

Satellite Imagery Classification by Process Description Graphs

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Outline

- Objectives
- MedioGrid Project
- MedioGrid Infrastructure – Architecture, Platform, Data Repository
- Satellite Images
- Diagrammatic Process Description - gProcess
- Application Development – Database, Processing, User Interface
- Imagery Applications – Greenland, Waterland, Minerals
- Conclusions

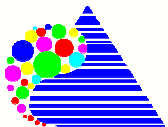


Research Objectives

- Develop a research and academic Grid infrastructure
- Develop Grid based satellite imagery processing platform
- Develop environment oriented applications based on satellite imagery classification

Paper's objectives:

- Flexible description and execution of processes
- Graph based process description
- gProcess – set of tools supporting DAG based description, instantiation and execution
- Experiments by environment applications



MedioGrid Project

MedioGrid

Parallel and distributed graphical processing on Grid structure of geographical and environment data, 19CEEX-I03 (2005-2008)

The **MEDIOGRID** project aims to accomplish a pilot program to process the images acquired in real time from meteorological and resource satellites, in order to extract the meteorological and environment parameters that characterize the atmospheric and terrestrial state.

Project consortium:

1. Computer Science Department, Technical University of Cluj-Napoca, coordinator
2. Faculty of Geography, Babes Bolyai University, Cluj-Napoca
3. iQuest Company , Cluj-Napoca
4. National Administration of Meteorology, Bucharest
5. Computer Science Department, Politehnica University of Bucharest
6. Informatics Department, West University of Timisoara
7. Computer Science Department, Politehnica University of Timisoara



MedioGrid Project

□ Main objectives

- Develop Grid structure to support the parallel and distributed processing of huge data (geographical and environmental)
- Develop algorithms for Grid based processing of satellite images
- Develop and experiment environment supervising applications with data extracted from satellite images
- Model and visualize the virtual geographical space

□ The project schedule:

- 1st year achieves and experiments the grid infrastructure, and analyzes the raw data and the processing techniques.
- 2nd year develops the Software Platform Kernel consisting of fundamental algorithms and components for image segmentation, and parallel and distributed data processing. It follows the kernel system experimentation over the grid by test and real input data.
- 3rd year develops and tests a pilot application specific for the analysis of social and ecological systems.

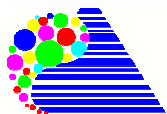
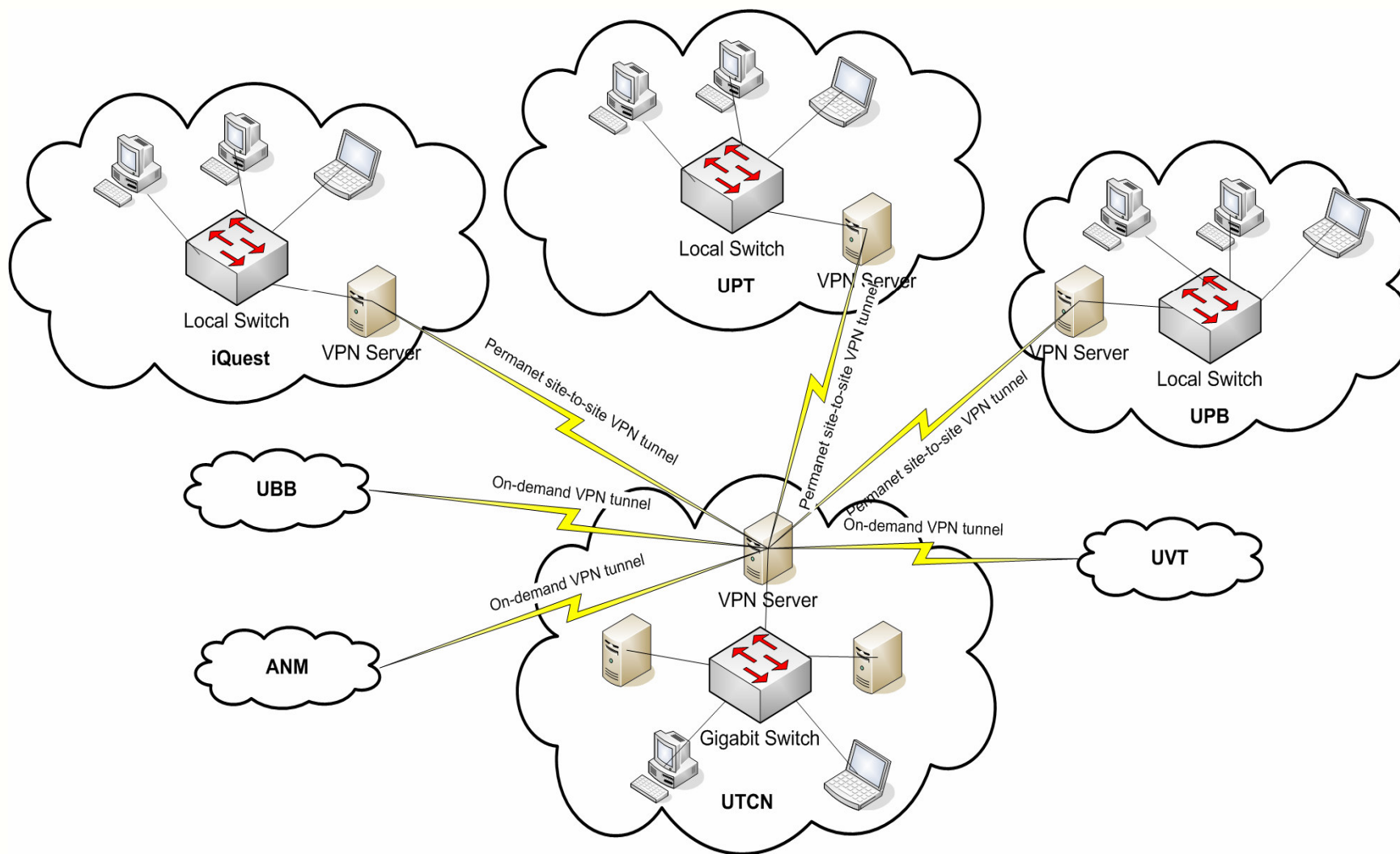


MedioGrid Project' Outcomes (2005-2007)

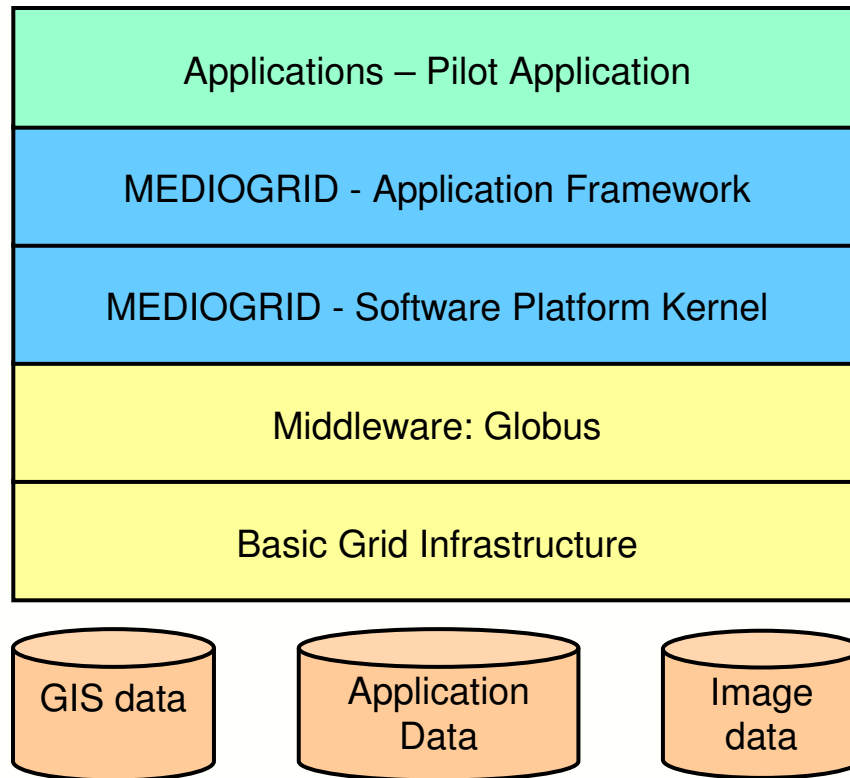
- Functional MedioGrid network (experimental Grid of 6 servers - Cluj, Timisoara, Bucharest and more than 50 workstations)
- Software applications: MedioGrid Software Platform Kernel, Image processing MODIS (NASA), Cloud detection, Vegetation classification (Greenland), Water detection (Waterland), Mineral area detection (Minerals)
- Modeling and visualization of the virtual geographical space, GIS and LBS Kernel (Location Based Services)
- Active Objects based modeling and execution
- User interaction techniques for image based applications
- Visual Grid process description and scheduling for satellite image domain
- Grid and Web services based architecture
- Organize conferences and workshops: GridCAD (Timisoara 2006, 2007), ICCP-Grid Computing Workshop (Cluj-Napoca 2007), MedioGrid Workshop (Cluj-Napoca 2005)



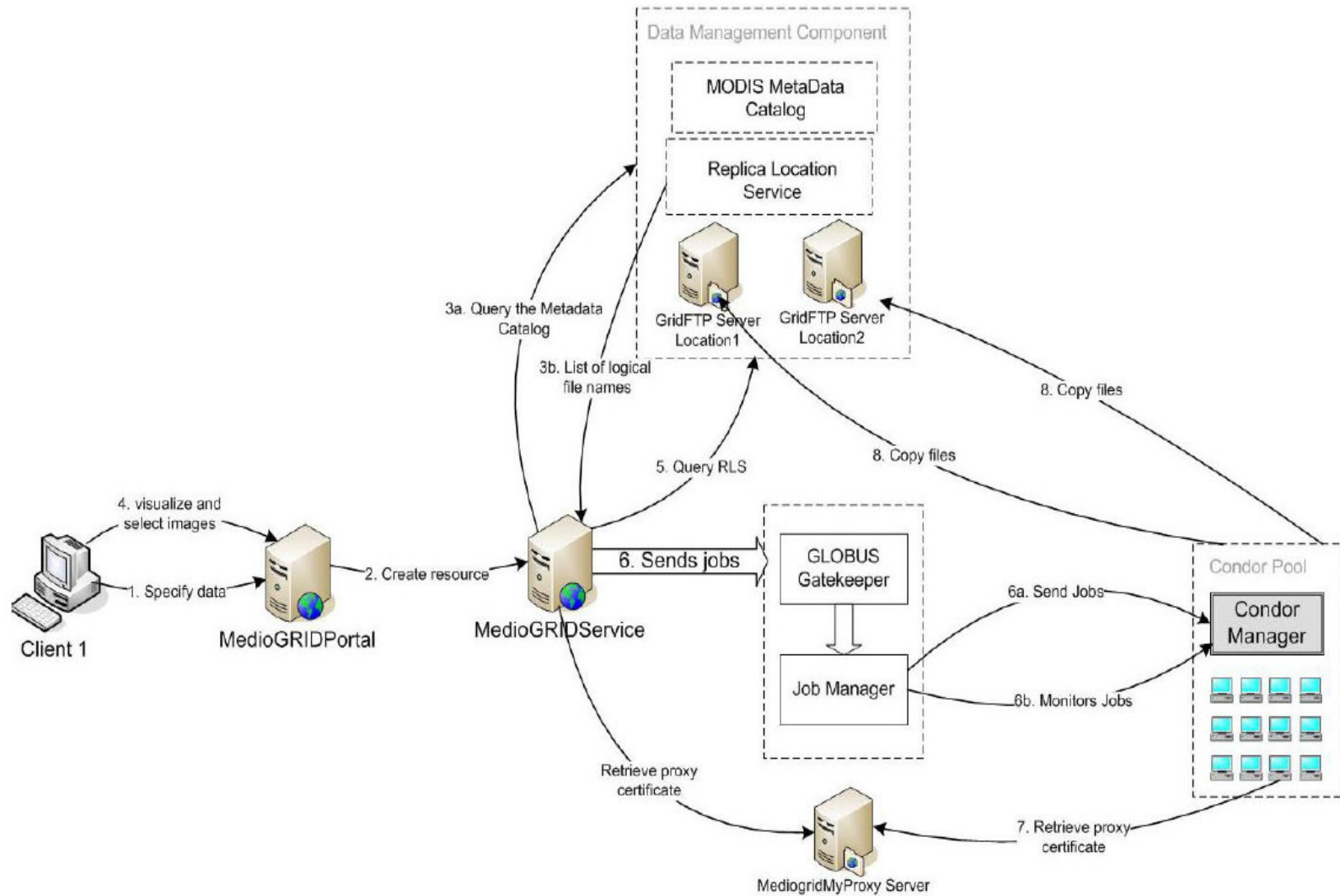
MedioGrid Architecture



Functional MedioGrid layers



MedioGrid Flow Control



MedioGrid Platform Kernel

- MediogridService
 - supports as Web and Grid service the creation, the execution, and the scheduling of the jobs
- MediogridFactory
 - creates resource entities which keep information about the jobs
- MediogridResource
 - contains information about the job state, the start and the end time of the job
- MediogridOGSADAI
 - provides access to the image database
- MediogridURLCopy
 - supports the file transfer using the GridFTP protocol
- MediogridRLS
 - returns a list of physical images in order to allow the worker to decide where is the most appropriate GridFTP location to download data

- Job Manager
 - Condor
 - Alternatives: PBS (Portable Batch System), Sun Grid Engine



Data Repository

- Satellite image

 - Landsat

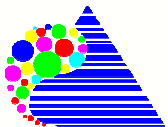
 - Massive data. E.g. One image is about 600MB
 - Seven bands, 1-7

 - Modis

 - Produced by sensors onboard the Terra and Aqua satellites
 - Covers the entire surface of the Earth
 - 36 observational channels
 - 250m to 1km spatial resolution
 - Data distributed by the NASA DAAC

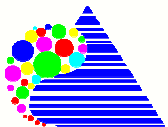
- Layered on eXist (XML database)

- OGSA-DAI technology



Landsat Satellite Images

- Massive data. E.g. One image is about 600MB
- seven bands 1-7
 - band 1 - water body penetration
 - band 2 - green reflectance of vegetation
 - band 3 - sensitive to chlorophyll absorption, determine the vegetation types
 - band 5 – information on vegetation and soil moisture
 - band 6 - vegetation stress
 - band 7 - discriminates the mineral and rock types
- Different information is highlighted by various band weighted combinations
 - bands 4, 3, and 2
 - Classify land water boundaries and different types of vegetation
 - bands 4 (NIR), 5 (SWIR), and 3 (RED)
 - Land/water boundaries and vegetation areas
 - Water detection



gProcess – Diagrammatic Process Description

The screenshot displays the gProcess software interface with several overlapping windows:

- GRID Plan Processing:** Shows satellite image type selection (Landsat, MODIS, ASTER, IKONOS, ALI, TM) and a world map.
- Viewer:** A table showing process execution details.

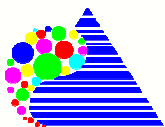
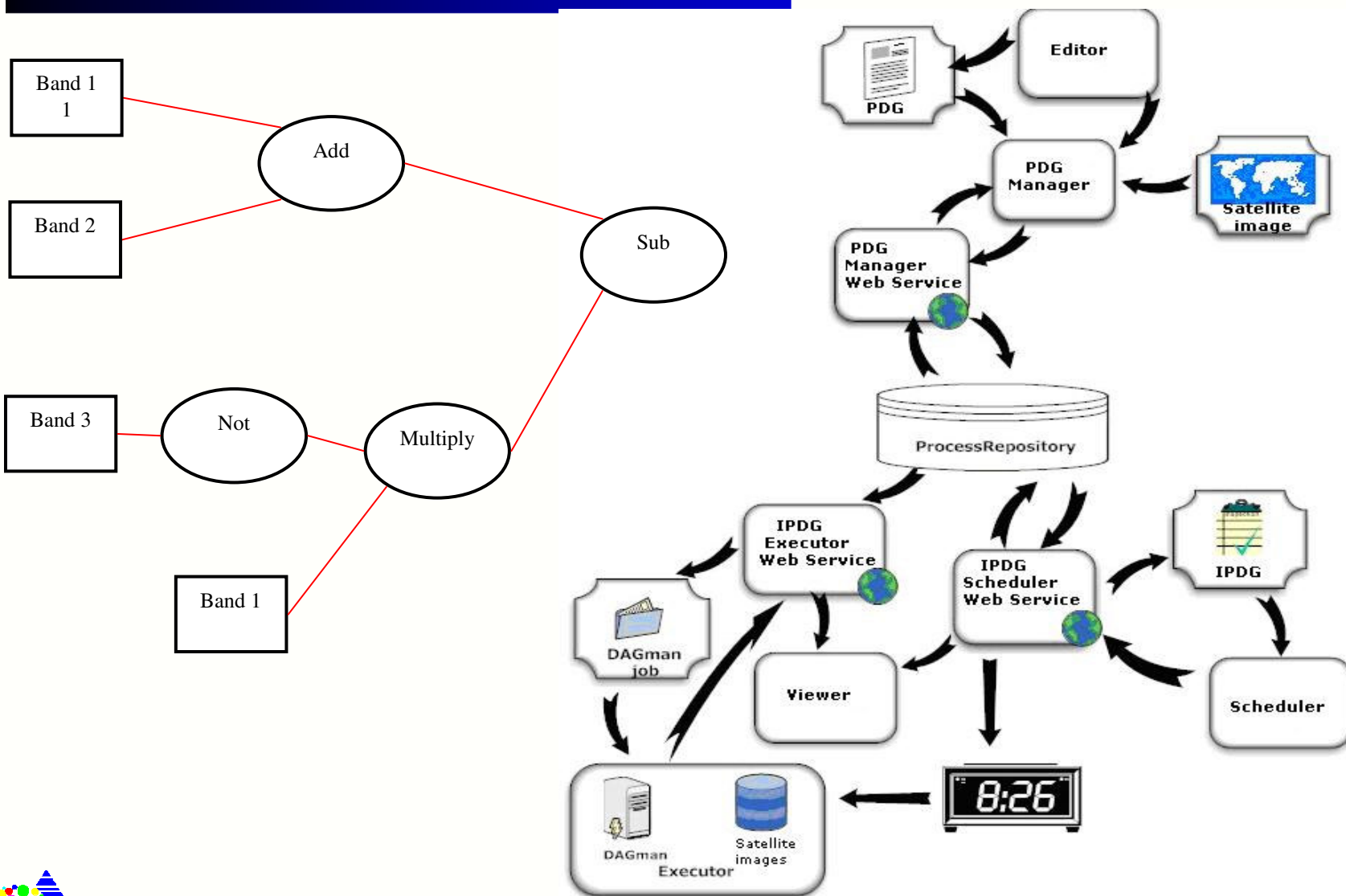
Process State	Name	Image Binded	Time Start	Time End	Result
Process not started	Process Test	romania1	5/30/2007 8:35 ...		
Successfully finish...	Test	romania1	5/31/2007 5:01 ...	5/31/2007 5:07 ...	SchedProc70.tif
- GRID Plan Processing Editor:** Shows a diagrammatic process flow with input bands (B1, B2, B3, B4, B5, B6, B7) and operators (Add, Subtract, Multiply, And).
- ProcessManager:** A form for process configuration.

Id:	17	Latitude1:	44 ° 10 ' 2 " 1
Name:	Process Test	Latitude2:	46 ° 6 ' 1 " <input checked="" type="checkbox"/> Scheduled
Author:	Anca Radu	Longitude1:	
<input type="checkbox"/> Secret Key Specified		Longitude2:	
Secret Key:		Time Start:	10/01/2007 09:01:08
Date Created:	<input checked="" type="checkbox"/> 26/34/2007 08:34:34	Time End:	10/01/2007 09:01:08
- Scheduler:** Shows process groups and a table of scheduled tasks.

Metadata Id	Process Groups	Process State	Time Start	Time End	Calc	Test	Result
34	{Invert-3 Add-1 Multiply-2 Subtract-4 }						
37	{Add-1 Multiply-2 Invert-3 Subtract-4 }						
38	{Add-1 Multiply-2 Invert-3 Subtract-4 }	Successfully finish...	5/31/2007 5:01 ...		Calc	Test	19
39	{Add-1 Multiply-2 Invert-3 Subtract-4 }				Calc	Test	19
40	{Add-1 Multiply-2 Invert-3 Subtract-4 }				Calc	Test	19
41	{Add-1 Multiply-2 Invert-3 Subtract-4 }				Calc	Test	19



Process description graph based workflow

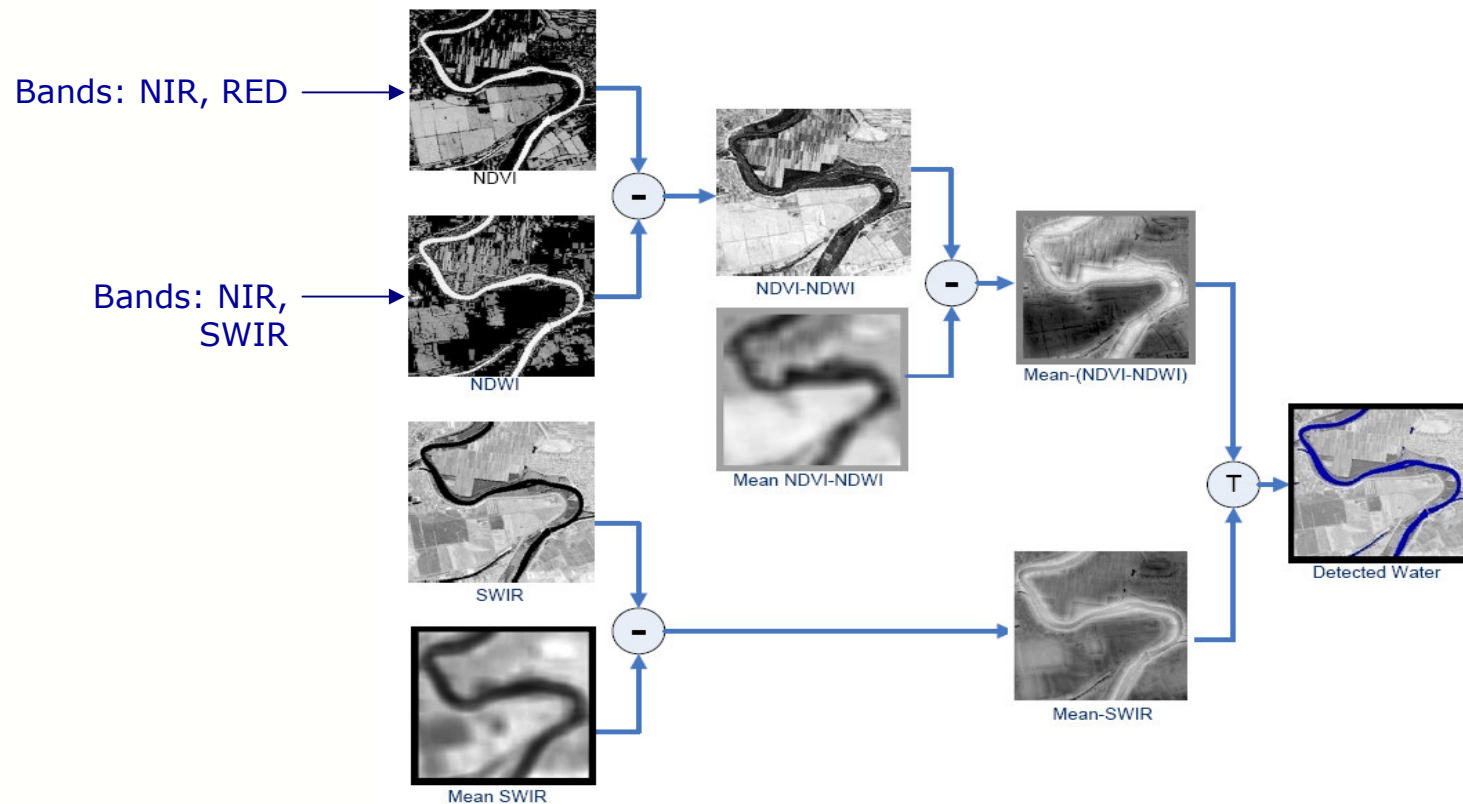


Gond's Water Detection Algorithm

- Gond's water detection algorithm

Gond V., Bartholom E., Ouattara F., Nonguierma A. and Bado I. Surveillance et cartographie des plans d'eau et des zones humides et inondables en rgions arides avec l'instrument VEGETATION embarque sur Spot 4, International Journal of Remote Sensing, 2004, 25,5. pp. 987- 1004.

- SWIR (5), Red (3) and NIR (4) spectral bands



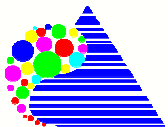
Water Detection Algorithm - Results



Pseudo colored initial Landsat image.



Samples of detected water areas.



Waterland Application

On-line available Web application: greenland.mediogrid.utcluj.ro

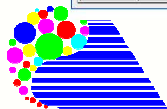
1

2

3

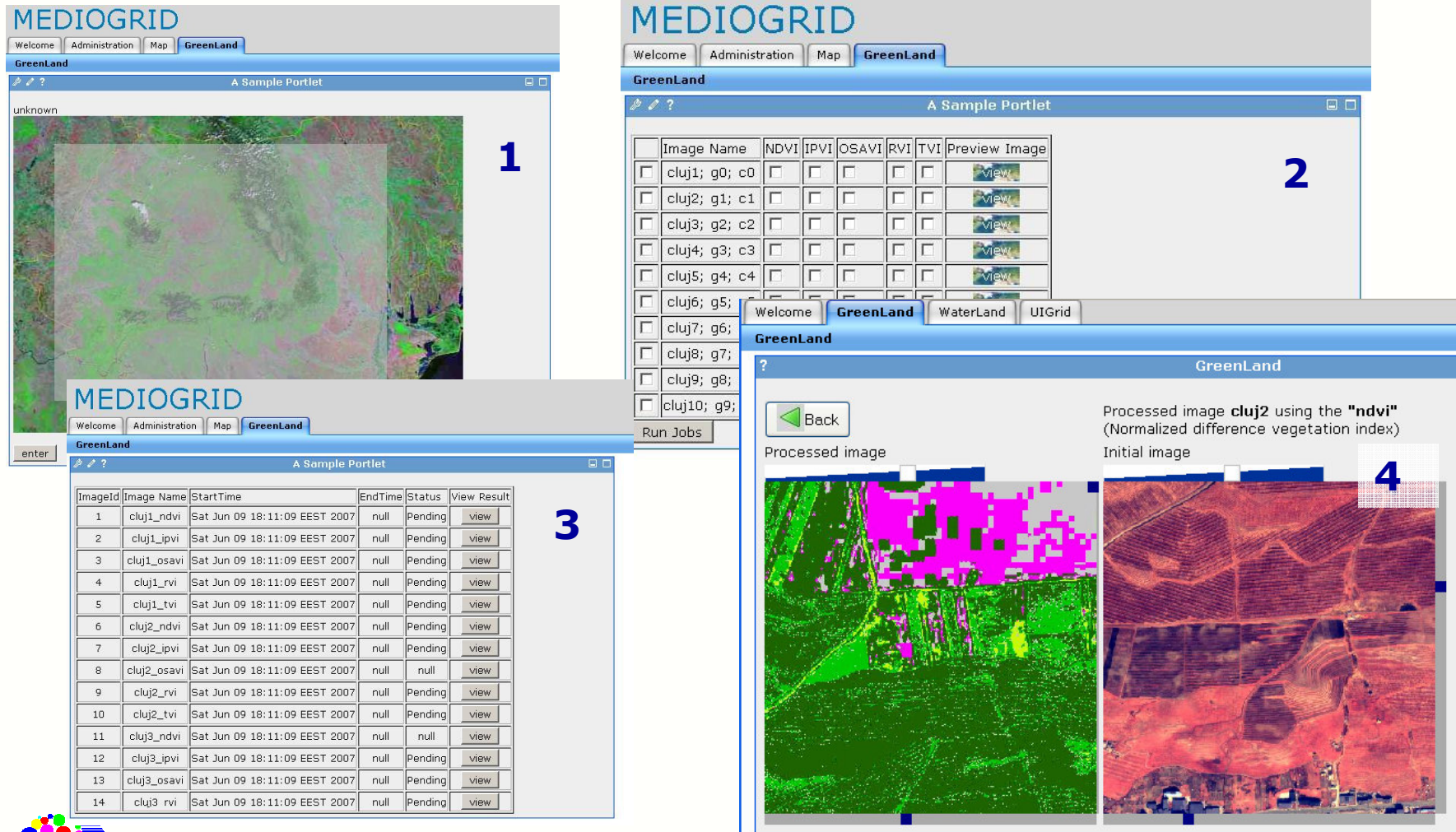
4

ImageId	Image Name	StartTime	EndTime	Status	View Result
1	romania1	Sat Jun 09 18:21:31 EEST 2007	null	Pending	view
2	romania2	Sat Jun 09 18:21:31 EEST 2007	null	Pending	view
3	romania3	Sat Jun 09 18:21:31 EEST 2007	null	Pending	view
4	romania5	Sat Jun 09 18:21:31 EEST 2007	null	Pending	view



Greenland Application

On-line available Web application: greenland.mediogrid.utcluj.ro



1 A satellite image view of a landscape, labeled 'unknown'.

2 A table listing image jobs with columns for Image Name, NDVI, IPVI, OSAVI, RVI, TVI, and Preview Image.

	Image Name	NDVI	IPVI	OSAVI	RVI	TVI	Preview Image
<input type="checkbox"/>	cluj1; g0; c0	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	cluj2; g1; c1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	cluj3; g2; c2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	cluj4; g3; c3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	cluj5; g4; c4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	cluj6; g5;						
<input type="checkbox"/>	cluj7; g6;						
<input type="checkbox"/>	cluj8; g7;						
<input type="checkbox"/>	cluj9; g8;						
<input type="checkbox"/>	cluj10; g9;						

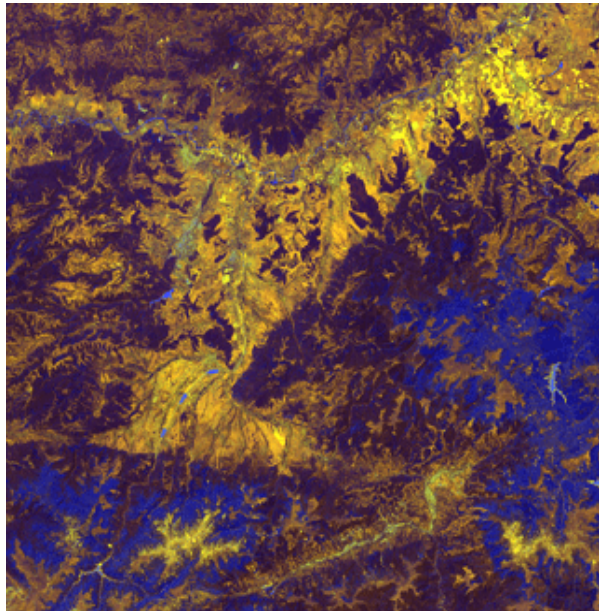
3 A table showing job status details with columns for ImageId, Image Name, StartTime, EndTime, Status, and View Result.

ImageId	Image Name	StartTime	EndTime	Status	View Result
1	cluj1_ndvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
2	cluj1_ipvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
3	cluj1_osavi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
4	cluj1_rvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
5	cluj1_tv	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
6	cluj2_ndvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
7	cluj2_ipvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
8	cluj2_osavi	Sat Jun 09 18:11:09 EEST 2007	null	null	view
9	cluj2_rvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
10	cluj2_tv	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
11	cluj3_ndvi	Sat Jun 09 18:11:09 EEST 2007	null	null	view
12	cluj3_ipvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
13	cluj3_osavi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
14	cluj3_rvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view

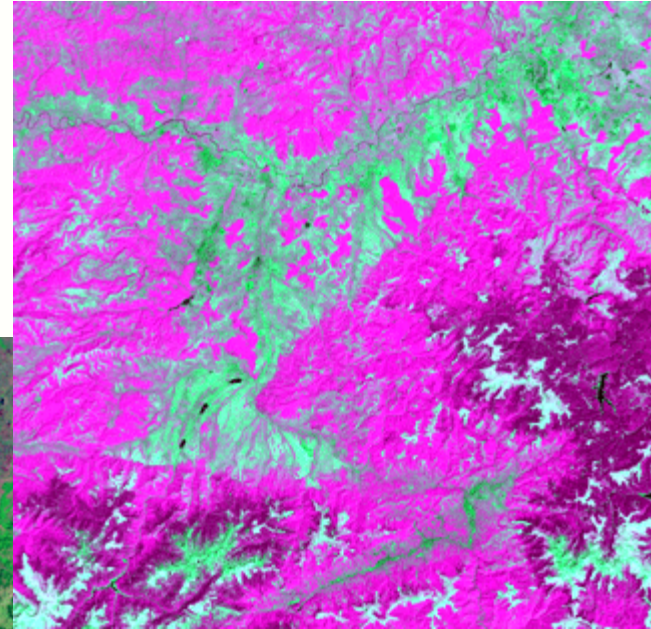
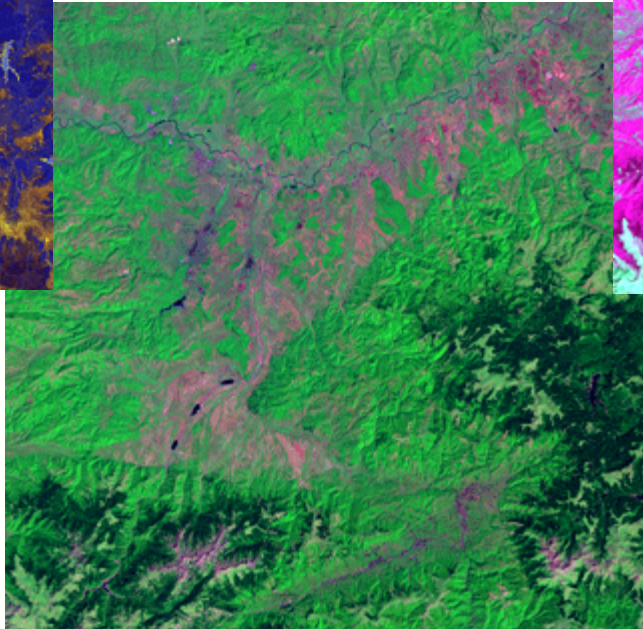
4 A comparison of a processed image (left) and an initial image (right). The processed image shows a color-coded NDVI map, and the initial image shows the original satellite data.



Minerals Application

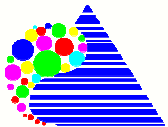


Hydrothermally-altered areas.



Iron-oxides and hydroxyl-bearing minerals.

The Metaliferi Mountains area presented as a false color image (Band 7 by red, band 4 by green and band 2 by blue).



Conclusions

- Future works:
 - Develop the Grid and Web services for geographical and environment applications
 - Web Semantic services toward MedioService Architecture
 - Geographical and Environmental Ontology and Knowledge Database
 - Geographical and environmental Grid pilot applications
 - Grid visualization
 - GIS and LBS applications
 - Active objects based distributed modeling and processing



Many thanks. Questions

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