CLOUD HYDROINFORMATION SYSTEM AND WEB SERVICES

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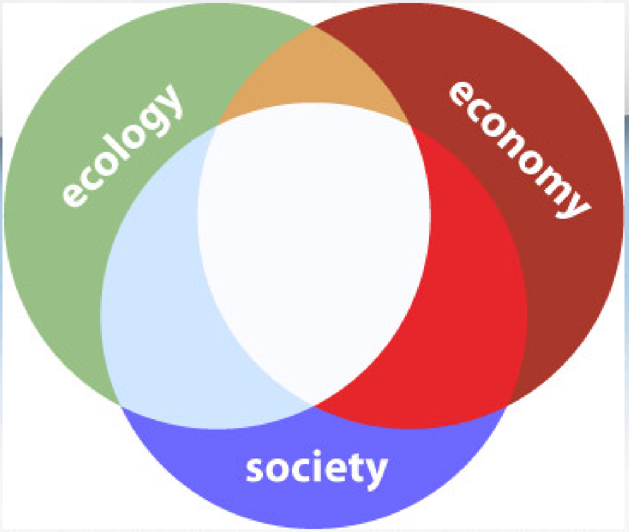
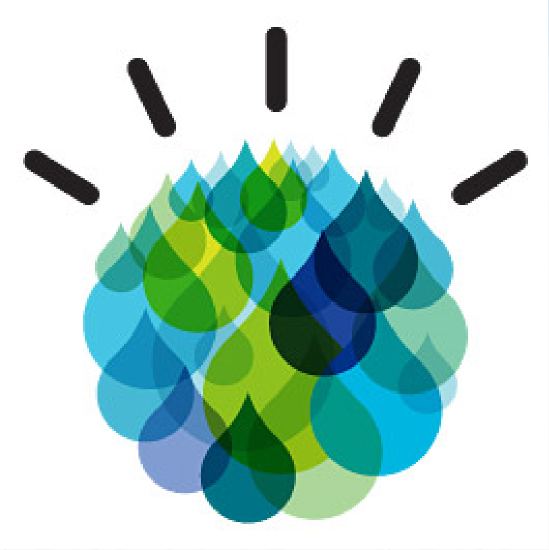
UNESCO-IHE PhD week 1 - 5 October 2012

Introduction

Successful water management needs long term planning concerning technical, economic, social and ecological aspects.





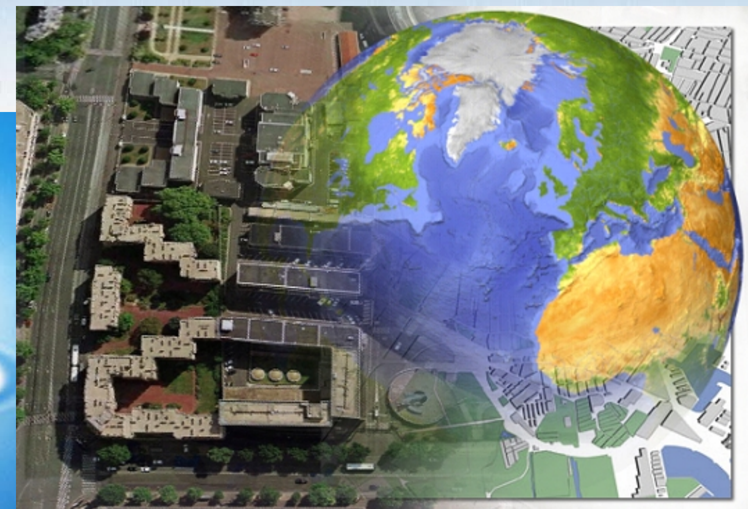
The complexity of integrated water management requires development of hydroinformatics systems (including Decision Support Systems – DSSs) that enable efficient and equitable distribution of water resources across all water users and functions.

Starting point is to develop a hydro information system

Motivation

Network is the computer !

Web based GIS (Geographic Information systems)

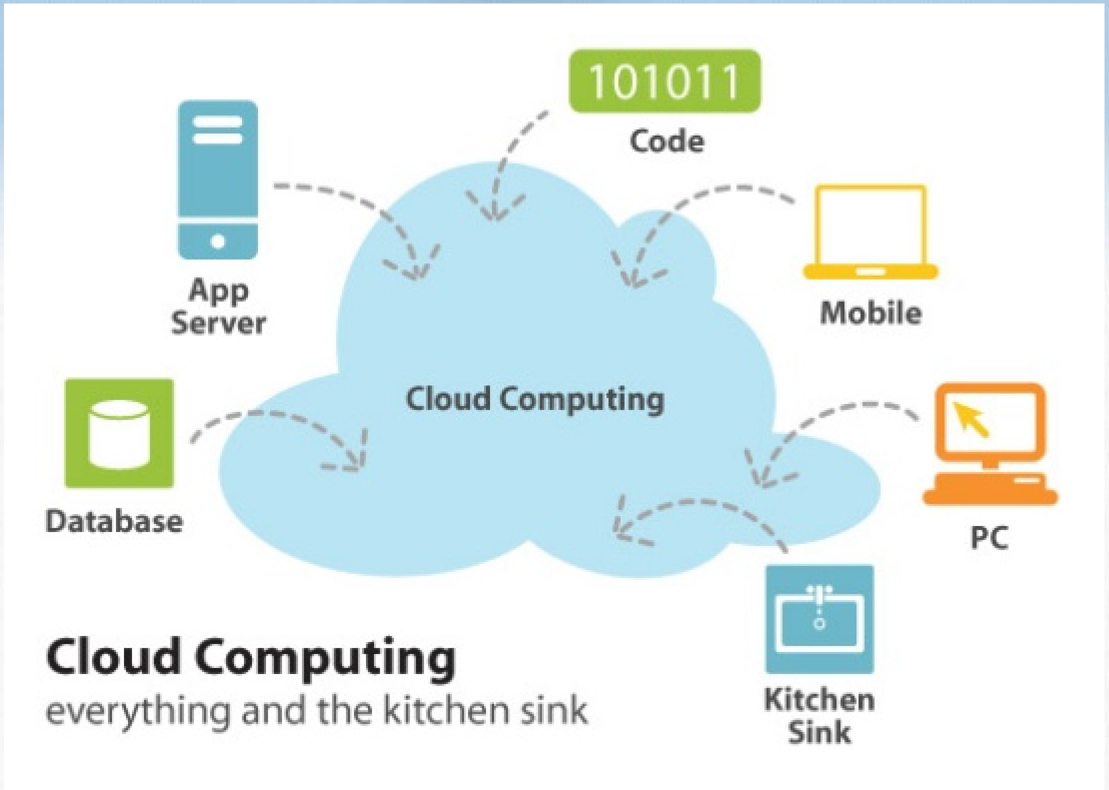


Water as Indispensable resource for our future

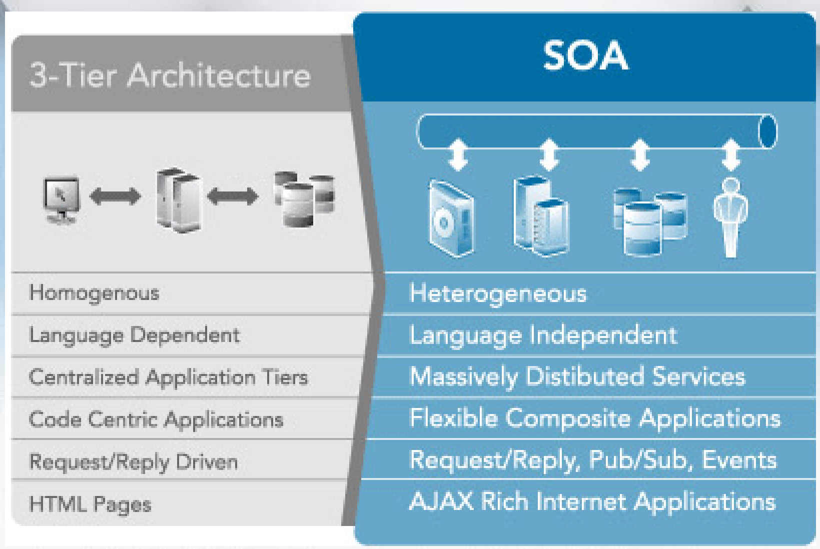
Cloud computing

Cloud is a system that enables data processing, software and access of data services independently of physical location and configuration.

Similar to this concept is the electric grid where users utilize power without understanding the system components.



SOA (Service Oriented Architecture)



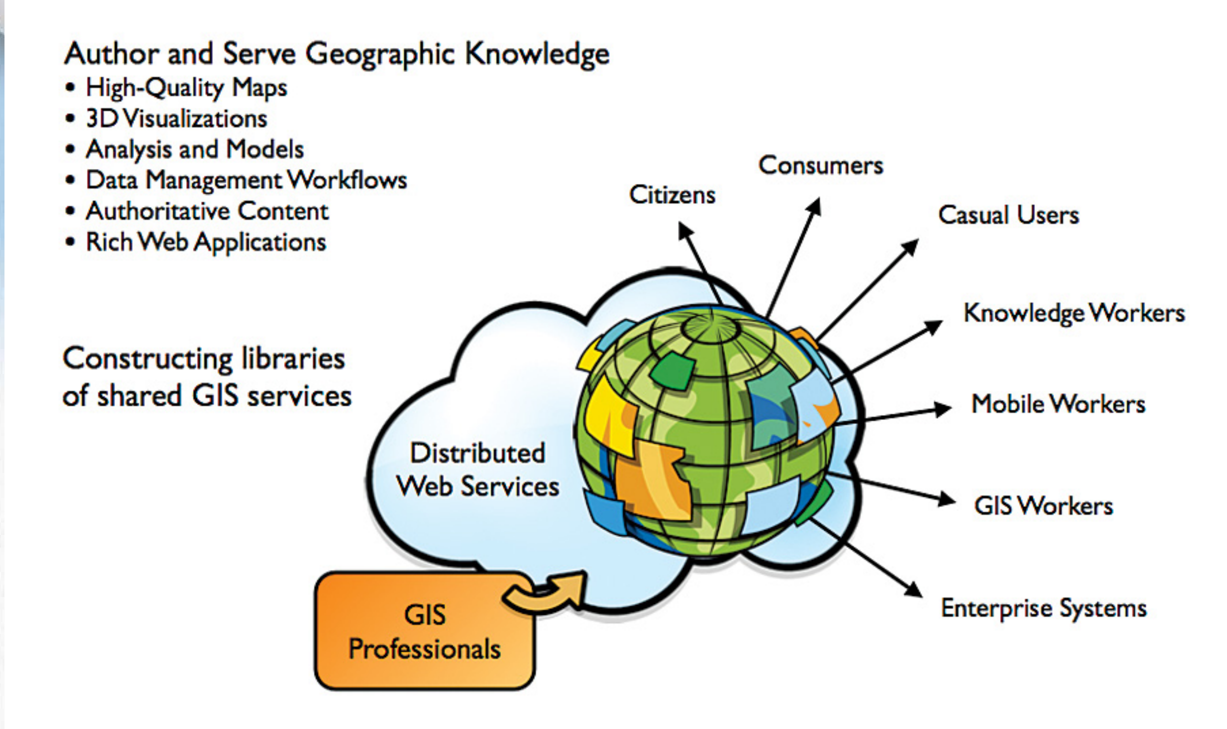
The core components which make up an SOA implementation

Functionality of system based on SOA is in interoperable services that work on different information systems. SOA defines how to integrate heterogeneous application and platform into web based solution.

SOA enables :

- Integration independent of the programing language.
- Components reuse
- Improving the existing systems

Web GIS

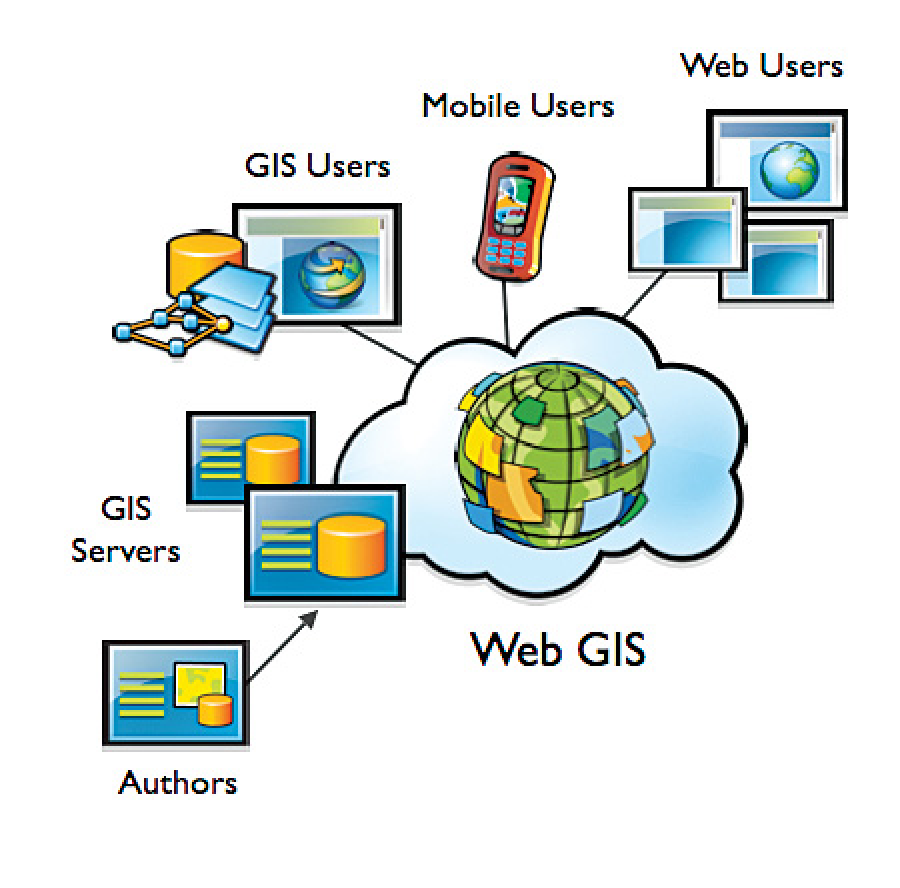


Web Service standards

Geospatial web service standards

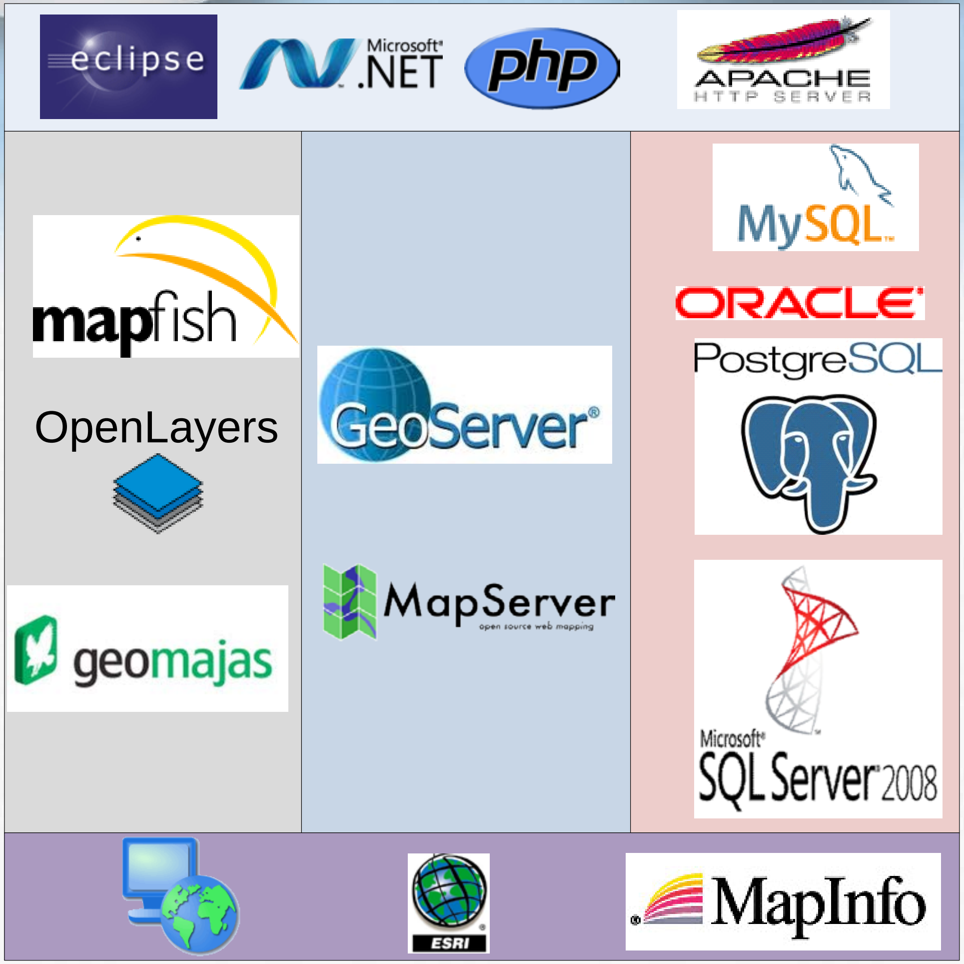
OGC geospatial web standards:
Web Coverage Service (WCS) Web Feature Service (WFS) , Web Coordinate Transformation Service (WCTS) ,Web Map Service (WMS), Web Image Classification Service (WICS)

Web GIS

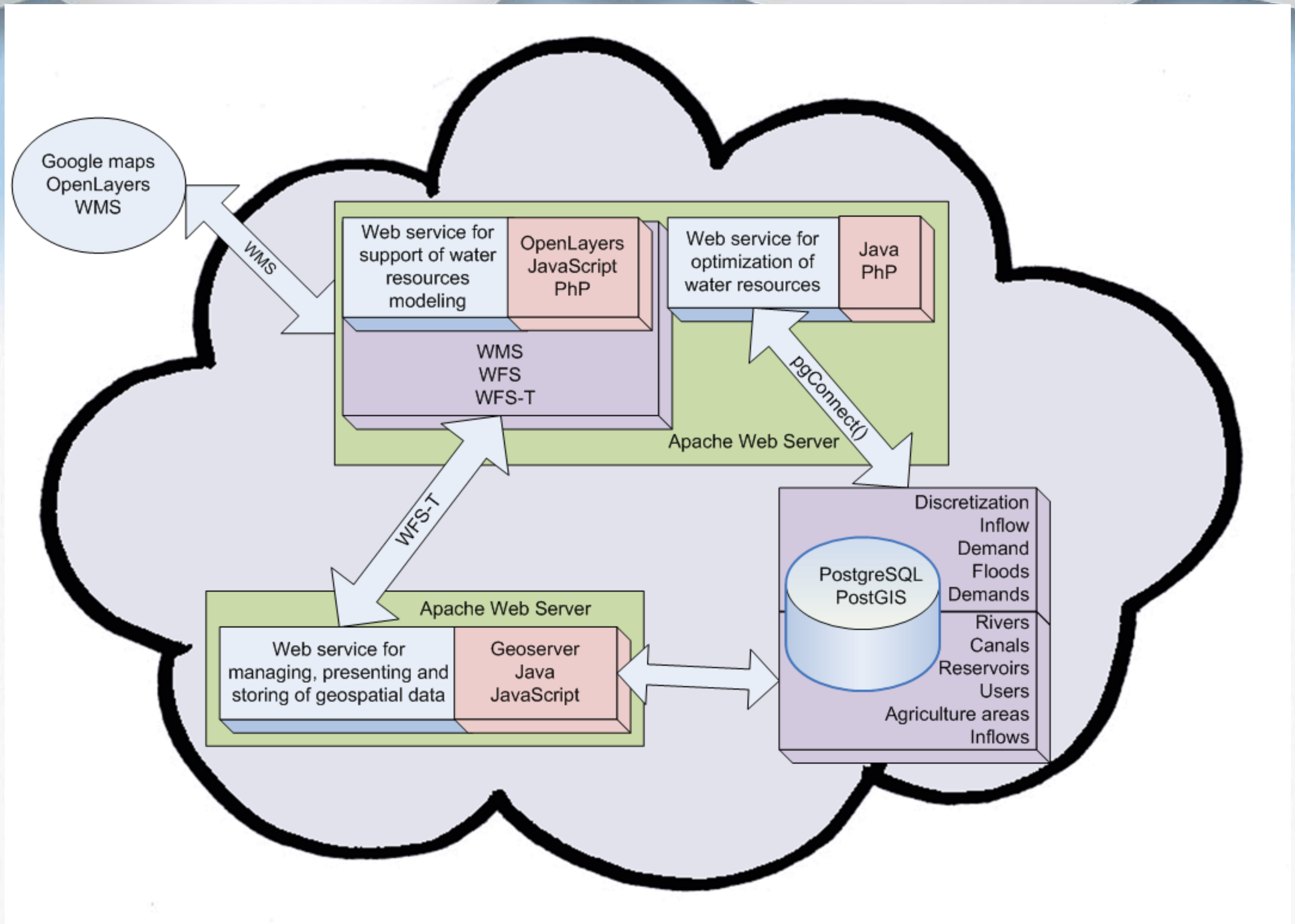


XML (eXtensible Markup Language) is a primary language for coding of data/messages of web services and interoperable structured information.

Software components and technologies



Architecture of the cloud hydroinformation system and web services



Development Cloud hydro information system

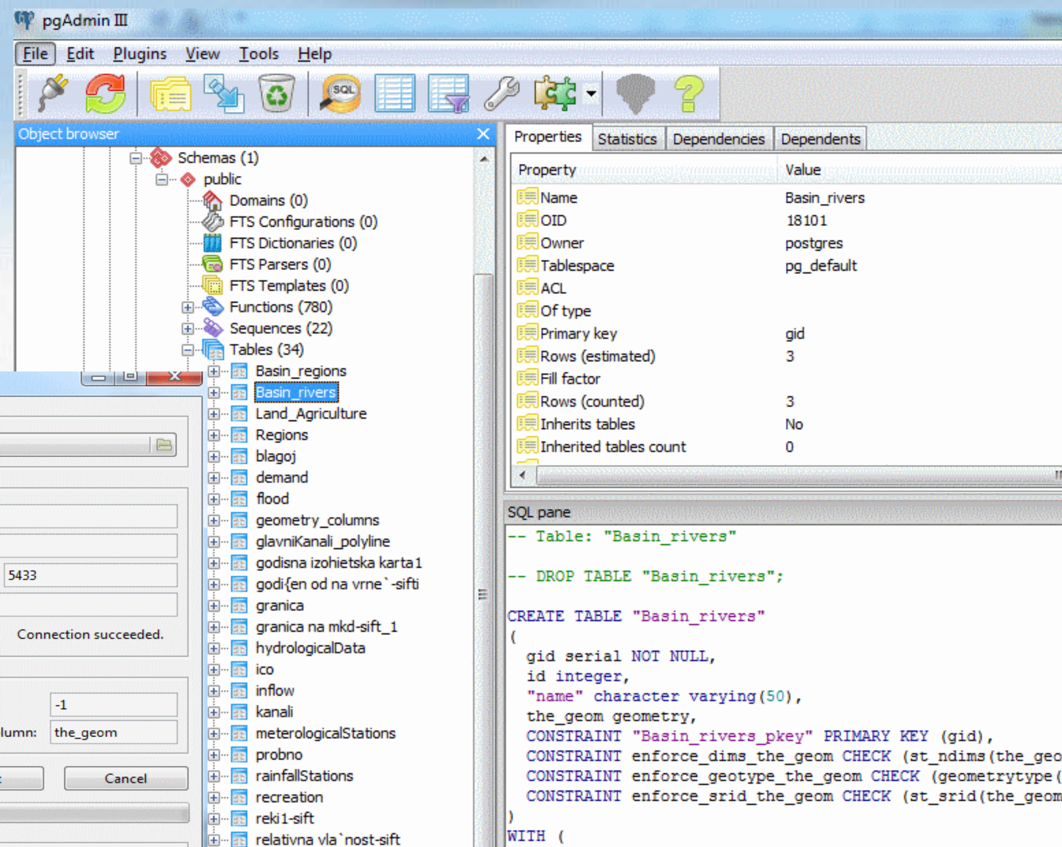
Creation of the geospatial relational database HMak

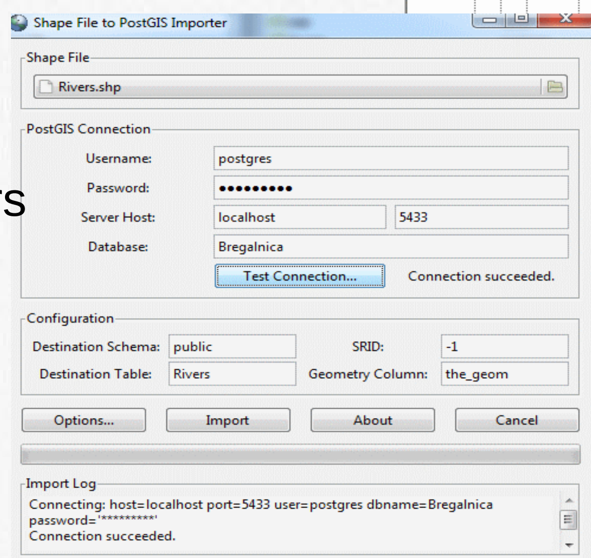
PostgresSQL together with PostGIS for support of standard and geospatial data. Main function of HMak is central database for the web services.

Mapinfo, ArcGIS

6 vector maps layers

- rivers
- canals
- reservoirs
- users
- water inflow,
- agriculture land

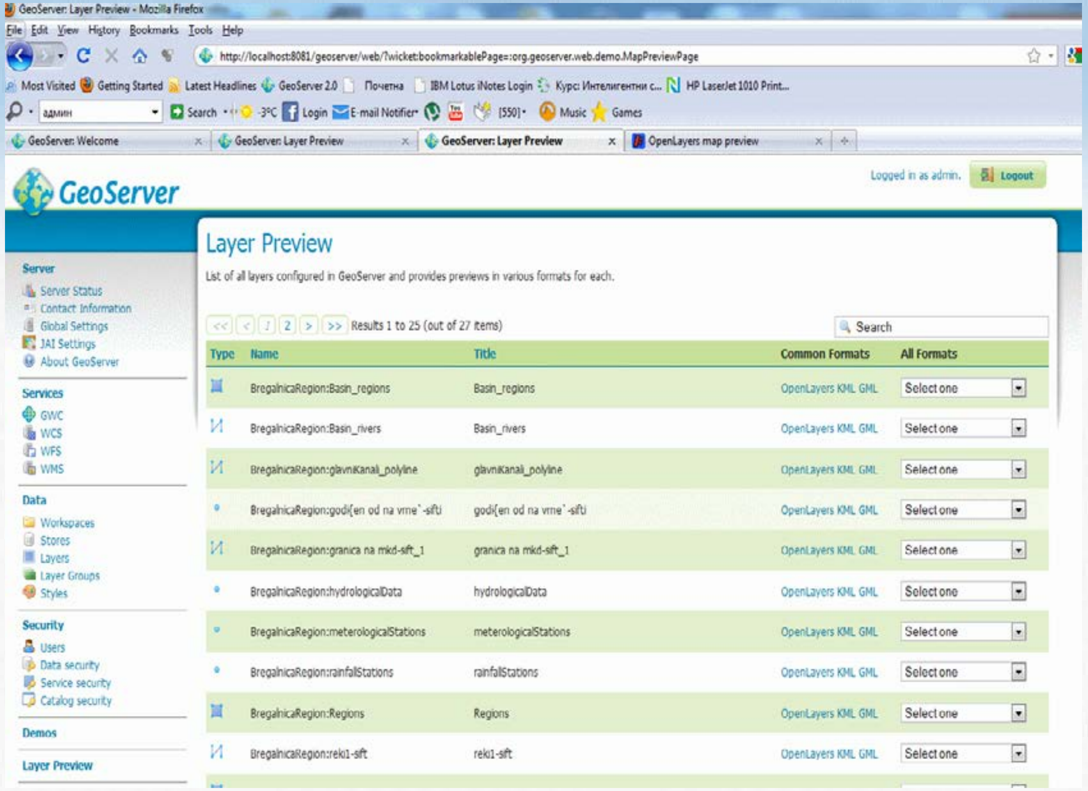




Development Cloud hydro information system

Geoserver

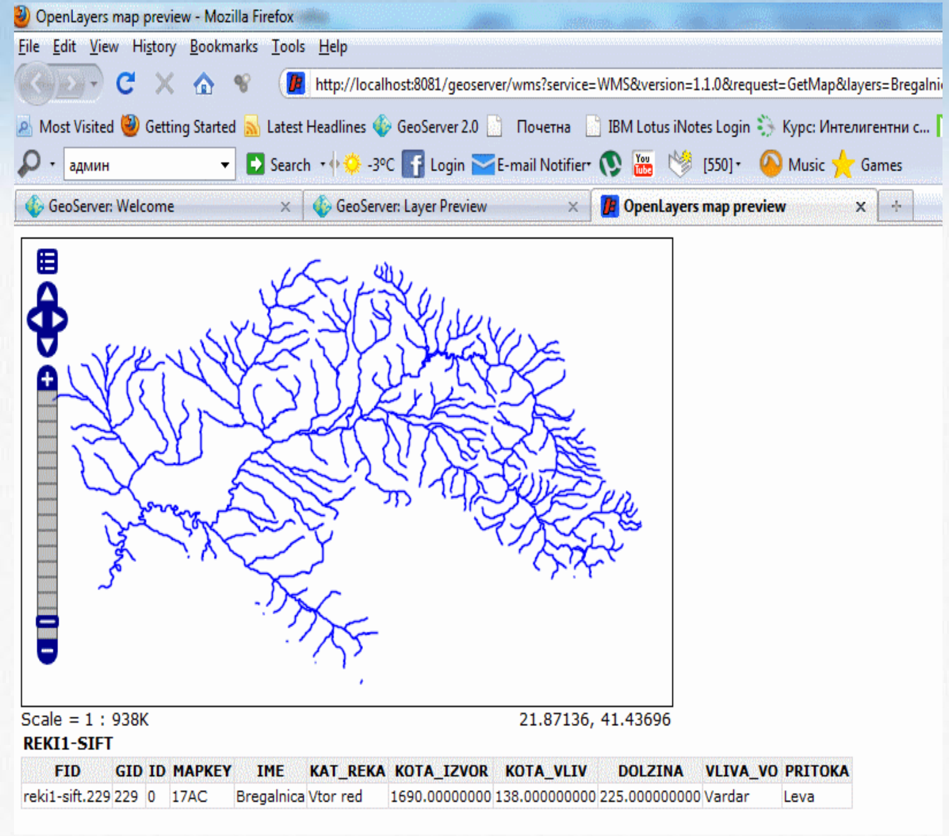
Geoserver is a Java web application that implements OGC standards for WFS, WMS, WMS and integrated web mapping server.



Development Cloud hydro information system

Geoserver

- Geoserver displays web interface for presenting and searching geospatial data
- Geoserver works on Apache web server and presents HMak geospatial data.
- Geoserver is middle layer application between data from HMak and created servise for modeling of water resources
- OGC standards
- Distribution and interoperability

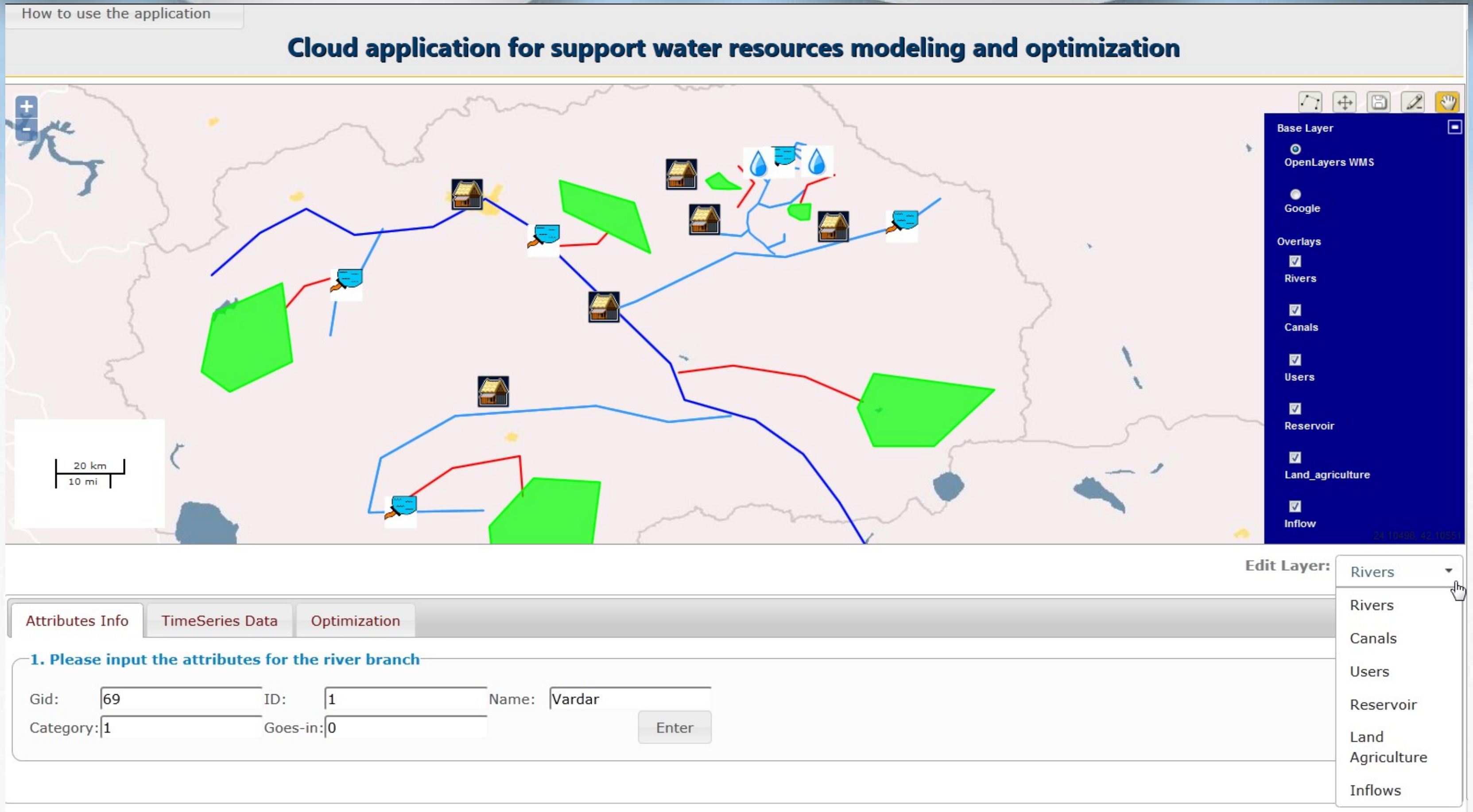


Development of web service for supporting water resources modeling

- Web service is build using OpenLayers library that support OGC standards WMS, WFS and WFS-T.
- Web service is working on Apache web server and it is developed using several programing languages like JavaScript, AJAX, PhP combining service for managing geospatial data Geoserver, database HMak and OpenLayers library.

```
function init() {
map = new OpenLayers.Map("map");
var    base1= new OpenLayers.Layer.WMS( "OpenLayers
WMS",
"http://vmap0.tiles.osgeo.org/wms/vmap0",  layers : 'basic' );
map.addLayer(base1);
var rivers = new OpenLayers.Layer.Vector("rivers-WFS", {
strategies: [new OpenLayers.Strategy.BBOX(), saveStrategy],
protocol: new OpenLayers.Protocol.WFS({
version: "1.1.0",
url: "http://localhost:8081/geoserver/wfs?",
featureType:     "rivers",
featureNS: "http://www.delipetrov.com",
srsName: "EPSG:4326"
       })
   });
   map.addLayer(rivers);
```

Development of web service for supporting water resources modeling



Development of web service for supporting water resources modeling

Entering new polilyne (comunication in XML)

```
$xml ='<wfs:Transaction xmlns:wfs="http://www.opengis.net/wfs" service="WFS"
version="1.1.0" xsi:schemaLocation="http://www.opengis.net/wfs
http://schemas.opengis.net/wfs/1.1.0/wfs.xsd"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance"><wfs:Insert><feature:Regions
xmlns:feature="http://www.delipetrov.com"><feature:the_geom><gml:MultiSurface
xmlns:gml="http://www.opengis.net/gml"
srsName="EPSG:4326"><gml:surfaceMember><gml:Polygon><gml:exterior><gml:Li
nearRing><gml:posList>23.36455078125 41.398999023437 23.095385742187
41.344067382812 23.172290039062 41.135327148437 23.743579101562
41.283642578125 23.36455078125
41.398999023437</gml:posList></gml:LinearRing></gml:exterior></gml:Polygon></
gml:surfaceMember></gml:MultiSurface></feature:the_geom></feature:Regions></wf
s:Insert></wfs:Transaction>';
```

Development of service for optimization of water resources

$$p_h^* = \arg\max_{p_h} \sum_{t=0}^{h-1} \gamma^t g_t(x_t, u_t, \varepsilon_{t+1})$$

$$x_{t+1} = f_t(x_t, u_t, \varepsilon_{t+1})$$

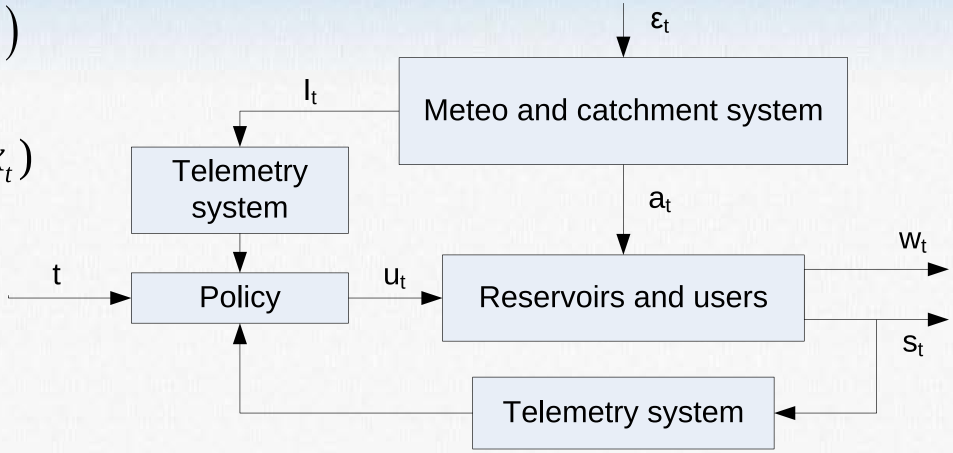
$$m_t(x_t) = u_t \in U_t(x_t)$$

$$\varepsilon_{t+1} = \phi(\cdot \mid x_t, u_t)$$

x_0 е дадено

$$p_h = \{m_t(\cdot); t = 0, \ldots, h-1\}$$

Dynamic programming (DP) and latter Stochastic dynamic programming (SDP) are one of the most used methods for optimal reservoir operation.

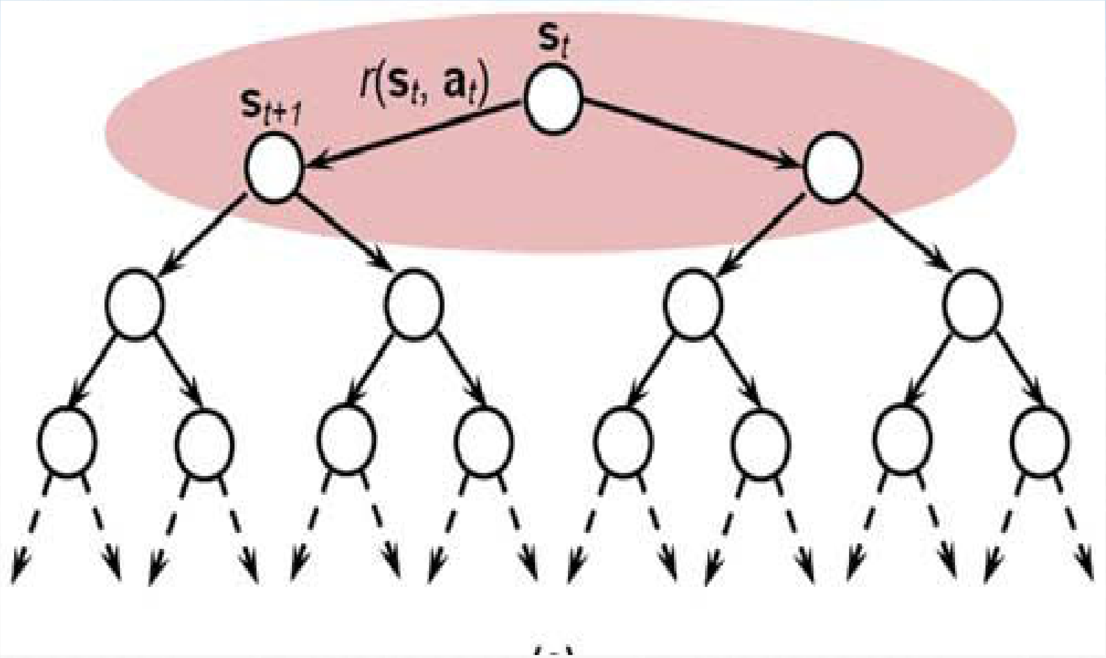


DP and SDP have two major limitation (Bellman 1957), 1Curse of dimensionality 2) Curse of modelling) and are difficult to be used in practical application of complex water systems.

Development of service for optimization of water resources

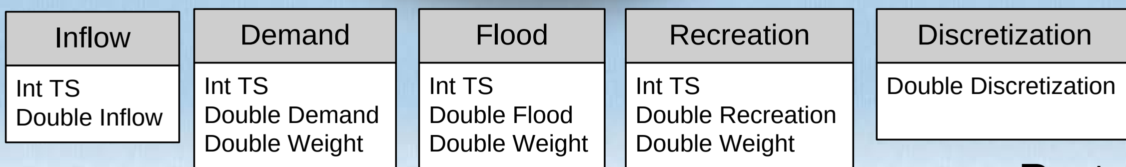
Solution of the problem is calculated recursively with Bellman equation:

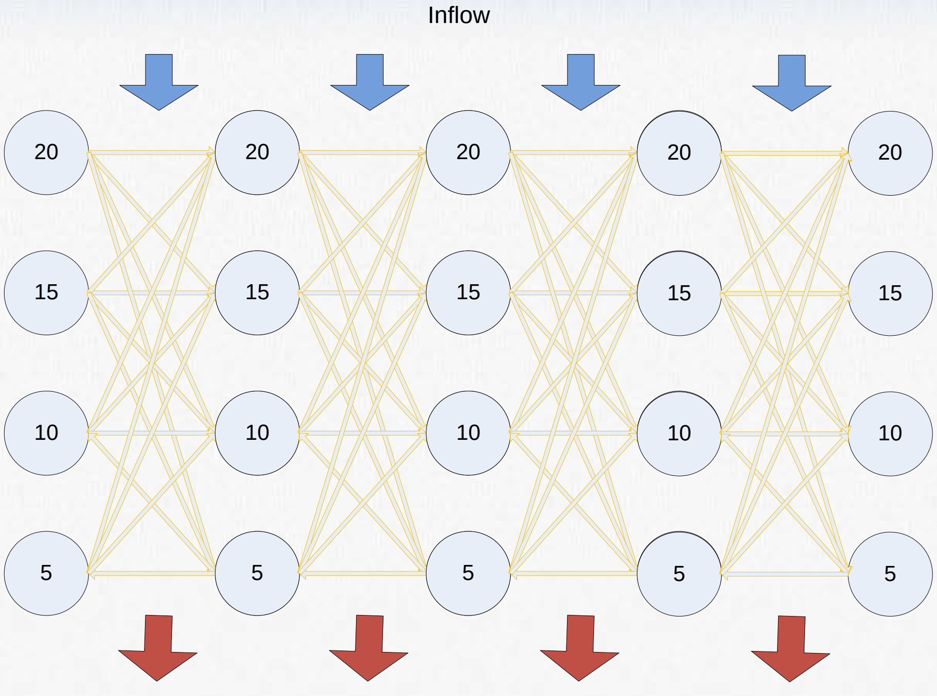
$$Q_t(x_t,u_t) = g_t(x_t,u_t,\varepsilon_{t+1}) + \gamma \max_{\mathbf{u}_{t+1}} Q_{t+1}(x_{t+1},u_{t+1})$$



$$m_t^*(x_t) = \arg\max_{\mathbf{u}_t} Q_t^*(x_t,u_t)$$

Development of service for optimization of water resources





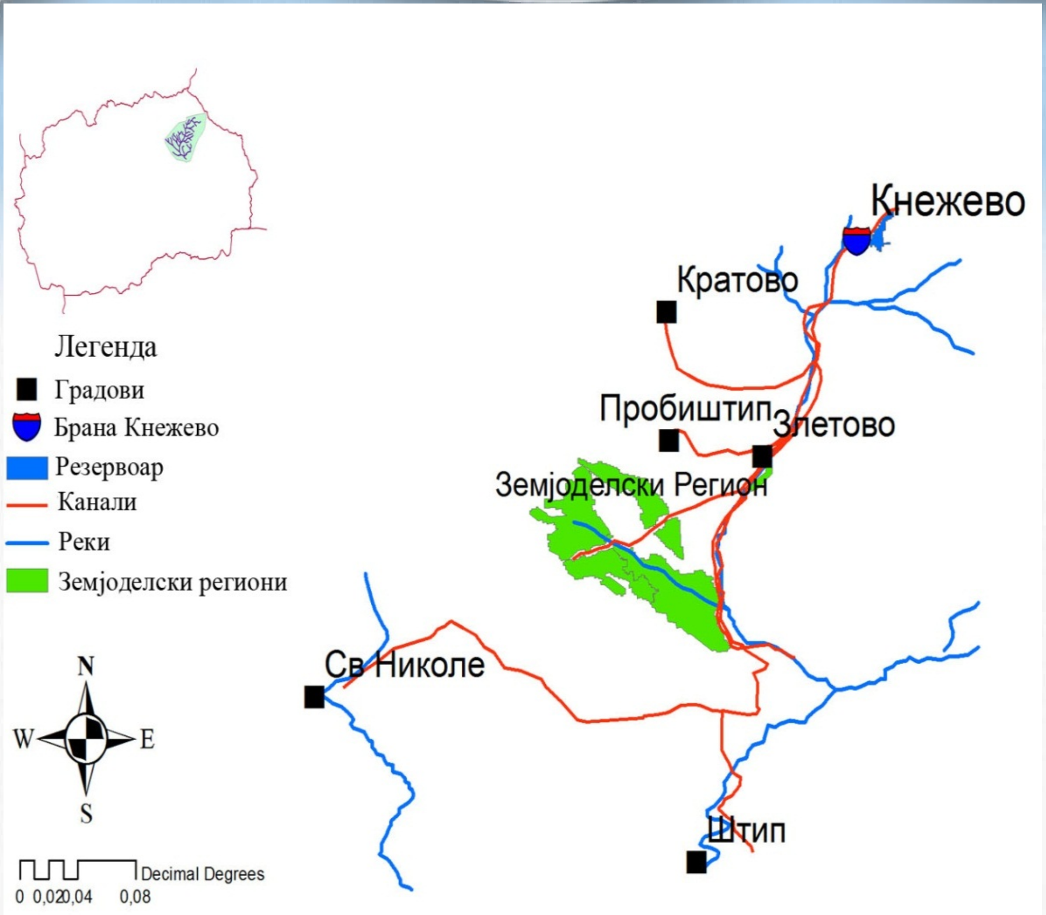
Prototype application DP is based on the algorithm of dynamic programming developed in Java using Eclipse.

Loucks, D. P., Van Beek E., Stedinger J. R., Dijkman J. P. M. and Villars M. T. (2005). *Water resources systems planning and management: an introduction to methods, models and applications*, Paris: UNESCO. pp. 90 - 113

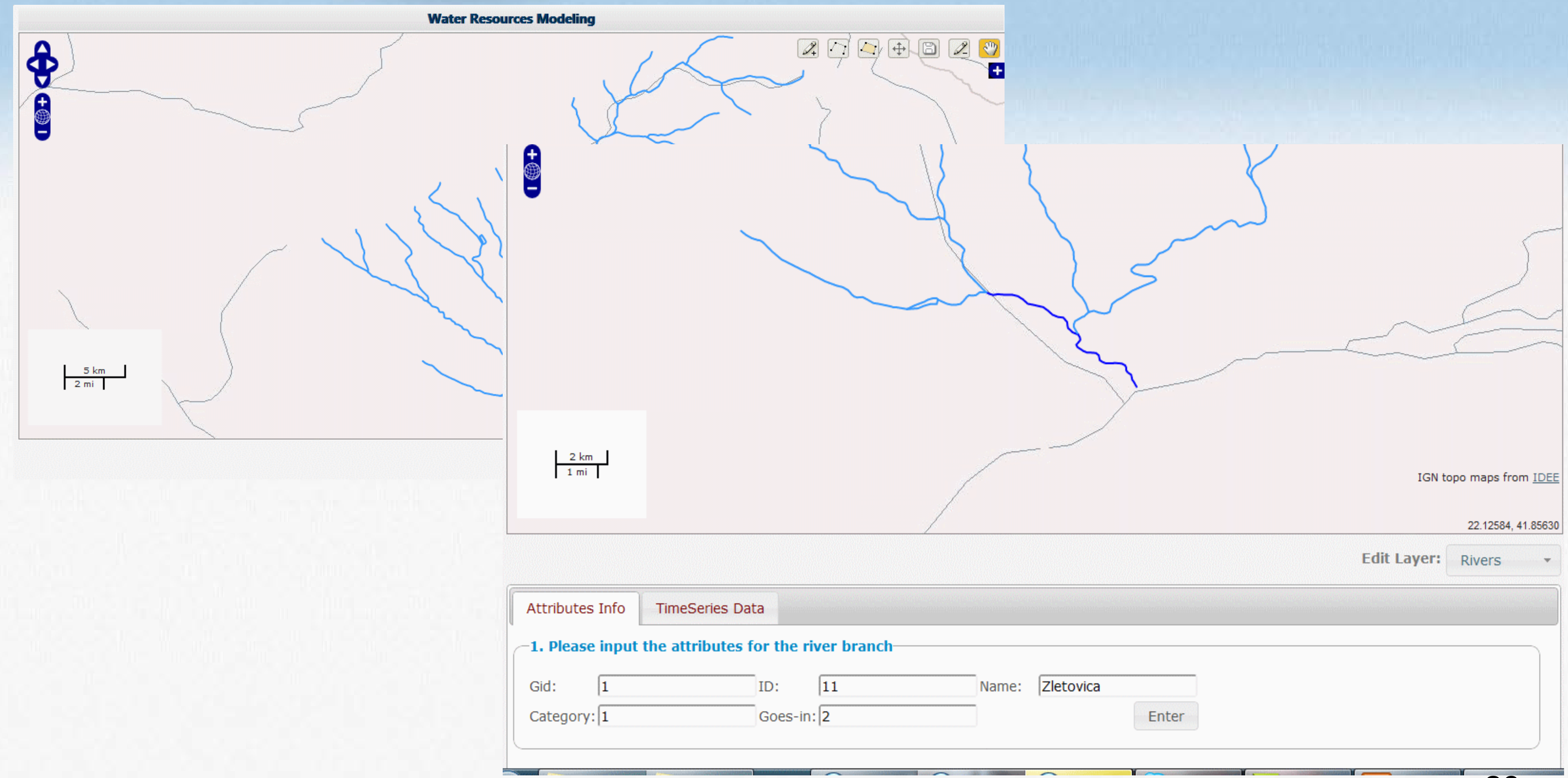
$$\min \sum_{t=0}^{T} TSD_t$$

Cloud hydro information system and web services implementaiton in HS Zletovica

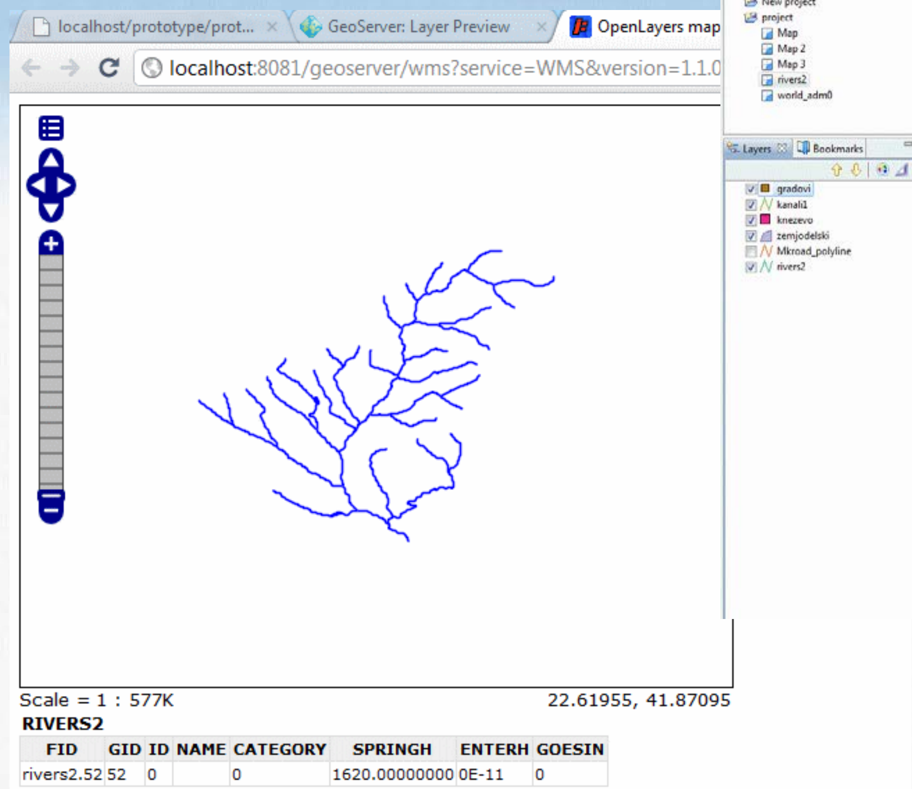
Hydro system Zletovica is in north east part of the Republic of Macedonia covering around 223.000 ha.



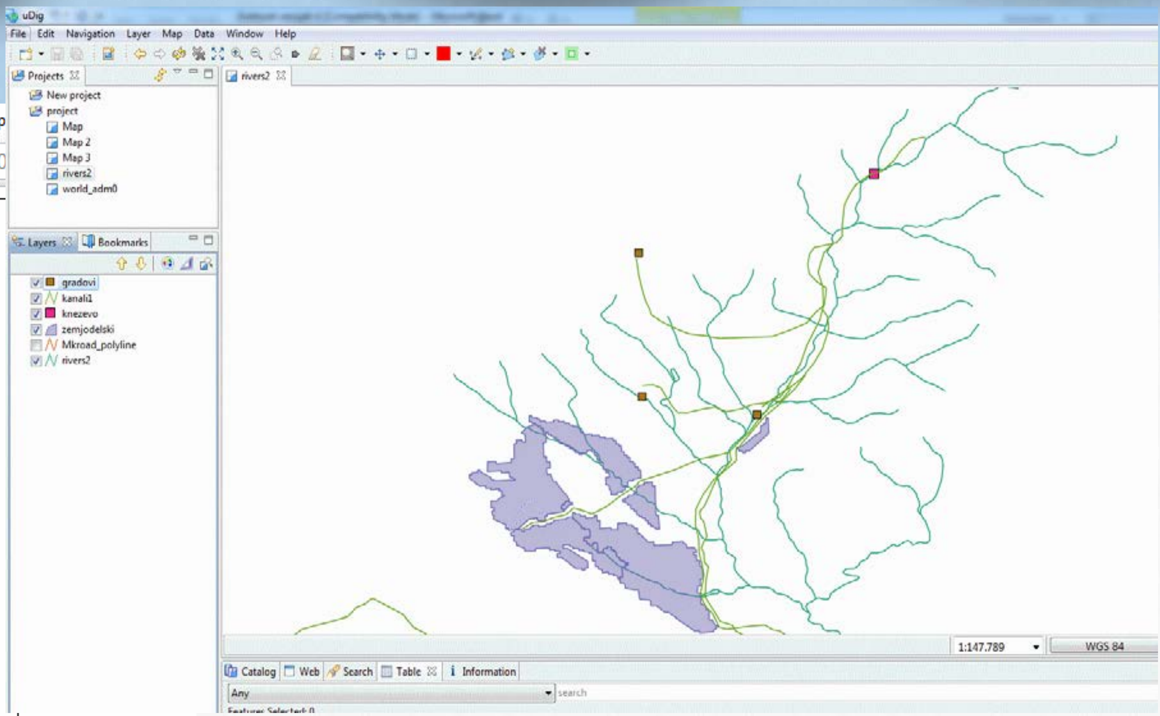
Cloud hydro information system and web services implementaiton in HS Zletovica



Cloud hydro information system and web services implementaiton in HS Zletovica



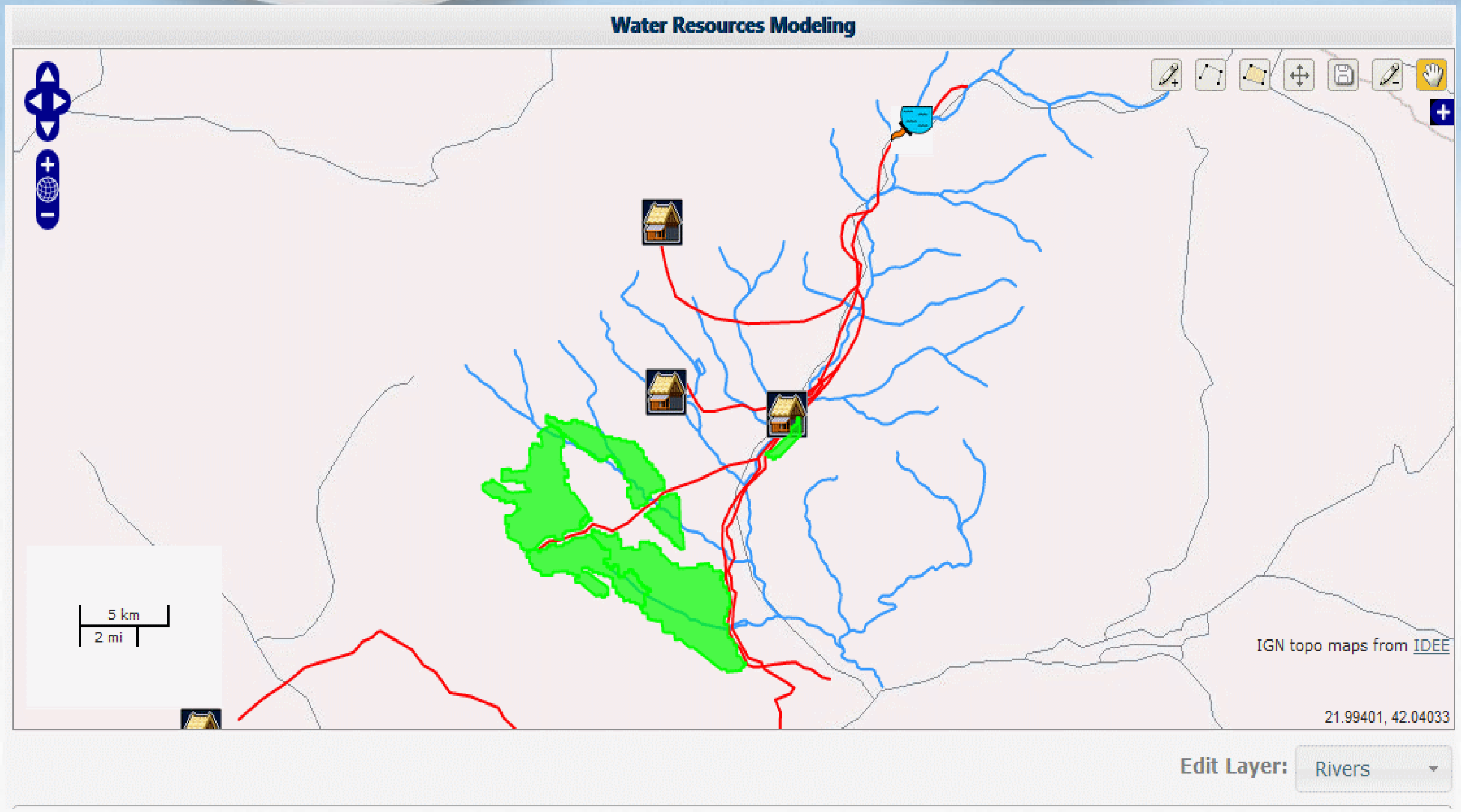
Geoserver



Desktop application uDig

- WFS
- WMS
- And others

Cloud hydro information system and web services implementaiton in HS Zletovica



Web service for water resources optimization

- Providing drinking water for municipalities Kratovo, Probistip, Zletovo, Stip, Karbinci, Sveti Nikole, Karbinci and Stip.
- Providing water for the agriculture for 3100 ha.
- Generating electrical power with three hydro power generators
- Biological minimun for Zletovica river

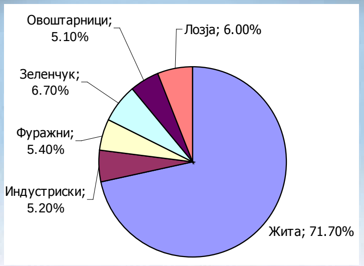
	Kratovo	Probistip	Stip	Sv. Nikole	Total
Average	0,11	0,13	0,50	0,09	0,72
Months	m3/s	m3/s	m3/s	m3/s	
1	0,10	0,11	0,43	0,08	0,621
2	0,10	0,12	0,47	0,09	0,681
3	0,11	0,10	0,39	0,07	0,559
4	0,11	0,13	0,50	0,09	0,719
5	0,11	0,13	0,52	0,09	0,742
6	0,12	0,15	0,59	0,11	0,845
7	0,12	0,15	0,58	0,11	0,840
8	0,12	0,15	0,58	0,11	0,840
9	0,12	0,18	0,70	0,13	1,006
10	0,11	0,13	0,51	0,09	0,738
11	0,10	0,09	0,37	0,07	0,531
12	0,10	0,09	0,37	0,07	0,531

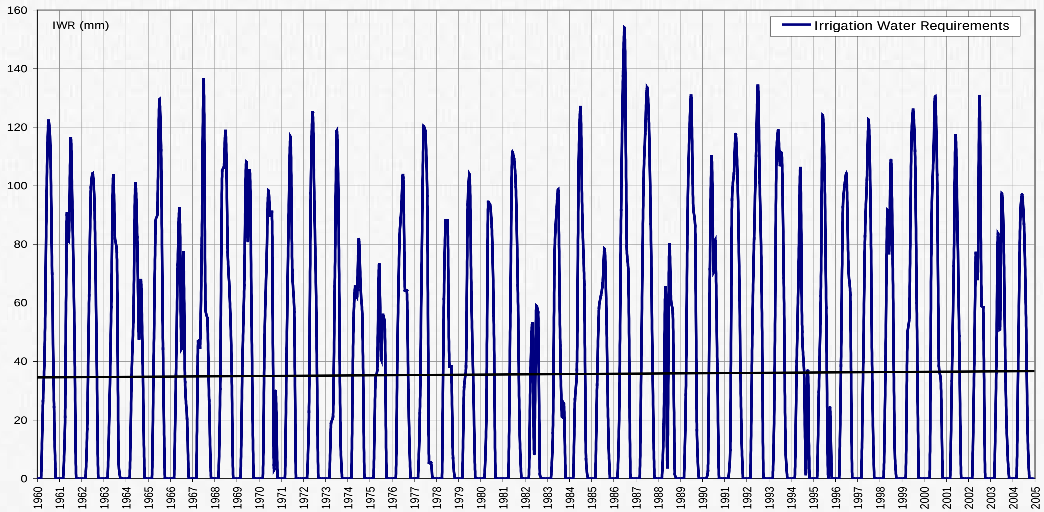
Water demand for municipalities

Web service for water resources optimization

Water for agriculture

Група култури	Кратово	Пробиштип	Регион
Жита	67.6%	74.6%	71.70 %
Индустриски	0.9%	8.3%	5.20 %
Фуражни	5.5%	5.3%	5.40 %
Зеленчук	11.4%	3.3%	6.70 %
Овоштарници	8.7%	2.4%	5.10 %
Лозја	6.0%	6.0%	6.00 %
Вкупно:	100%	100%	100%





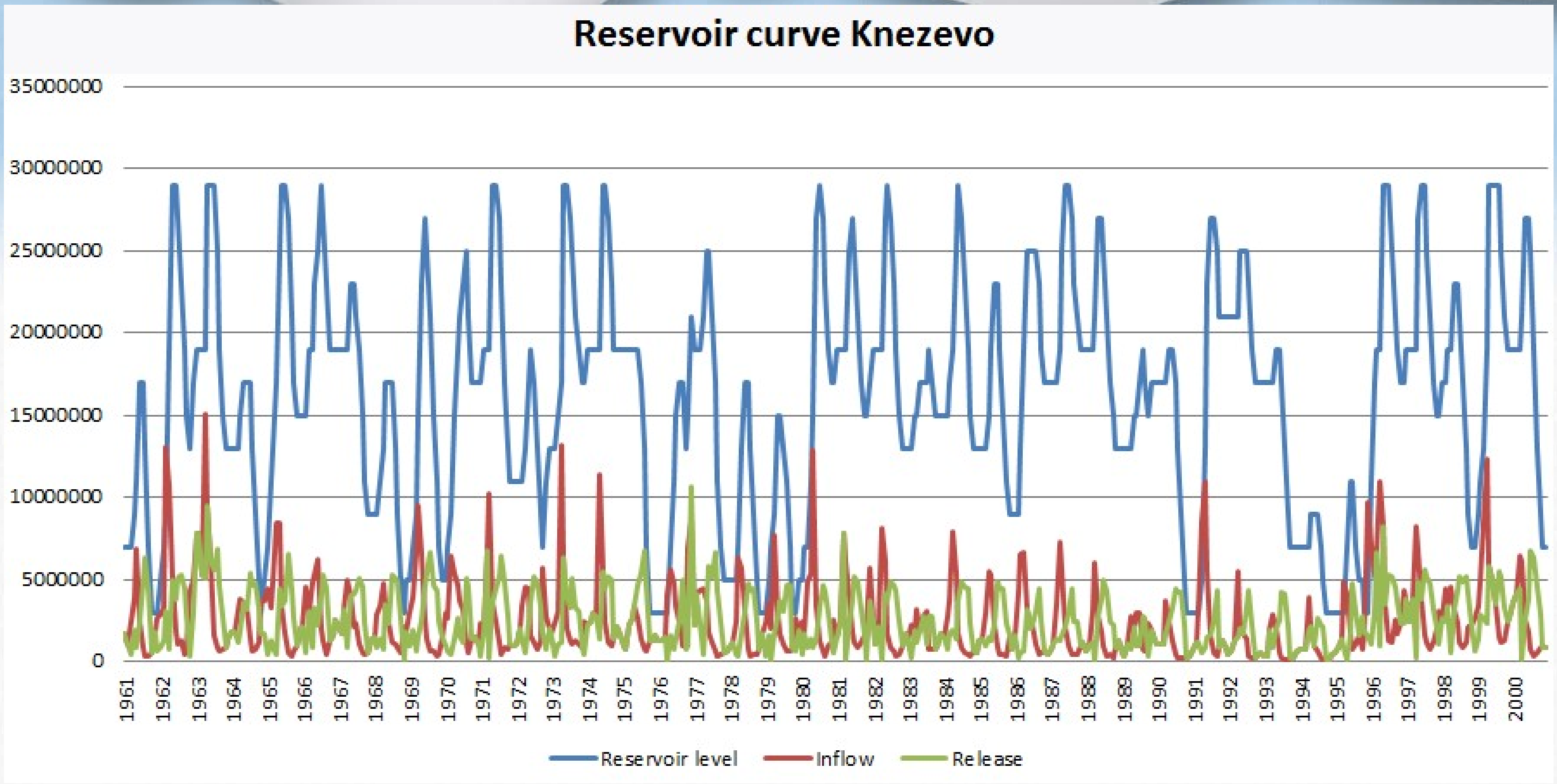
Web service for water resources optimization

Month	Floods(m^3)	Weight factor of floods	Recreation (m^3)	Weigh factor recreation
1	28000000	1	3000000	0.7
2	27000000	1	3000000	0.7
3	25000000	1	3000000	0.7
4	25000000	1	3000000	0.7
5	27000000	1	3000000	0.7
6	29000000	1	6000000	0.7
7	30000000	1	6000000	0.7
8	30000000	1	6000000	0.7
9	29000000	1	3000000	0.7
10	25000000	1	3000000	0.7
11	25000000	1	3000000	0.7
12	28000000	1	3000000	0.7

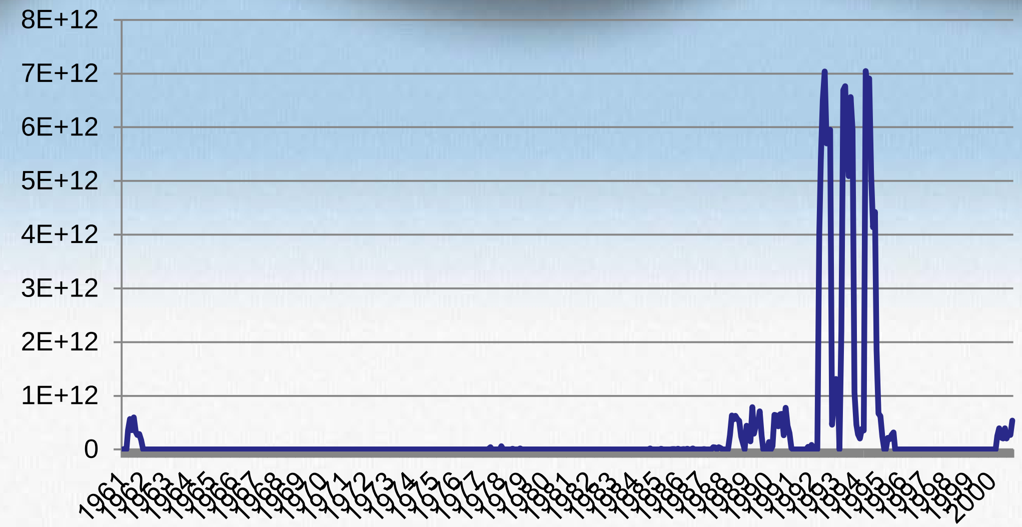
Input data for flood and recreation of the first simulation

0	**0**
1	500000
2	1000000
3	1500000
4	2000000
5	2500000
6	3000000
7	3500000
--	--
	3000000
60	0

Web service for water resources optimization



Web service for water resources optimization



Average water quantity in the reservoir (m³)	**18.072.917**
Average reservoir inflow (m³)	2.539.221
Average reservoir release (m³)	2.539.221
Total TDK	$1{,}43*10^{14}$

Overall results of the first simulation and optimization

Conclusion

- Open Source Components

- System advantages over previous technologies are:
- Accessibility (Anywhere)
- Availability (Anytime)
- Flexibility
- Supporting distributed computer resources
- Scalable computational power

- Ultimate internet based collaboration platform
- Tested with several users simultaneously using the web services
- Further system development can include additional water related data, urbanization, population growth, infrastructure, etc. and creation of additional web services.
- Optimization of water resources with using Reinforcement Learning, Decision threes, Artificial Neural Network and others
- The cloud computing framework is build, tested and ready for improving the existing or developing new web services

THANK YOU ☺
FOR YOUR ATTENTION

http://79.99.60.36/prototype/

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