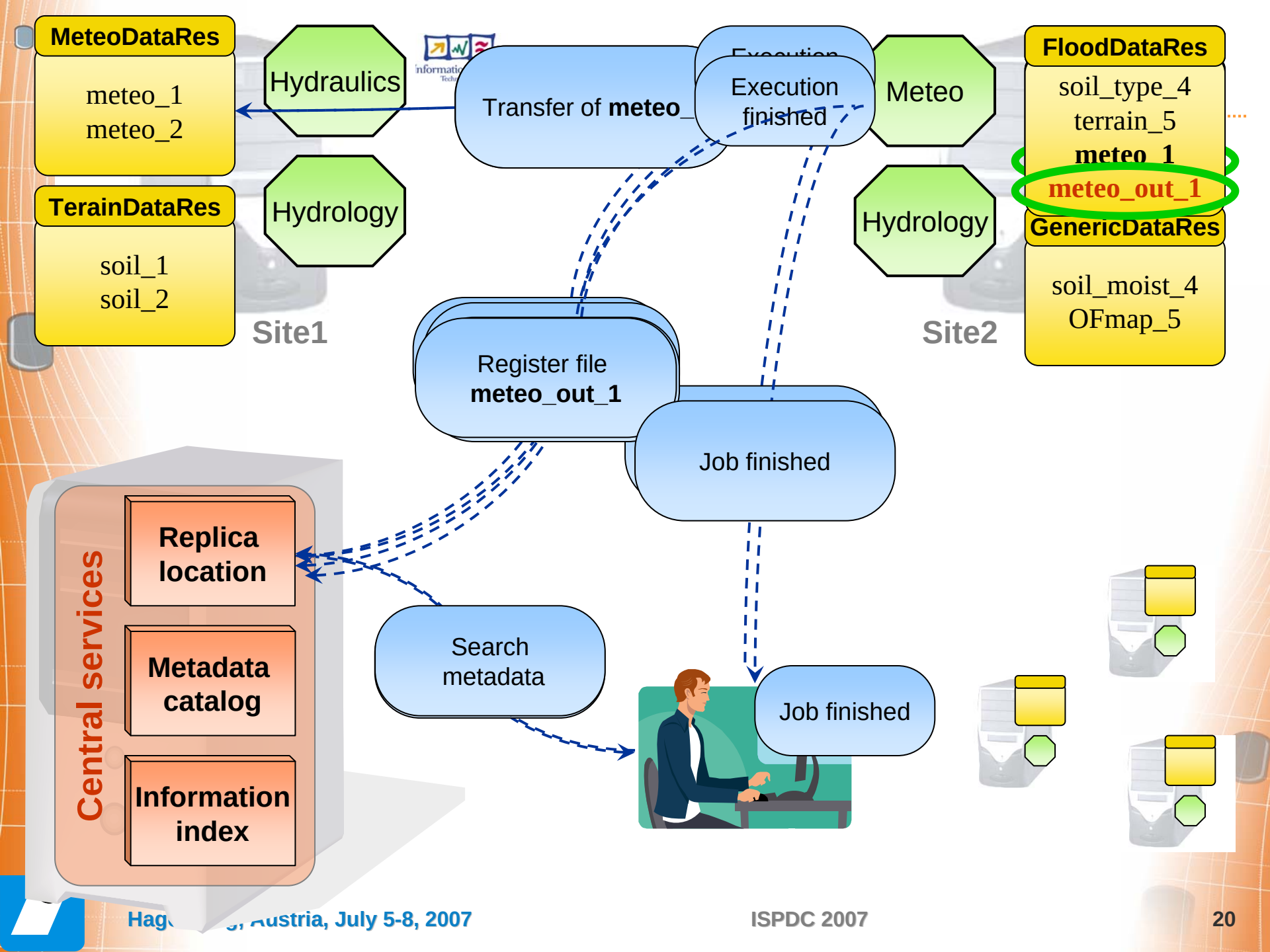
GenericDataRes

soil_moist_4
OFmap_5

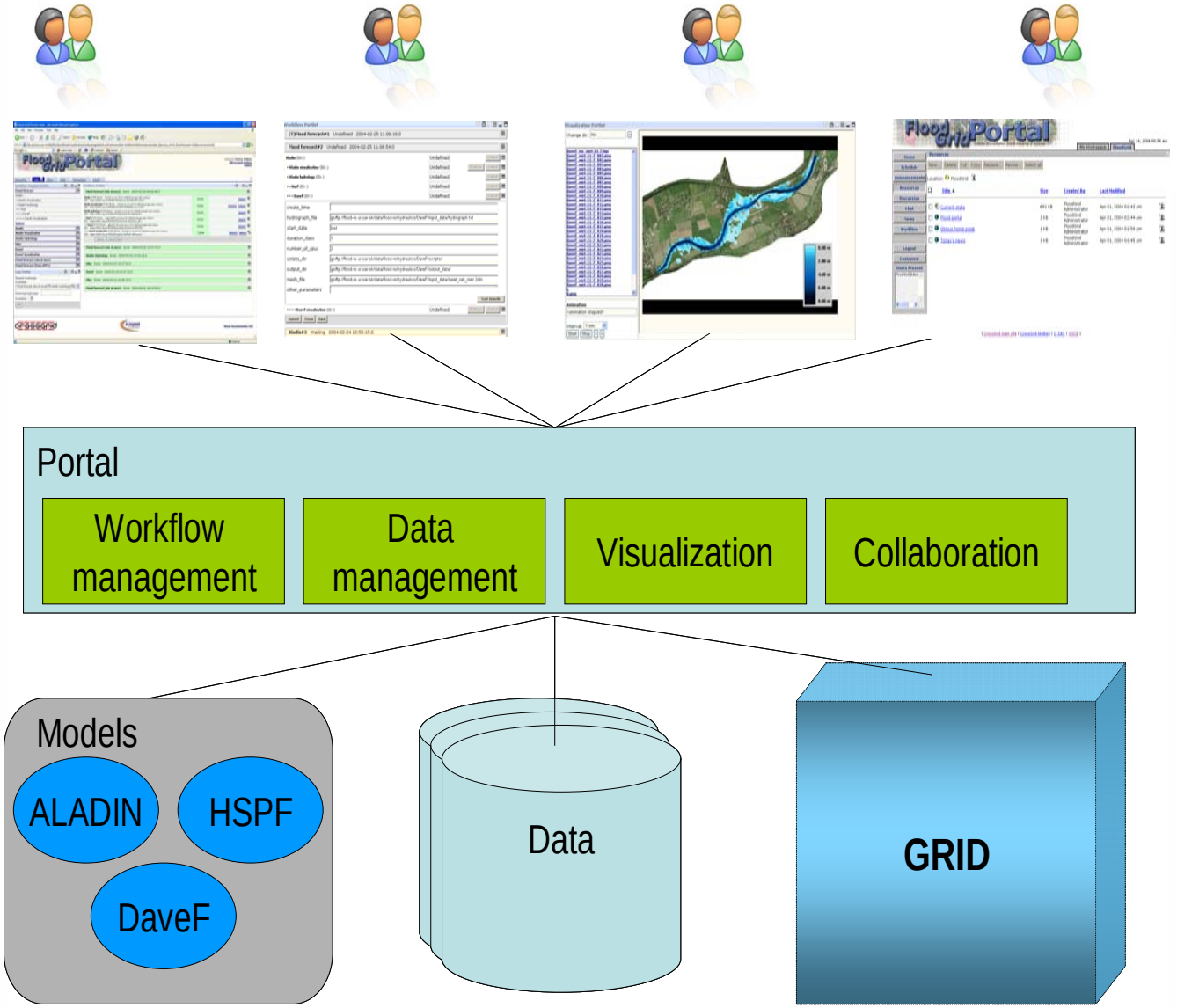
Central services

- **Replica location**
- **Metadata catalog**
- **Information index**

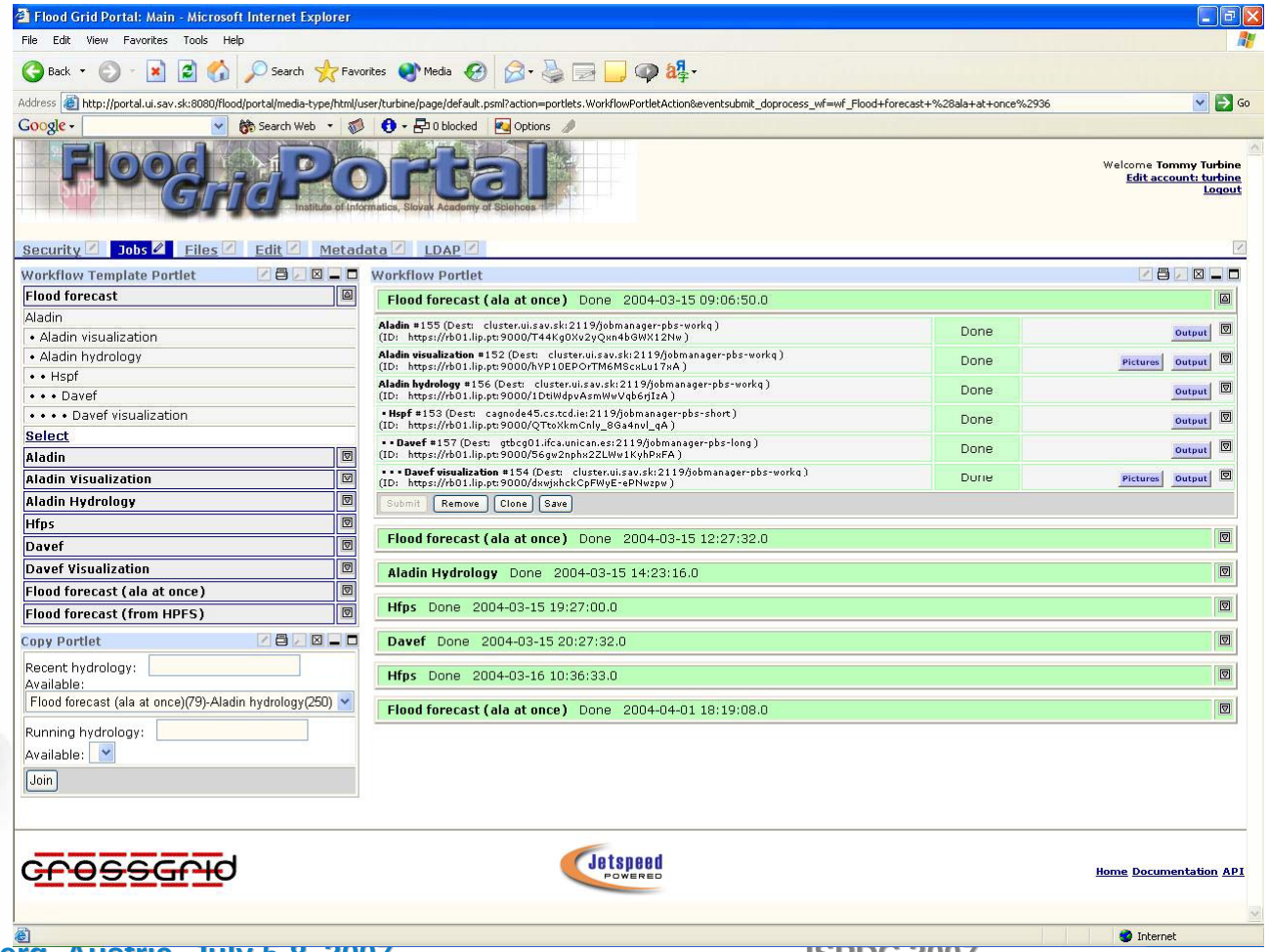



MeteoDataRes
meteo_1
meteo_2
TerainDataRes
soil_1
soil_2
Hydraulics
Hydrology
Transfer of meteo_
Execution finished
Meteo
Hydrology
FloodDataRes
soil_type_4
terrain_5
meteo_1
meteo_out_1
GenericDataRes
soil_moist_4
OFmap_5
Site1
Site2
Register file
meteo_out_1
Job finished
Central services
Replica location
Metadata catalog
Information index
Search metadata
Job finished

FloodGrid Portal



FloodGrid Portal



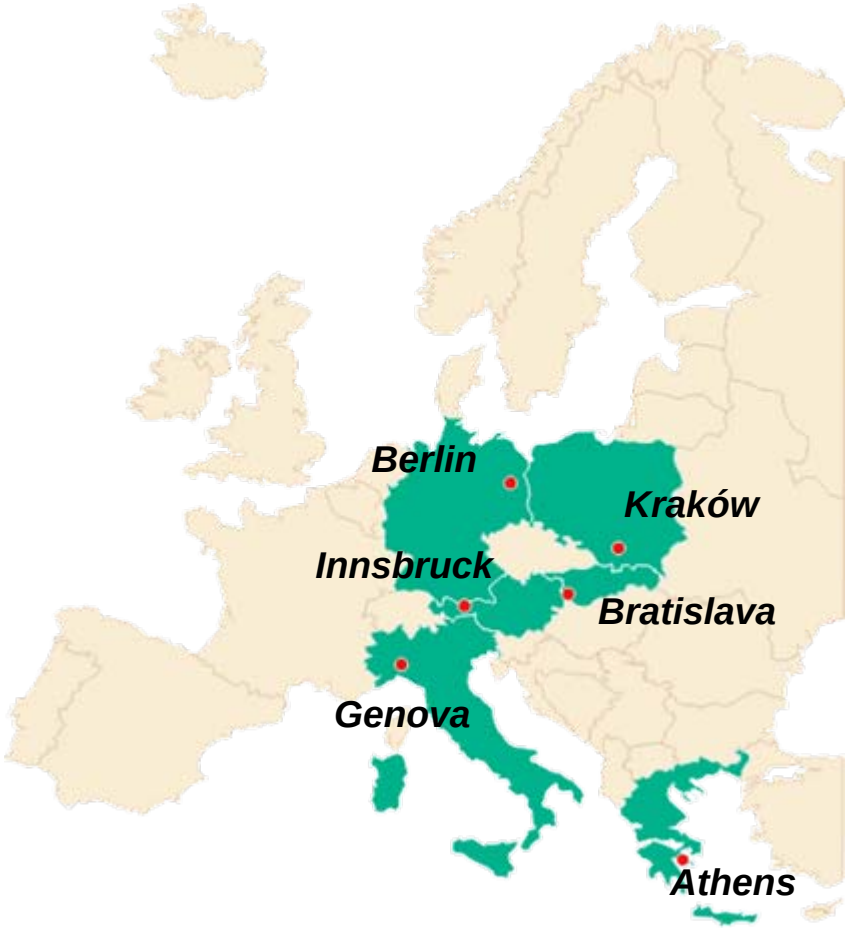
K-Wf Grid - Objectives

- **To enable users to** create complex workflows **and use grid resources without detailed knowledge of grid**
- **To construct workflows optimized for underlying infrastructure,** using its advantages and avoiding its bottlenecks
- **To (semi-)automatically** construct workflows based on user's requirements**, using semantic annotation of services, data, applications and resources**
- **To constantly renew information about the grid by using complex monitoring network –** to learn from experience
- **To provide** simple, easy-to-use interface **to K-Wf Grid services**

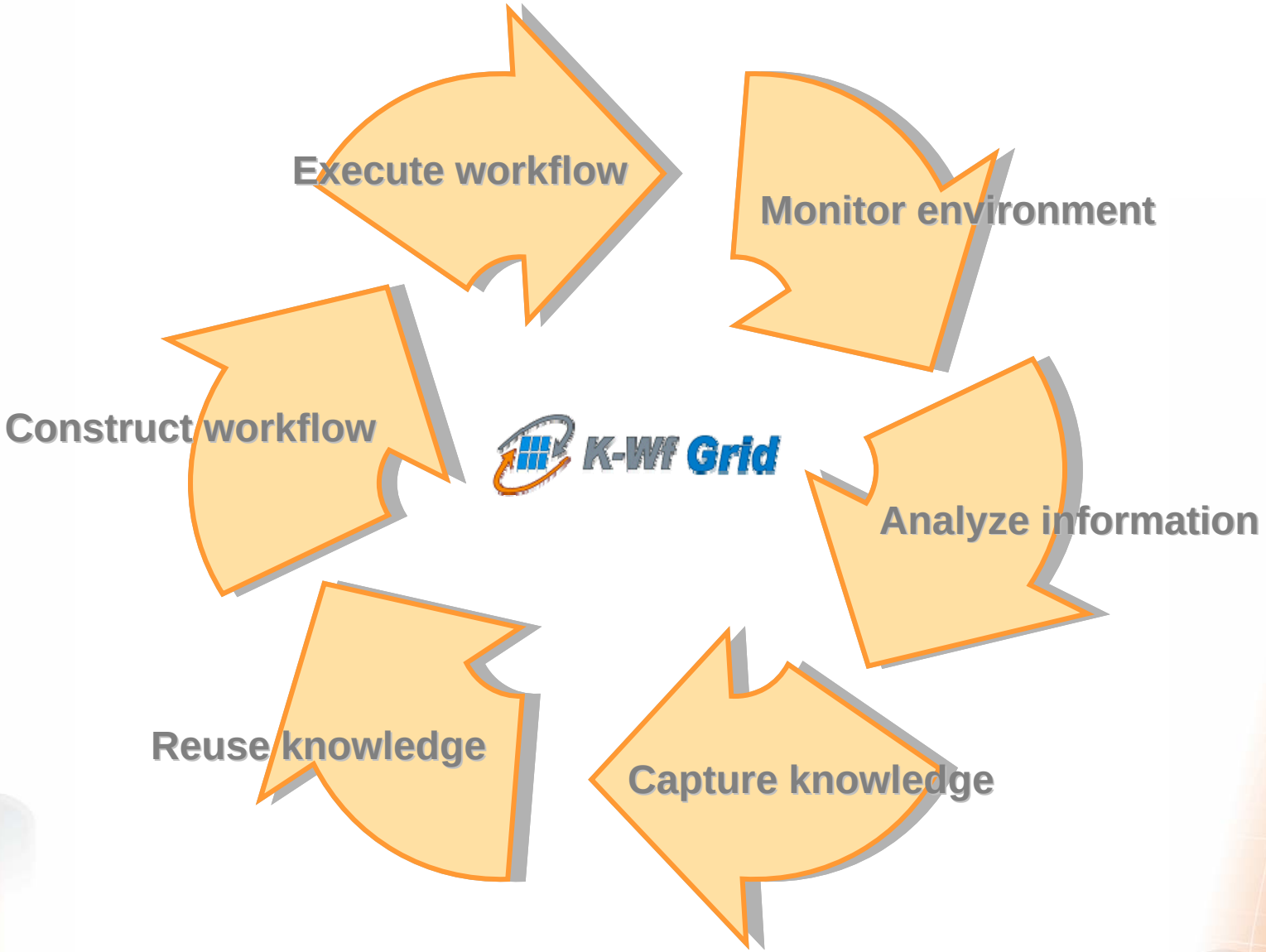
K-Wf Grid - Partners

- Fraunhofer FIRST (Berlin, Germany)
- UIBK (Innsbruck, Austria)
- IISAS (Bratislava, Slovak Republic)
- CYFRONET (Cracow, Poland)
- LogicDIS S.A. (Athens, Greece)
- Softeco Sismat SpA (Genoa, Italy)

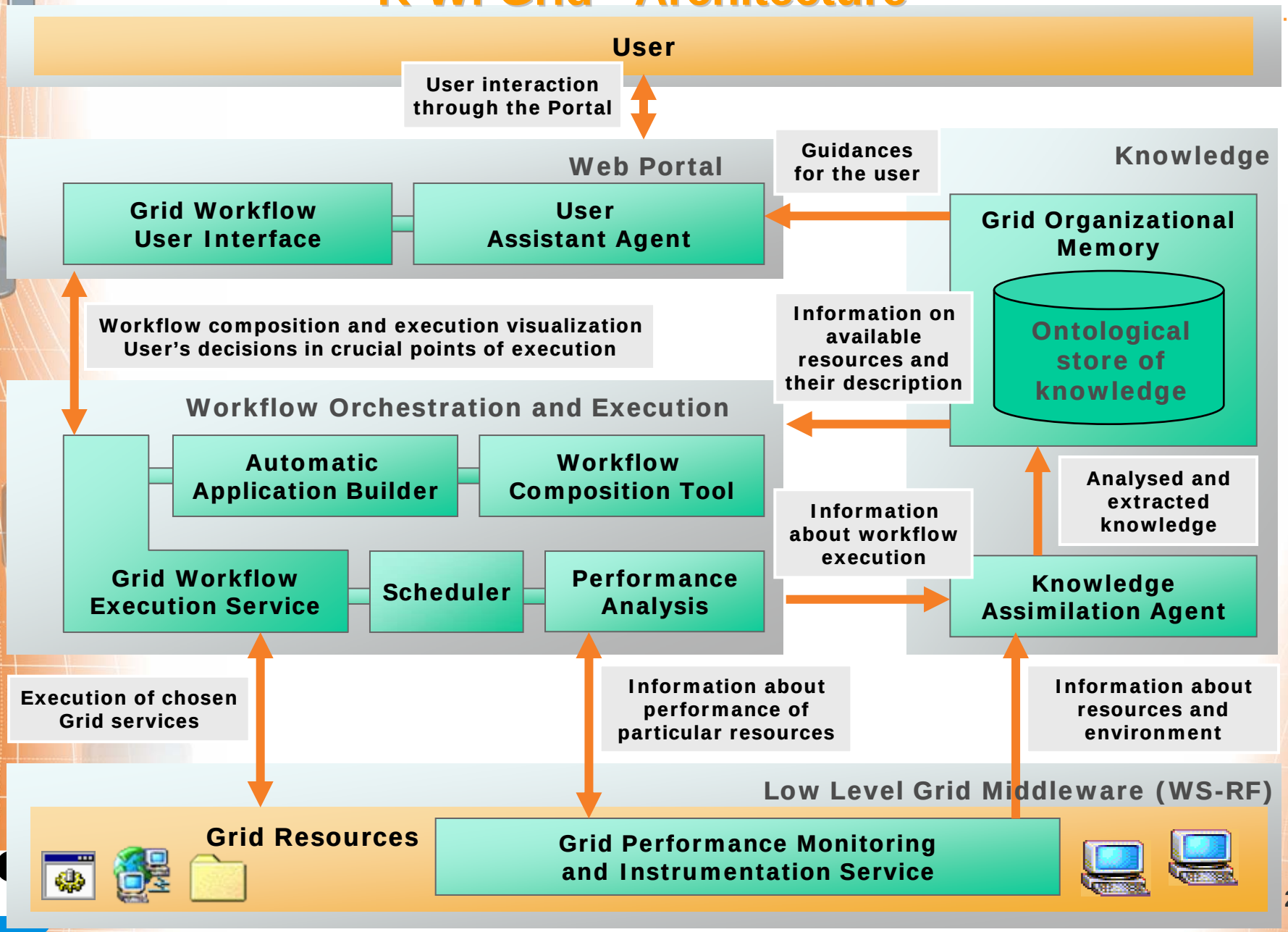
K-WfGrid Consortium



K-Wf Grid: Concept



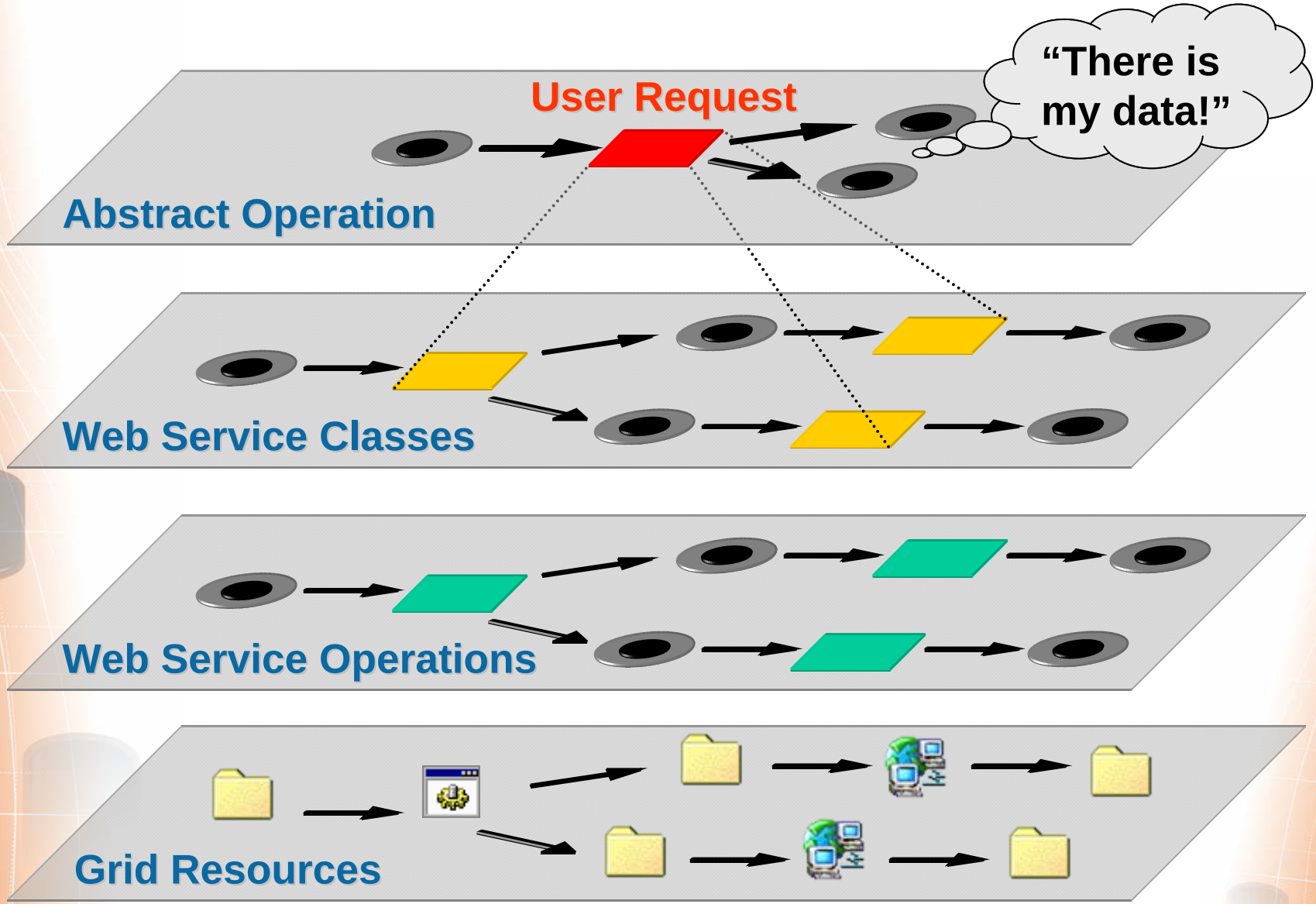
K-Wf Grid - Architecture

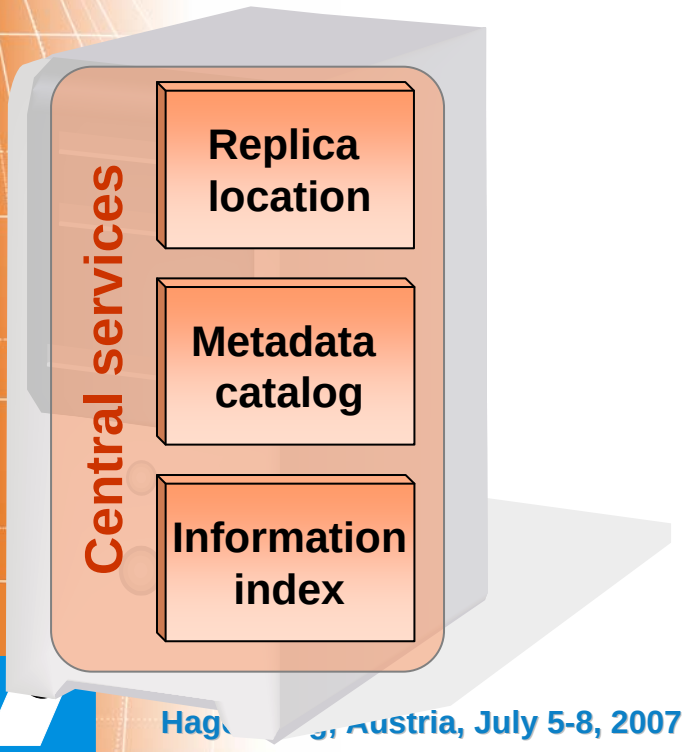


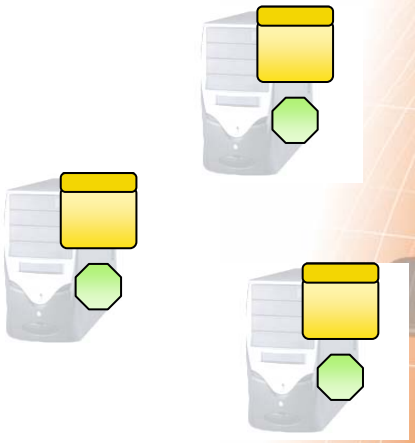
K-Wf Grid: Advantages

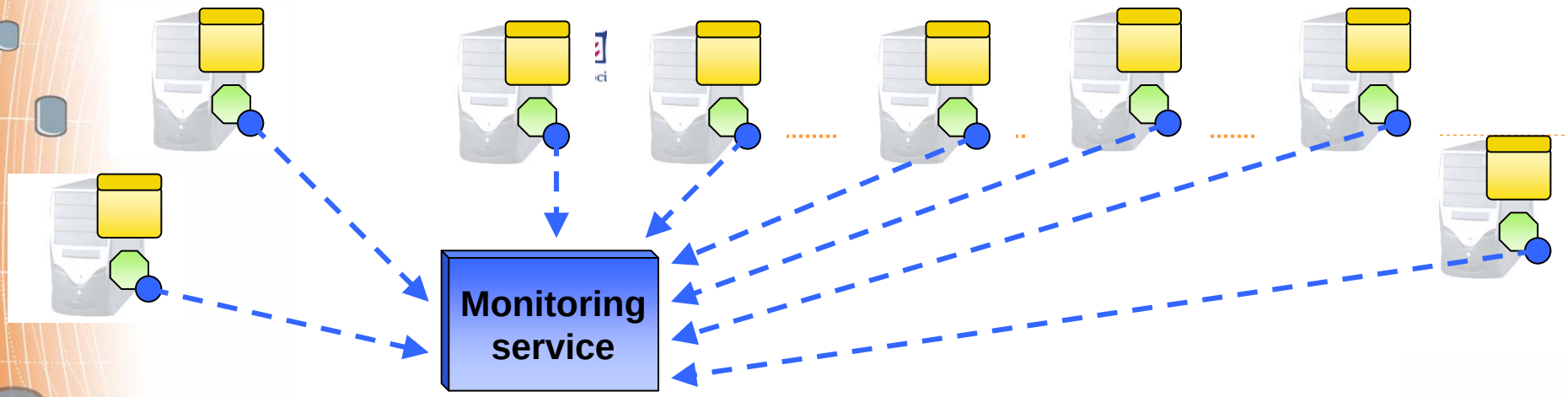
- **Composition of workflow from a set of services**
  - System composes the workflow for you – just tell him **what you want to get at the end**
  - System uses services which are **available at the time** and which are expected (based on past experience) to provide good results (good = what you want)
- **Usability**
  - Less grid language, more application domain language
  - Integrated collaboration interfaces
- **Reuse of components**
  - K-Wf Grid is based on respected standards

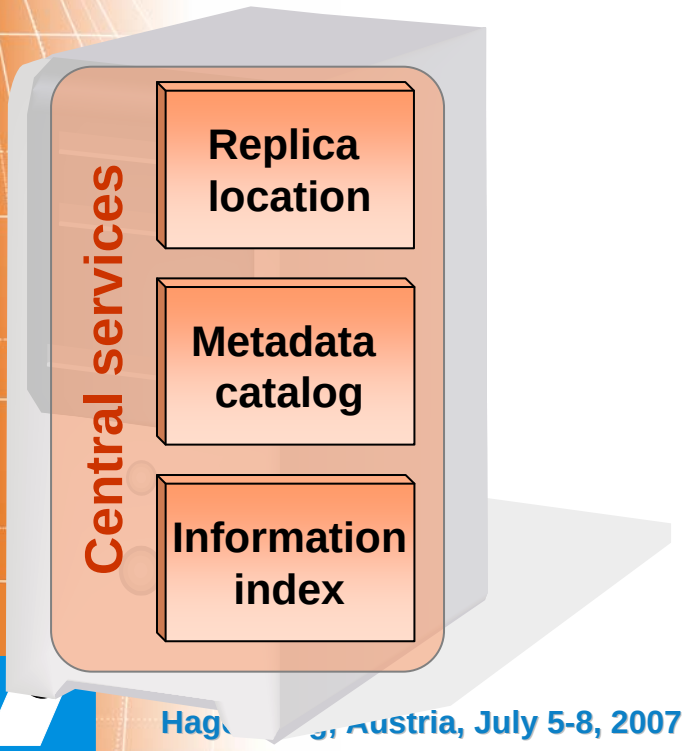
K-Wf Grid: Workflow Refinement

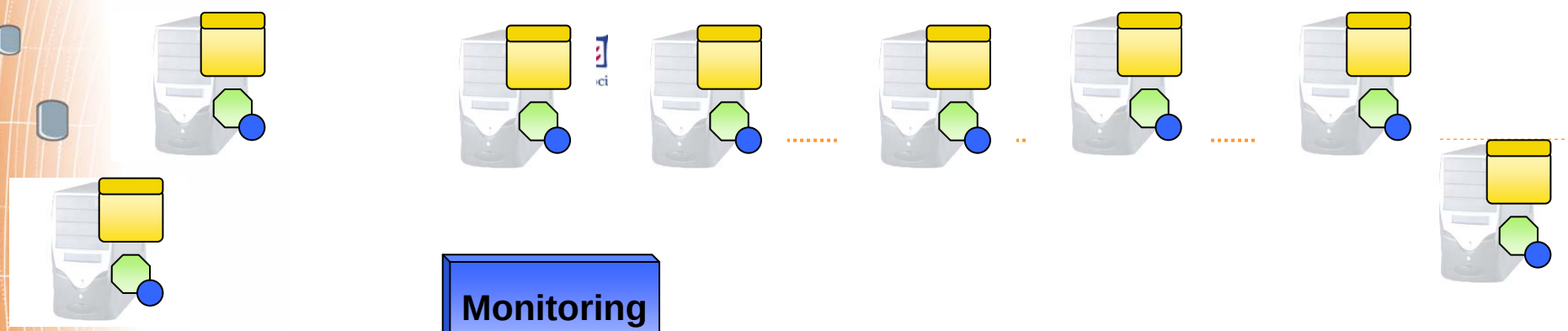



Central services
Replica location
Metadata catalog
Information index




Monitoring service


Central services
Replica location
Metadata catalog
Information index



Monitoring service

Information processing

Knowledge store

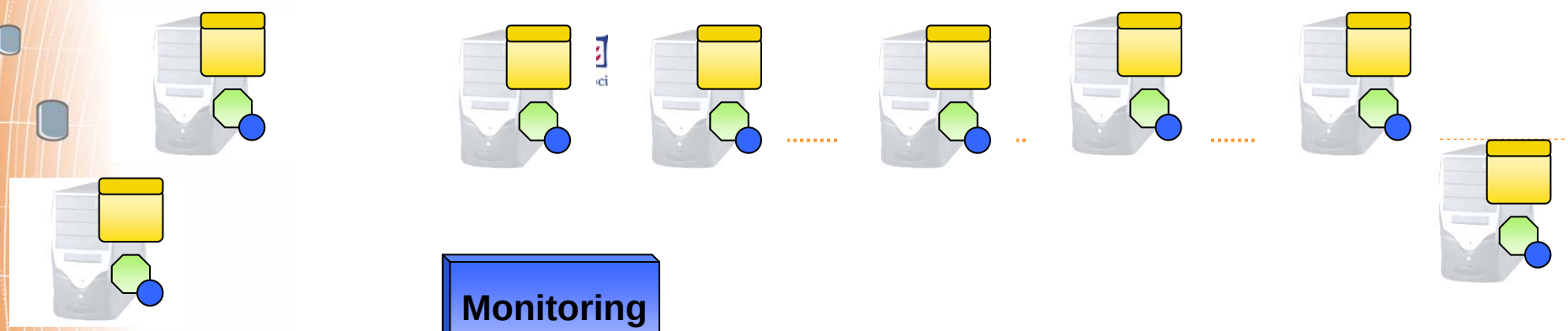
Workflow management

Central services

Replica location

Metadata catalog

Information index



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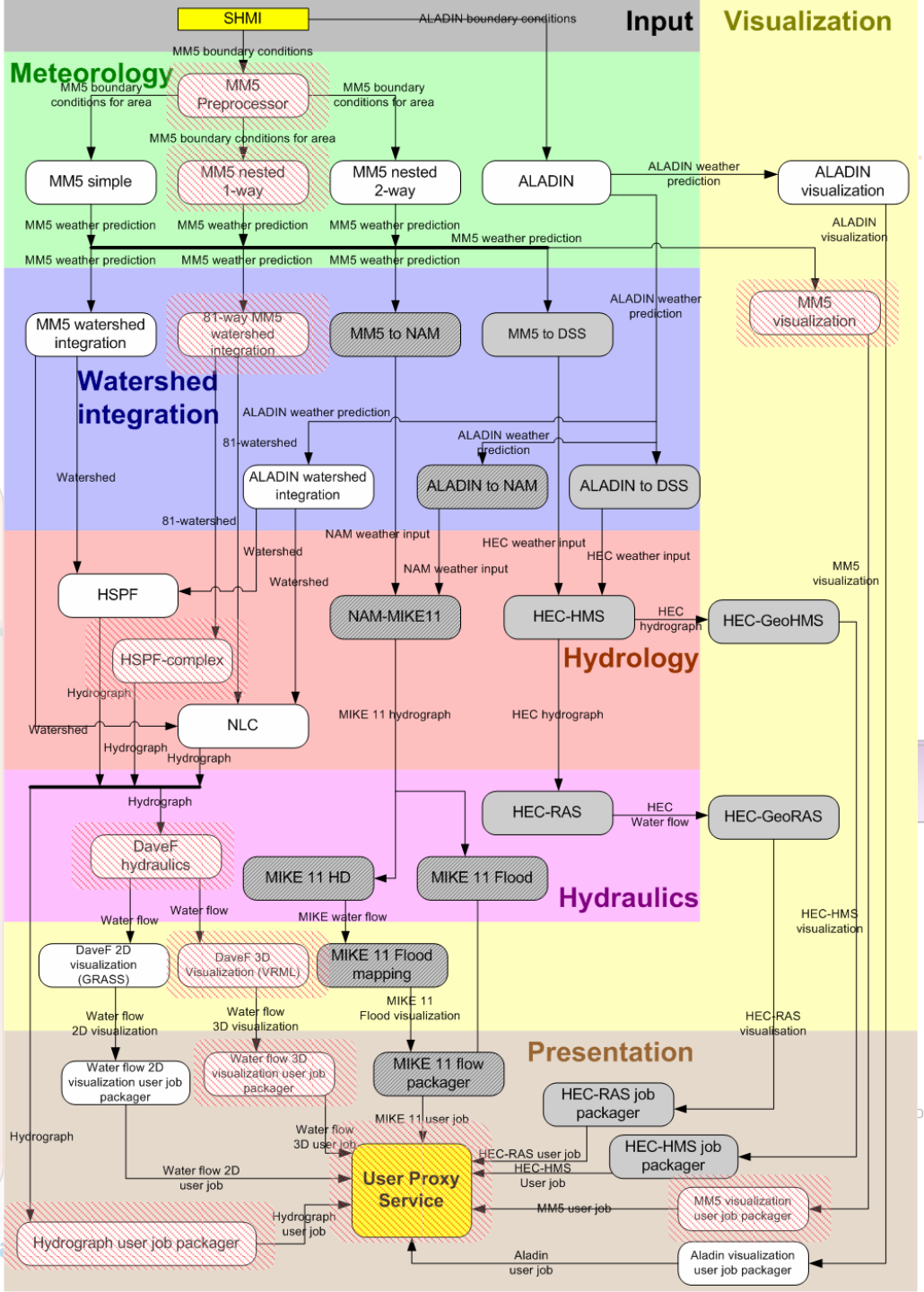

Knowledge store

Replica location

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Information index

Central services

Execute workflow

Monitor environment

Analyze information

Capture knowledge

Reuse knowledge

Construct workflow

K-WF Grid

Monitoring service

Central services

Knowledge store

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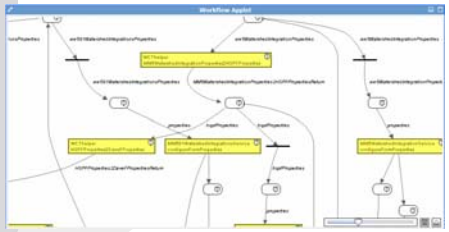

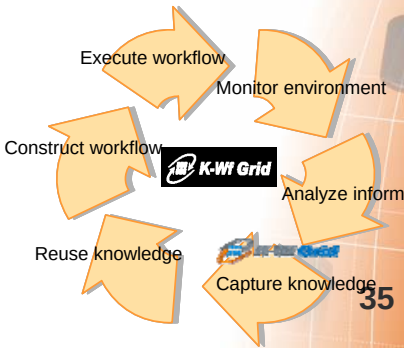

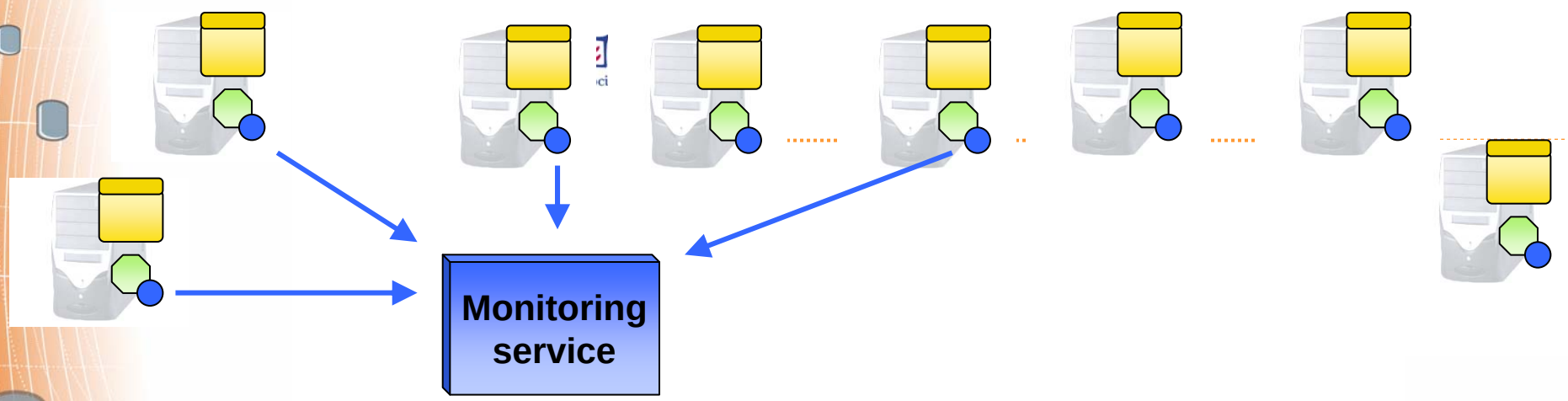

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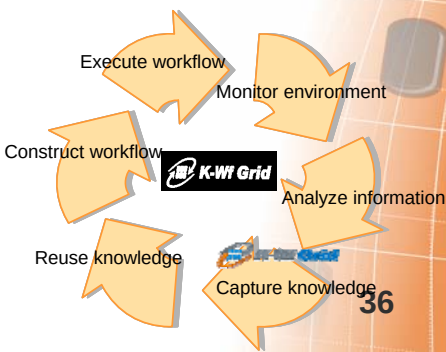

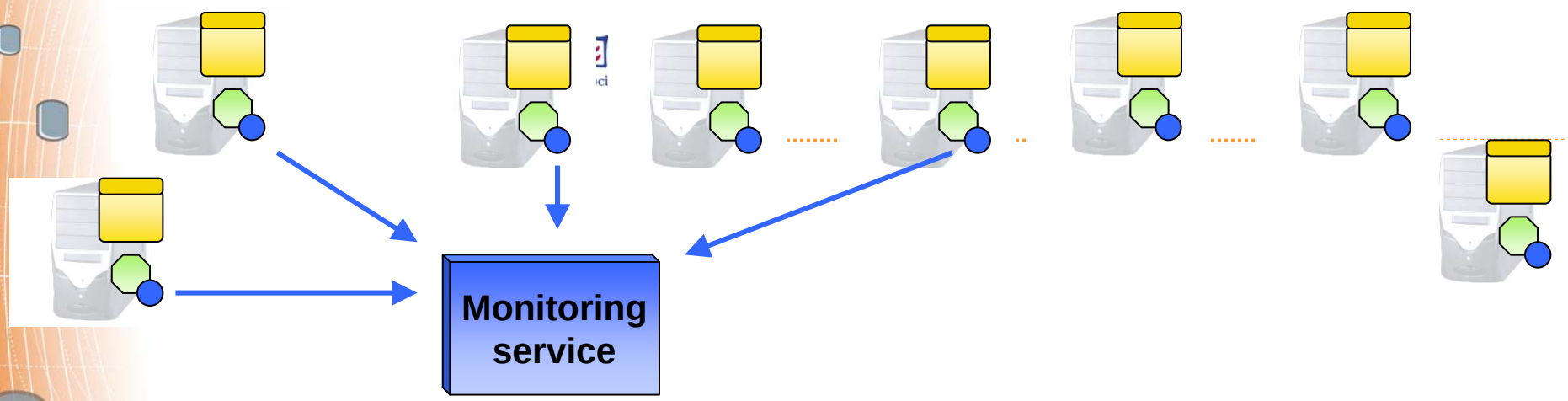

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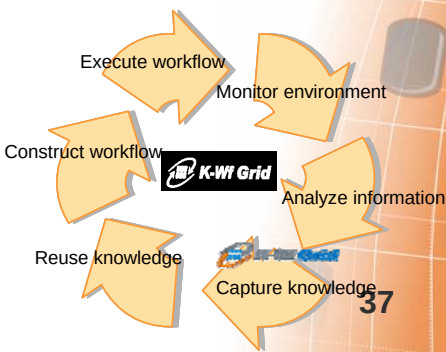

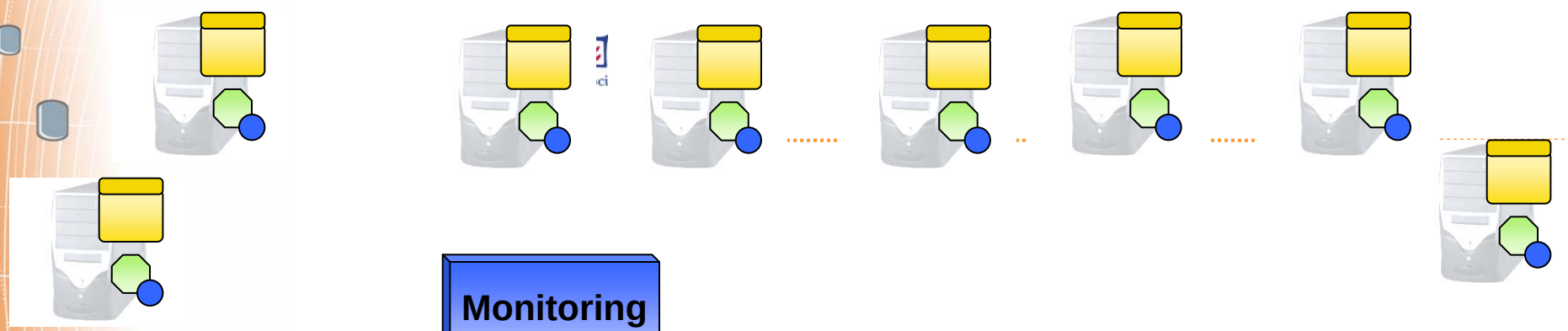

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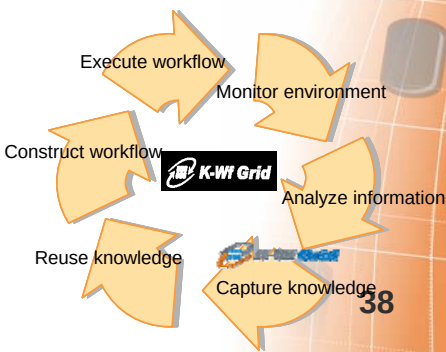

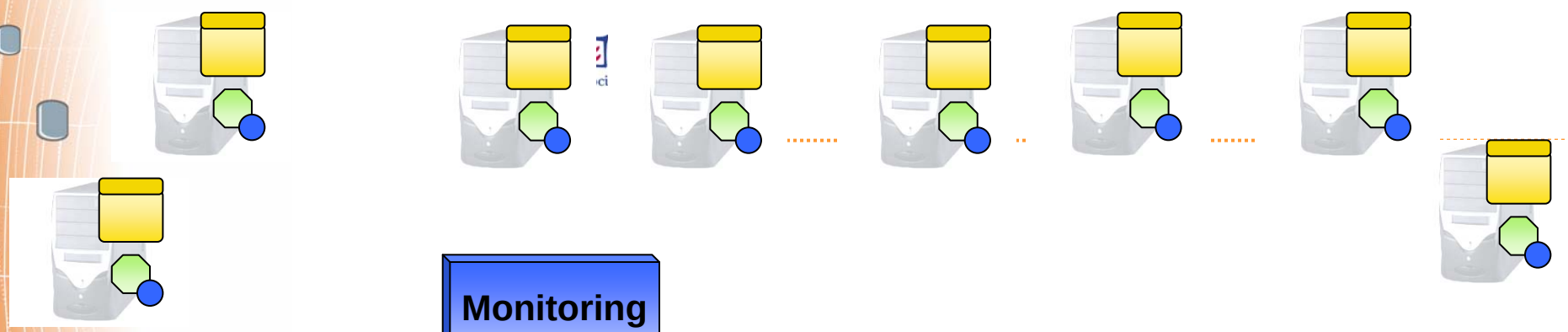

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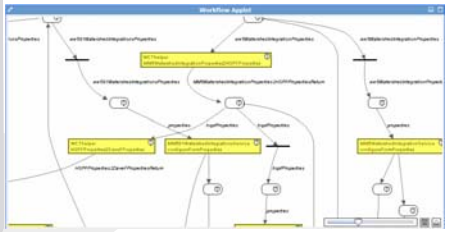

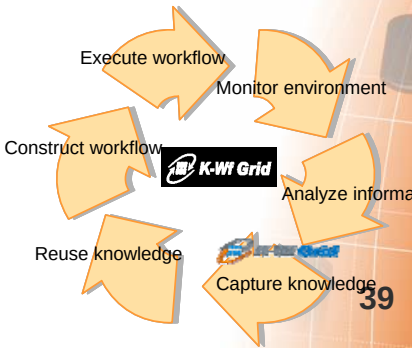

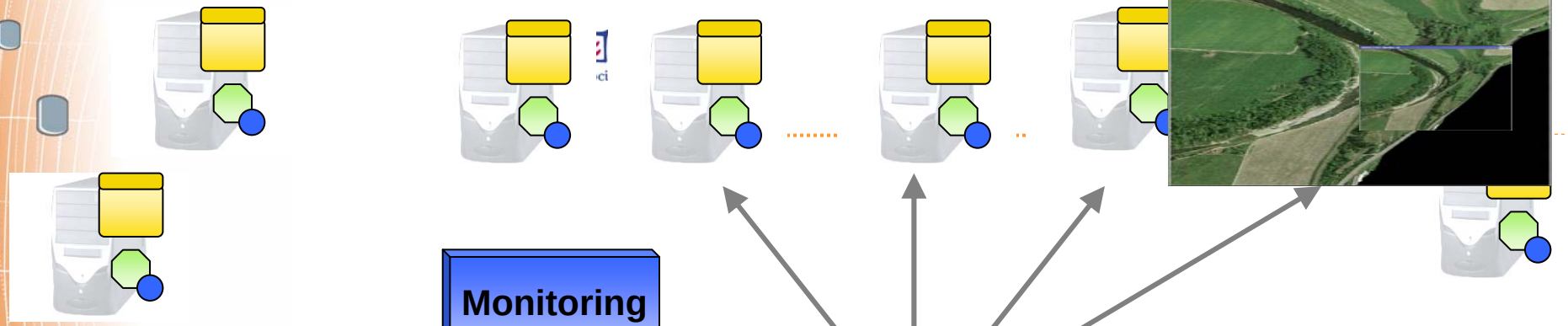

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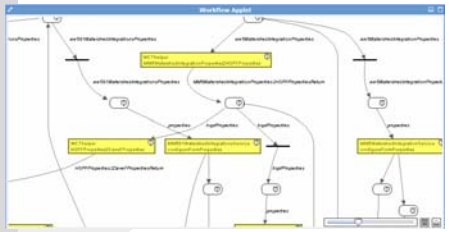

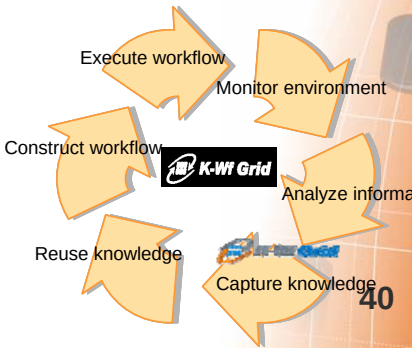

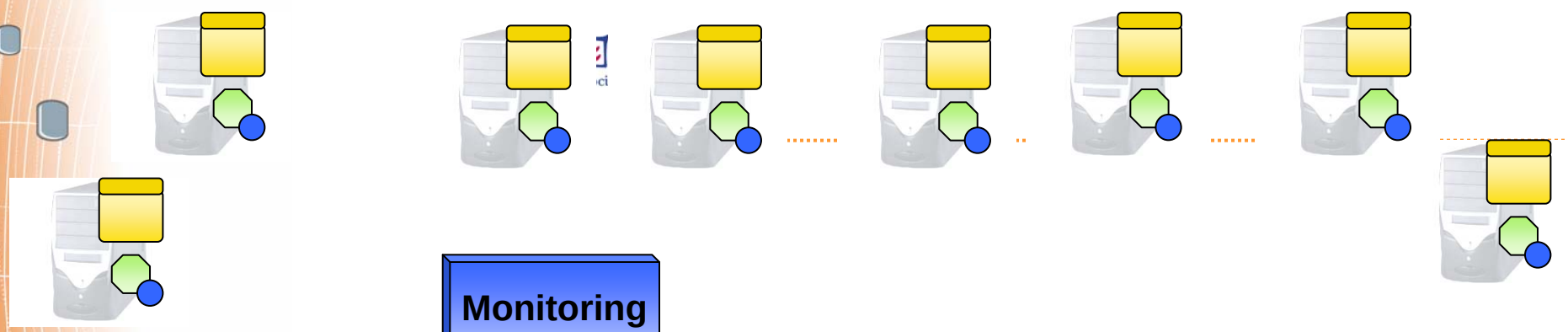

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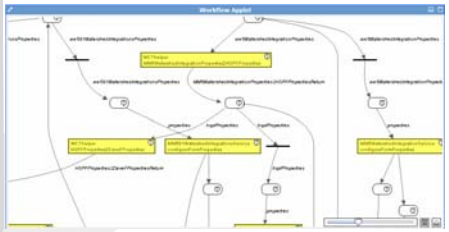
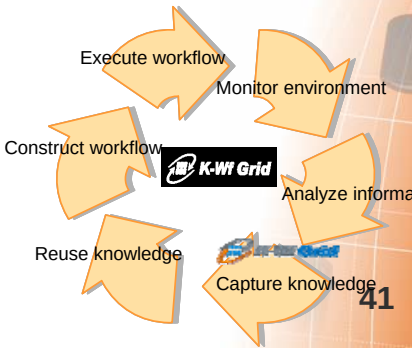
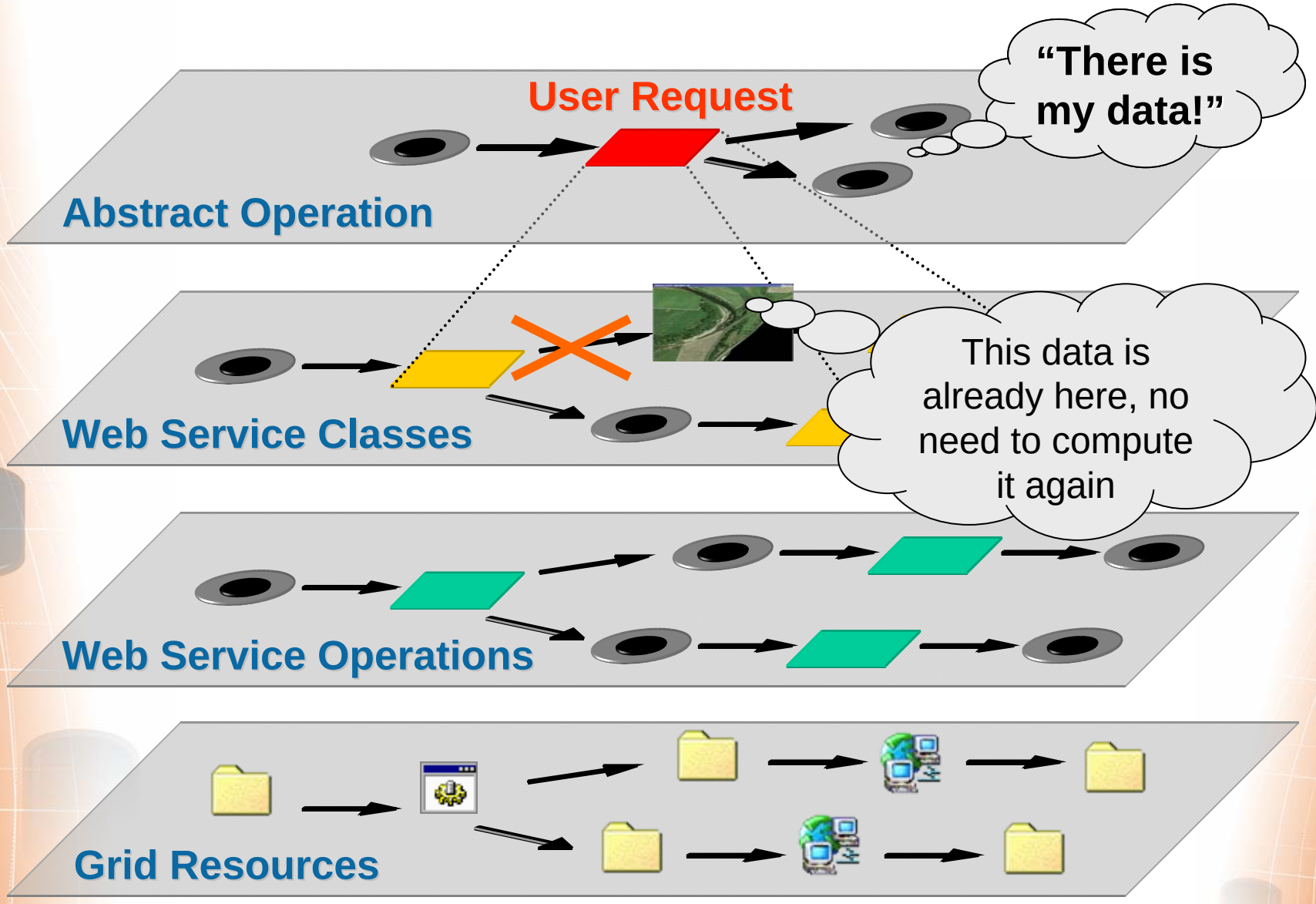




Process of Workflow Refinement

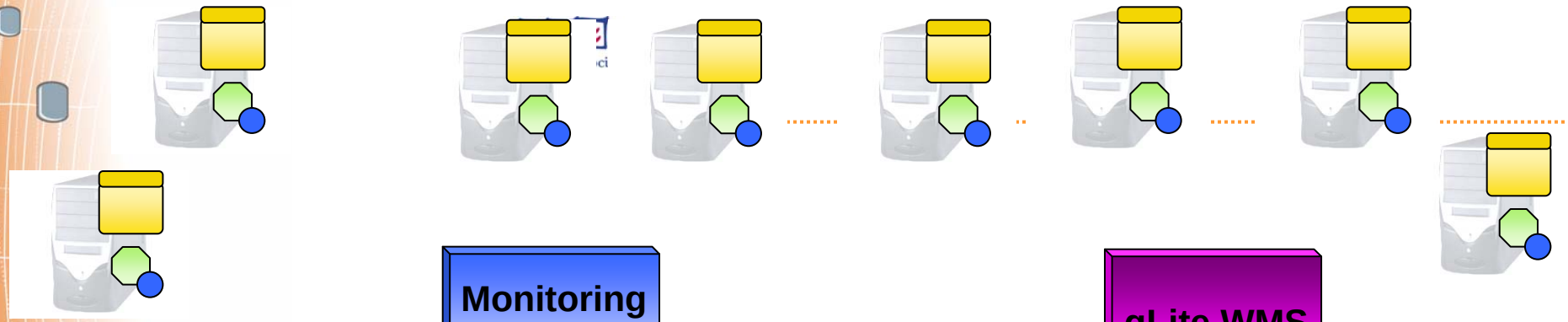


Required Advancements

- **Automated metadata construction and processing**
- **Using existing data in workflow construction**
  - Significant extension of OWL-S
  - Implementation of new OWL-S engine
- **Standard-based workflow construction**
  - BPEL4WS – using ontologies
  - Modelling of stateful resources (WS-RF)

Porting to gLite

- **In K-Wf Grid, applications are implemented as WSRF services**
- **In gLite, the services are replaced by a set of worker jobs that are submited by workflow manager via gLite WMS**
  - When started, the worker jobs will contact to workflow manager for executing tasks



Monitoring service

gLite WMS

Knowledge store

Information processing

Workflow management

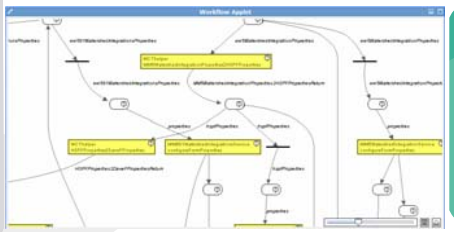
Replica location

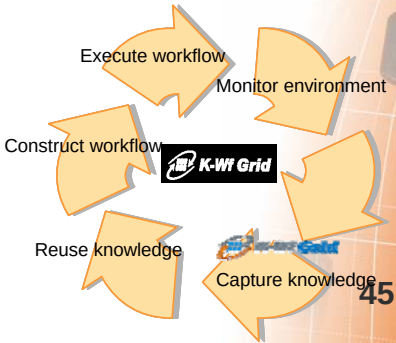
Portal

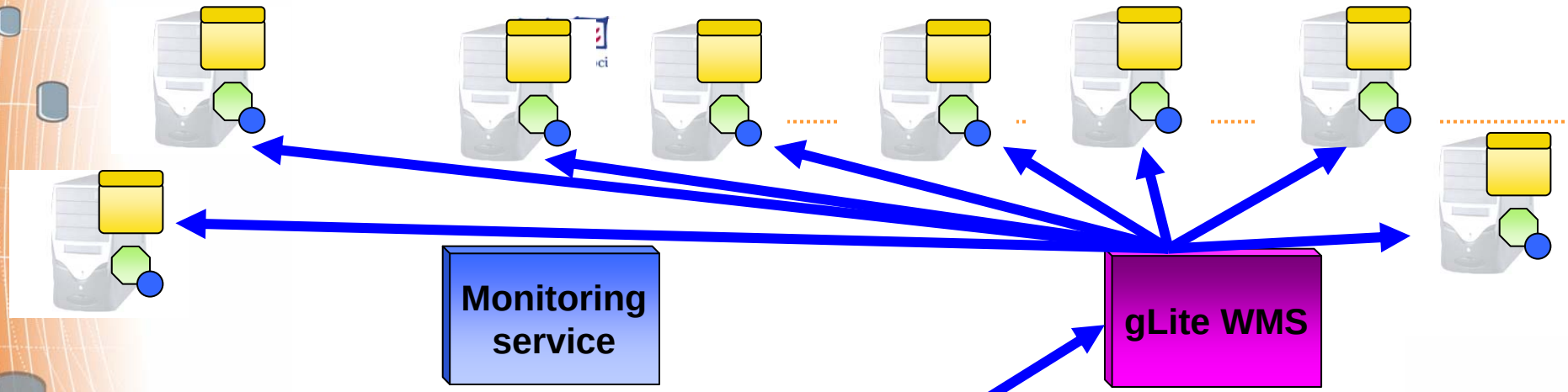
Metadata catalog

Information index

Central services







Central services

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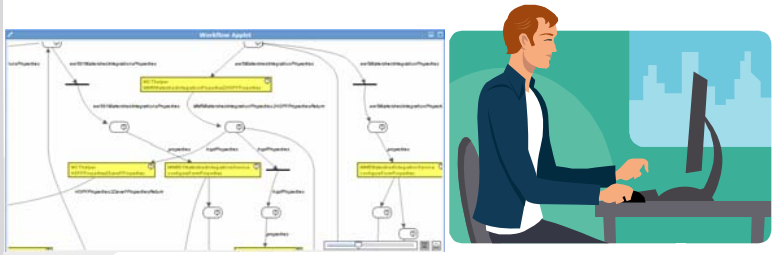
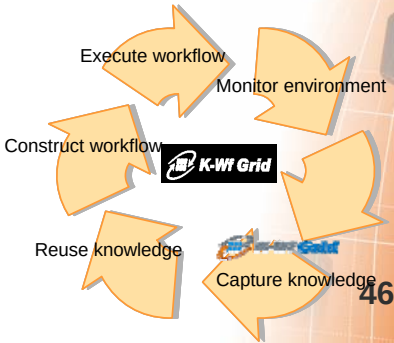




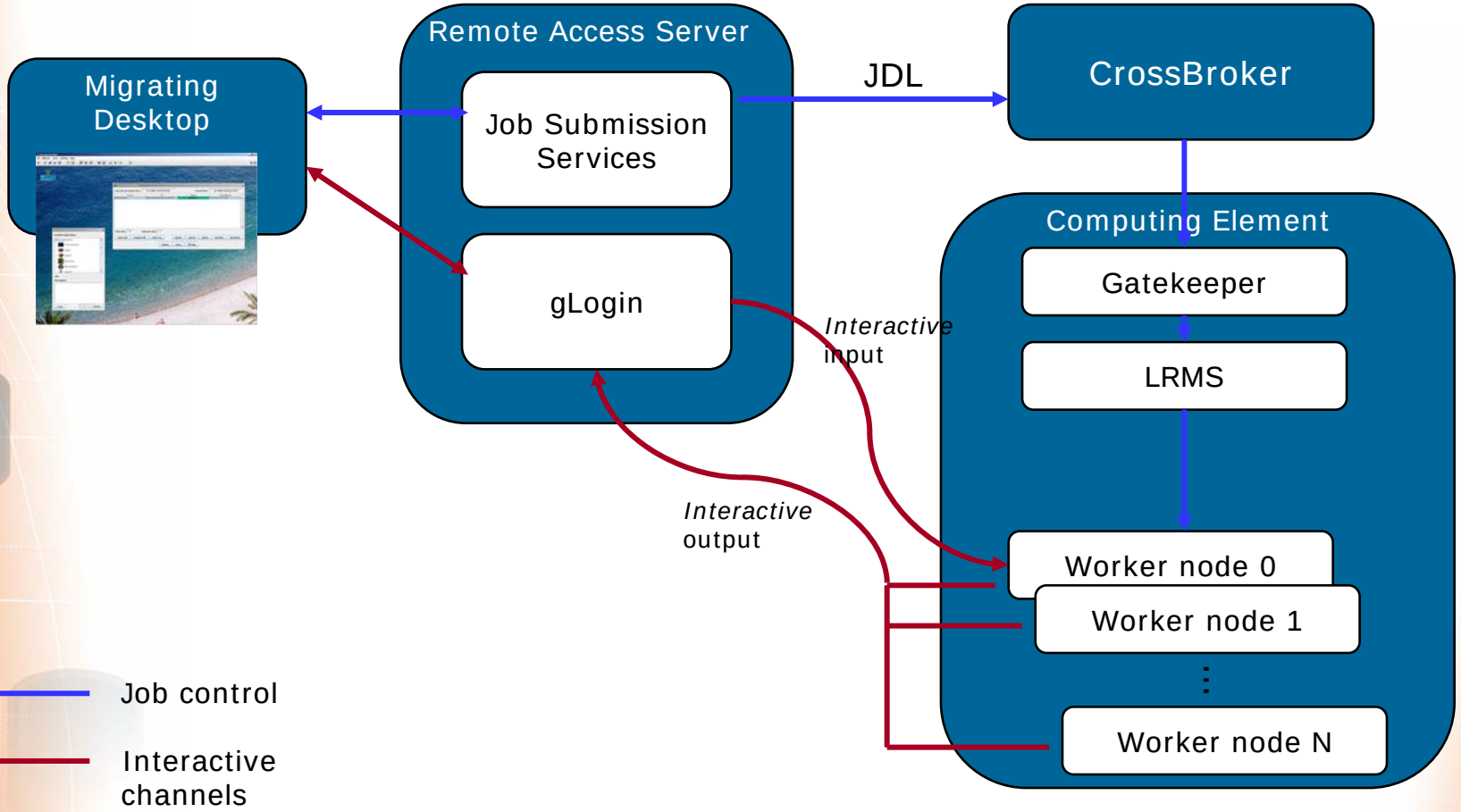
Int.eu.grid

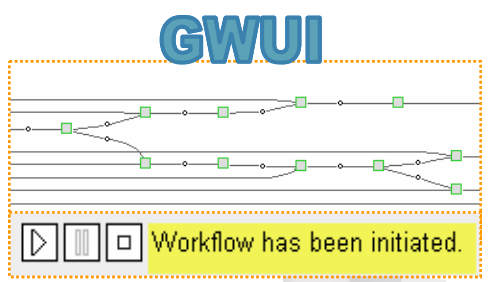
- **Goals**
  - Deploy and operate an interoperable production-level e-Infrastructure for demanding interactive applications
  - Distributed (MPI-) parallel interactive computing and storage at Tera level
  - User friendly access through a interactive Grid desktop
  - Support for virtual organizations at all levels:
    - Setup, Collaborative environment, Grid enhancement of applications, Execution and monitoring tools
- **Project details**
  - Project start: May 1, 2006
  - Project duration: 24 months
- *Contribution of UI SAV*
  - Operation of computer cluster with 32 CPUs and 32GB RAM as part of the project production testbed
  - User support, organization of tutorials and users' trainings
  - Support for environmental applications and their users
  - Implementation of interactivity to flood simulation application
  - Support for gridification and interactivity of radiocative pollution simulation aplication (owned by MicroStep-MIS)

Int.eu.grid - Partners

- BIFI, Zaragoza/Spain
- CESGA, Santiago de Compostela/Spain
- CSIC-IFCA, Santander/Spain
- CYFRONET, Cracow/Poland
- FZK, Karlsruhe/Germany
- GUP, Linz/Austria
- HLRS, Stuttgart/Germany
- ICM, Warsaw/Poland
- LIP, Lisbon/Portugal
- PSNC, Poznan/Poland
- TCD, Dublin/Ireland
- UAB, Barcelona/Spain
- UI SAV, Bratislava/Slovakia

Int.eu.grid - Interactivity





GWES

MM5 DAVEF HSPF

Migrating Desktop

Control

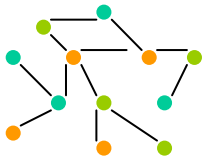
Output/visualizations /state

Interactive job

Information Society Technologies

int.eu.grid

GWES



Ontology of modules and data

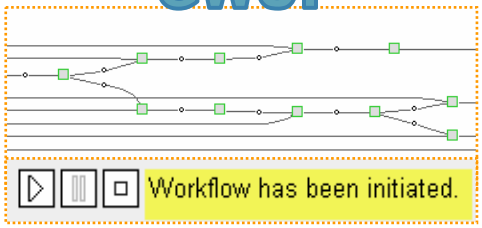
Construction of workflows

Execution of workflows

Monitoring of workflows

Migrating Desktop

GWUI



Control

Output/visualizations

Interactive job

GWES

MM5 DAVEF HSPF

Flood Interactivity in Int.eu.grid

- **Job is internally controlled by a workflow manager**
  - Job steps can be added/removed during runtime
  - Can be paused/restarted/modified
- **Job outputs/visualized data are available through the MD interface**
- **Job may be cloned**
  - State = workflow state + intermediate data, may be easily transferred
  - Good for parameter studies

Challenges for grid infrastructures

- **Current research focuses on SOKU (Service Oriented Knowledge Utilities)**
  - K-Wf Grid is one of the early implementations of SOKU concepts
  - How to adapt infrastructure research to this shift in paradigm?
- **Application developers & end users need easy access to grid infrastructure**
  - SOKU is the way to achieve this
  - How to extend gLite towards SOKU?

Information Society Technologies

Thank you!

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Hydraulic modeling

- **FESWMS**
  - supported and used by US Federal Highway Administration
  - distribute in SMS commercial package
  - two-dimensional, time-implicit, finite element models
  - suitable for steady-state simulation
- **DaveF**
  - from the same author like FESWMS
  - two-dimensional, time-explicit, finite volume models
  - suitable for unsteady-state simulation (flood wave)

Governing equations

$$\frac{\partial H}{\partial t} + \frac{\partial (HU)}{\partial x} + \frac{\partial (HV)}{\partial y} = q$$

Mas

Momentum conservation equation in y-direction

$$\frac{\partial (HU)}{\partial t} + \frac{\partial}{\partial x}\left(\beta_{uu} HUU + (\cos\alpha_x \cos\alpha_z)^2 \frac{1}{2} gH^2 \right) + \frac{\partial}{\partial} \left(\beta_{uv} HUV \right)$$

$$+ \cos\alpha_x gH \frac{\partial z_b}{\partial x} - \Omega HV + \frac{1}{\rho}\left(\tau_{bx} - \tau_{sx} - \frac{\partial (H\tau_{xx})}{\partial x} - \frac{\partial (H\tau_{xy})}{\partial y} \right) = 0$$

$$\frac{\partial (HV)}{\partial t} + \frac{\partial}{\partial x}\left(\beta_{uv} HVU \right) + \frac{\partial}{\partial y}\left(\beta_{vv} HVV + (\cos\alpha_y \cos\alpha_z)^2 \frac{1}{2} gH^2 \right)$$

$$+ \cos\alpha_y gH \frac{\partial z_b}{\partial y} + \Omega HU + \frac{1}{\rho}\left(\tau_{by} - \tau_{sy} - \frac{\partial (H\tau_{yx})}{\partial x} - \frac{\partial (H\tau_{yy})}{\partial y} \right) = 0$$

Data needed for modeling

- Topographical data (cross-sections, orthophotomap, LIDAR)
- Roughness conditions
- Hydrological data
- Wind data
- Boundary data
- Calibration and validation data

Complexity

If the simulated area increases 2 times in every dimension (or the distances between two neighbor nodes decrease 2 times for better accuracy), then:

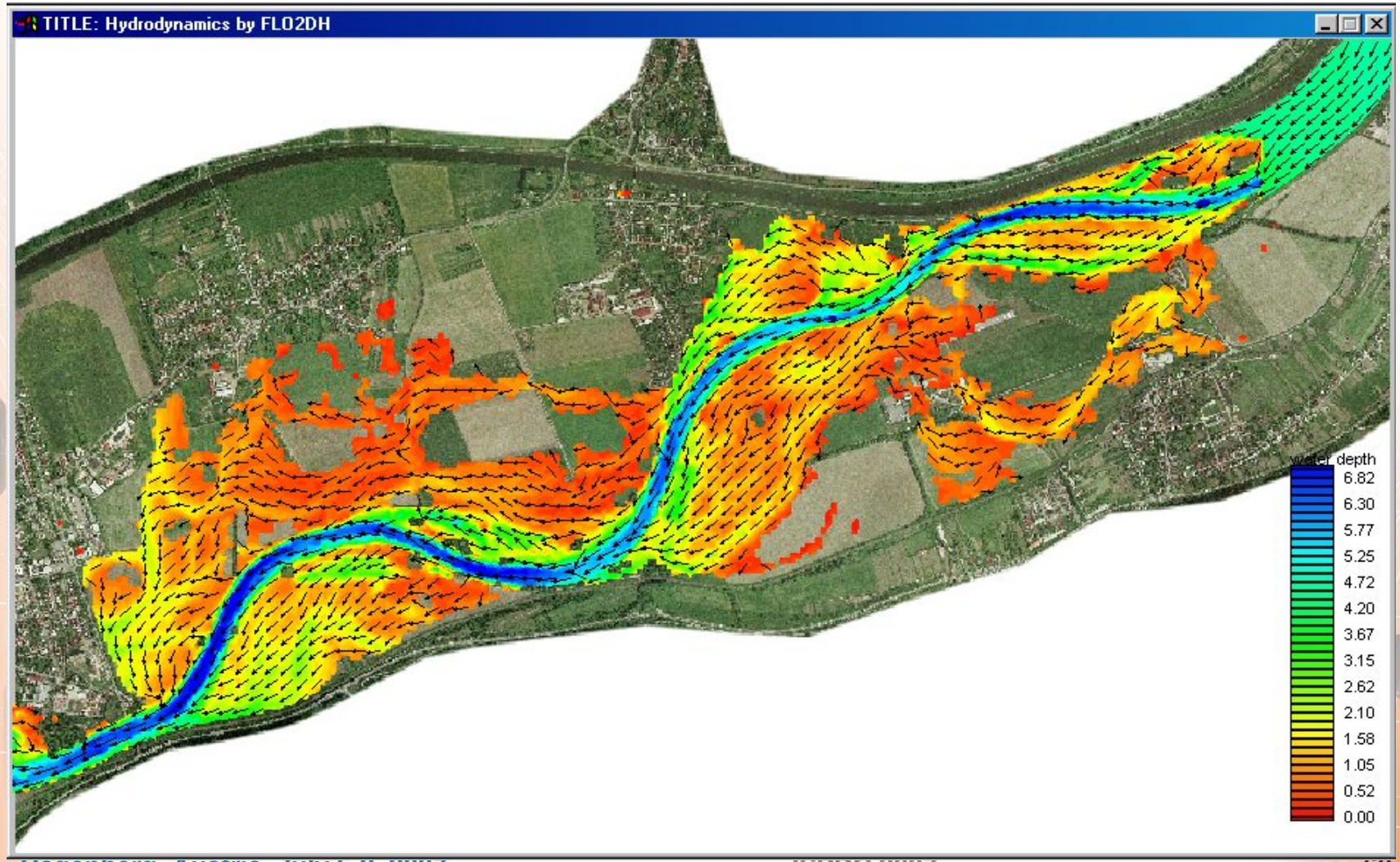
- Number of nodes increases 4 times ($O(N^2)$)
- Number of equations increase 4 times ($O(N^2)$)
- Length of fronts in FESWMS increases 2 times ($O(N)$)
- Total memory requirement increases 8 times ($O(N^3)$)
- ***Computation time increases 16 times ($O(N^4)$) !!!***

High performance computing and Grid computing is necessary.

Parallel iterative solvers

- In current HPCN version, several iterative solvers (**Bi-CGStab**, GMRES, QMR, …), several preconditioners (**ASM**, **ILU**, LU), several parameters for each solver/preconditioner (e.g. fill-levels of ILU) are integrated
- Users can change the solvers/preconditoners by command-line parameters

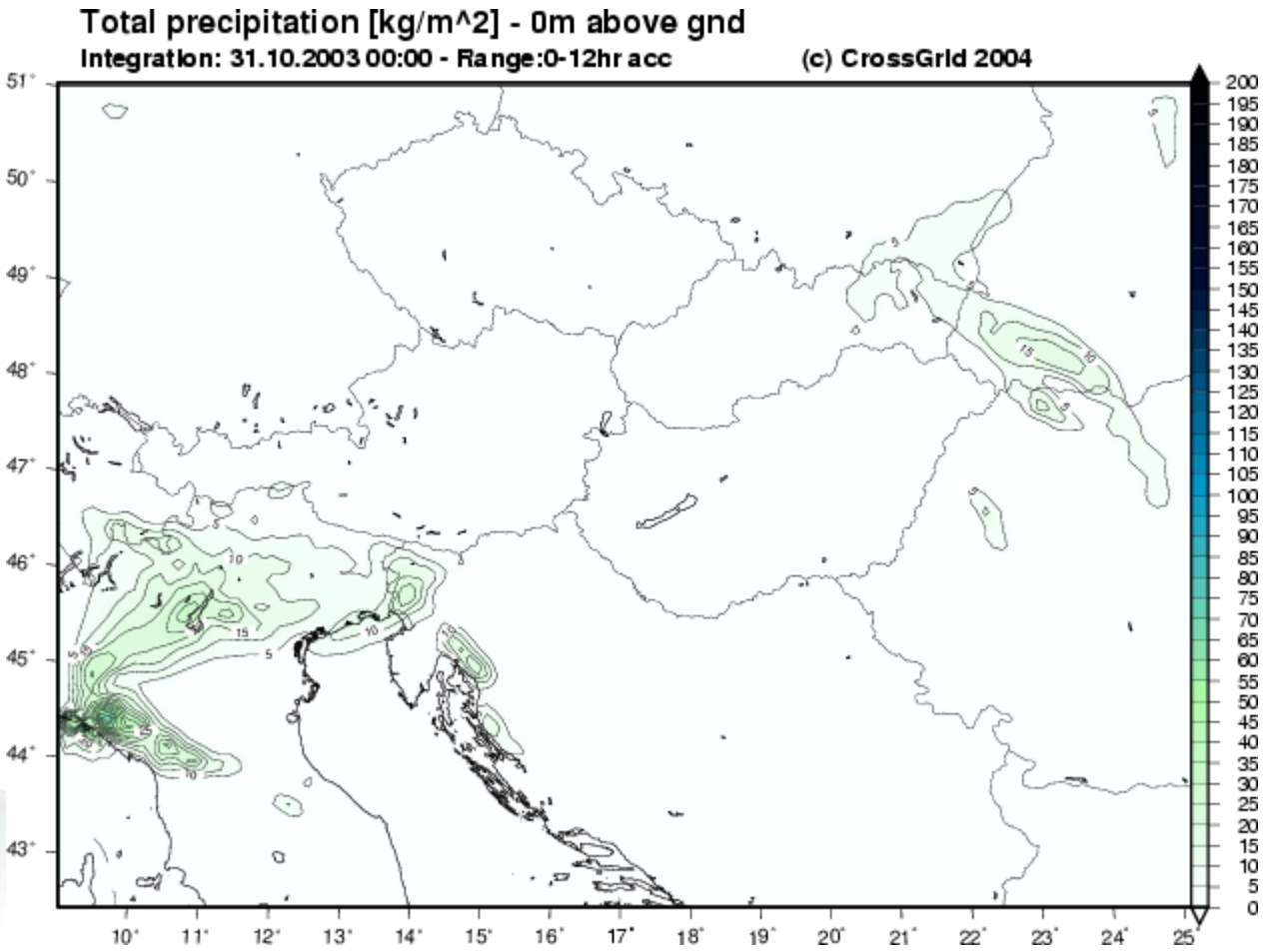
Detailed results



MM5

- Developed at NCAR (National Center for Atmospheric Research)
- The MM5 model is a limited-area, nonhydrostatic terrain-following sigma-coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation.
- MM5 is a regional model, it requires an initial condition as well as lateral boundary condition to run.
- The model is supported by several auxiliary programs, which are referred to collectively as the MM5 modeling system.
- MM5 source code is based on Fortan and C, the distributed memory option to MM5 is implemented using MPI.

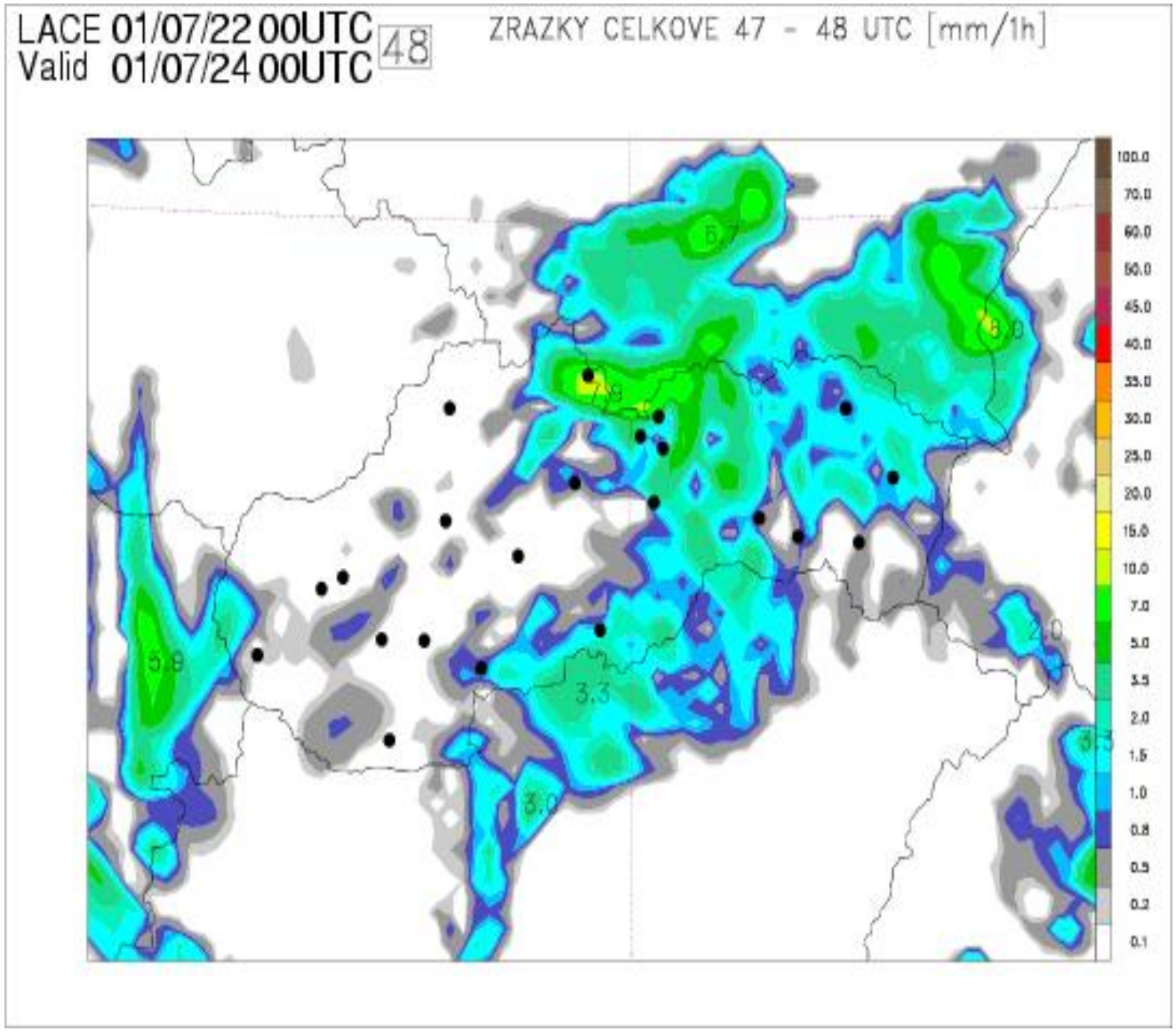
Visualization output from MM5



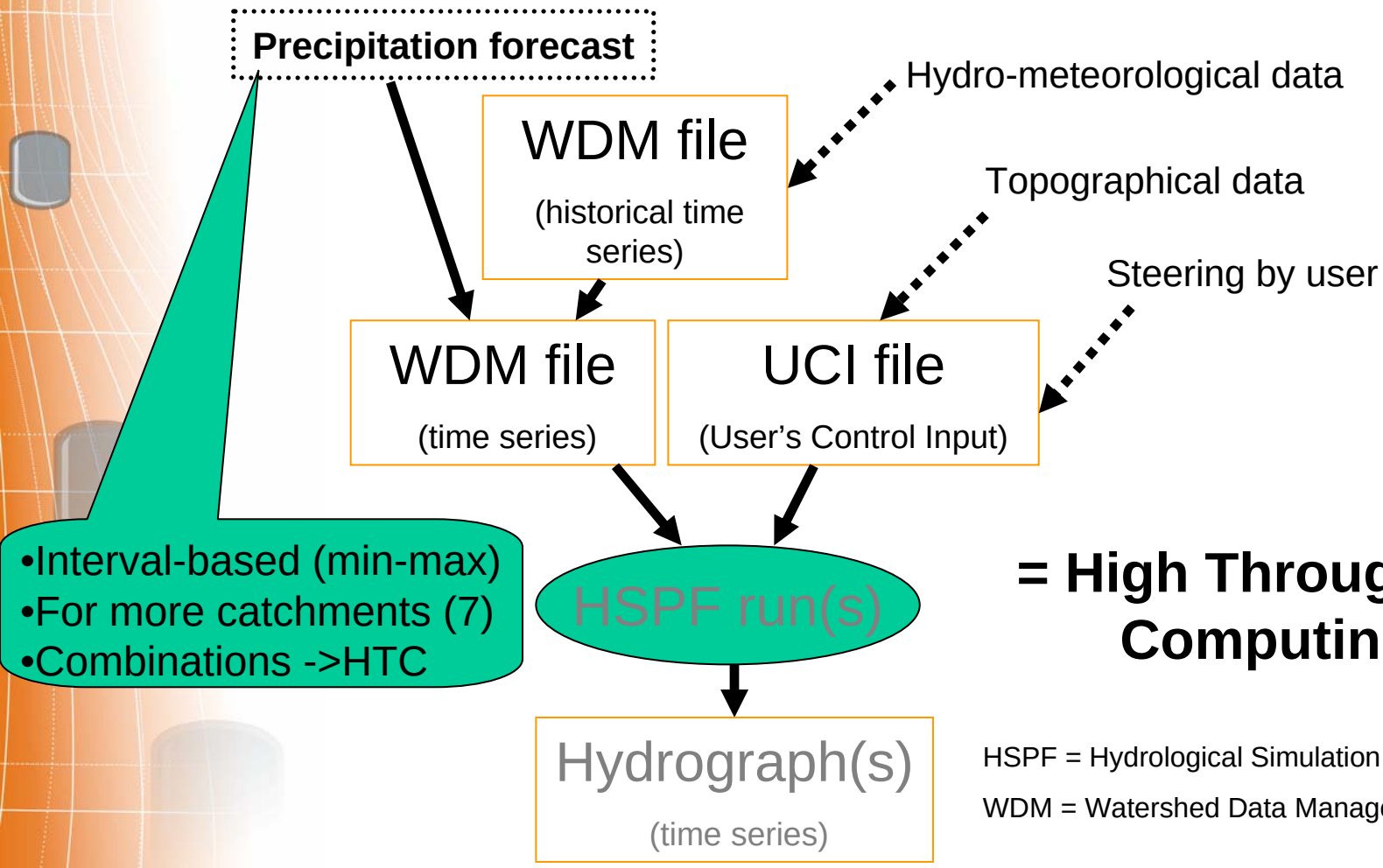
Aladin

- The concept of the ALADIN project was proposed by Meteo France in 1990.
- About one hundred scientists, from fifteen countries are permanently contributing to the model (more that 250 person-years during the ten years of the project).
- Aladin is a limited area model
- It needs coupling files and initial file which may be an Aladin analysis
- MPI application, written in Fortran

Visualization output from Aladin



Hydrological simulation - HSPF



= High Throughput Computing

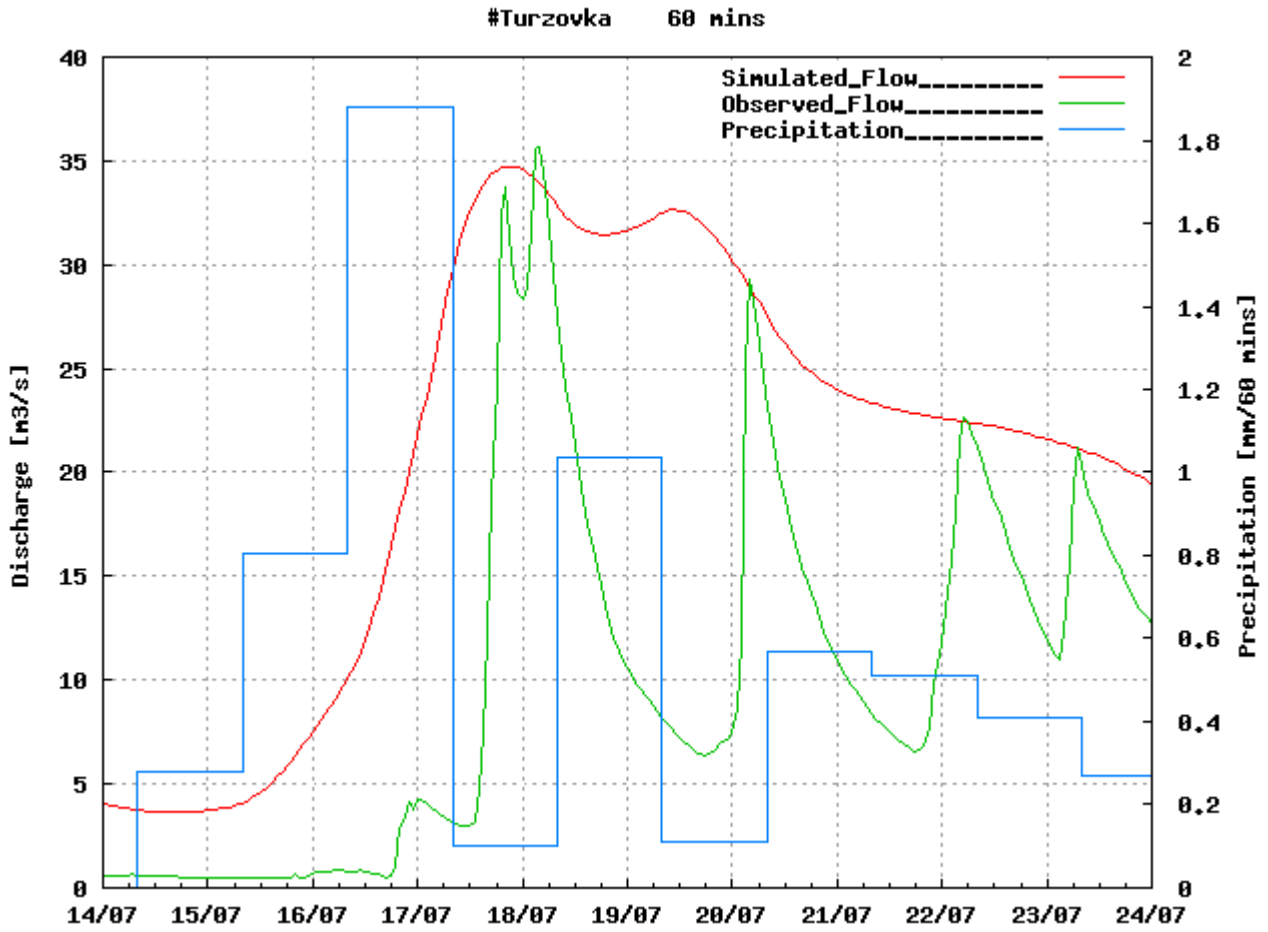
HSPF = Hydrological Simulation Program - FORTRAN

WDM = Watershed Data Management

Model characteristics

- **HSPF (hydrological model)**
  - Type: sequential task, multiple executions (high throughput computing)
  - CPU time: very small (seconds - minute)
  - I/O size: 1-10 MB
  - Scalability: HTC
  - Input data: quantitative precipitation, temperature, topographical data
  - Output data: hydrograph

HSPF output


#Turzovka 60 mins
Simulated_Flow_____
Observed_Flow_____
Precipitation_____
Discharge [m3/s]
Precipitation [mm/60 mins]
0
5
10
15
20
25
30
35
40
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
14/07
15/07
16/07
17/07
18/07
19/07
20/07
21/07
22/07
23/07
24/07