The GENI Initiative Visualization

1. Abstract

This is an initial exploration of how GIS information, global development issues, electricity and transmission are currently being created, stored, made available, and promulgated on the Internet for use by GIS researchers, analysts, and policy makers.

2. Introduction

This paper is the result of a series of meetings over the last 18 months by GENI (Global Energy Network Institute) staff, SDSU (San Diego State University) Calit[2] Visualization Lab personnel and GENI interns, Jens Klawitter and Vivienne Seles. The initial "GENI Visualization" outline was created in Microsoft PowerPoint with a series of graphics captured from open data web sites. That "working model" and a one-page text description (The GENI Visualization), were used to create an initial video presentation for GENI's exhibit at the 2007 World Energy Conference in Rome.

Several months of research by Vivienne, aided by Paul-Michael Dekker, with coaching from SDSU Calit[2] Lab expert John Graham preceded the arrival of Jens from Germany. Upon Jens' arrival, GENI provided the hardware and software upgrades needed to continue the work on a workstation donated by a GENI supporter. The upgrades were needed to proceed with the work beyond the use of PowerPoint and still images.

3. Global Map Projections

3.1 Map Projection Choices Available

The selection of map projections was dependent on the software we used ArcGIS 9.2, which supports a large number of map projections[1].

3.2 Projections Used for the Online Presentation

The most familiar map projection is the "Universal Transverse Mercator coordinate system" (UTM). This projection was used in the project because most people are "accustomed" to it.

Spheroid used: WGS 1984 (World Geodetic System 1984)

3.3 Future Projections and their Usefulness for the World Resources Simulation Center

A further version, which uses the "Fuller Dymaxion projection," is conceivable. The advantages of the "Fuller Dymaxion projection" are as follows:

- It presents geographic information in a single, comprehensive picture without breaks in any of the continental contours or any visible distortion of the relative shapes or sizes of the land masses.
- It's a projection with negligible distortion[2].

4. Global Issues / Human Issues

This is a list of issues targeted for display by the WRSC (World Resources Simulation Center, a GENI project):

- ❖ energy ++
  - ➢ fossil fuels, nuclear (non-renewable)
  - ➢ renewable energy (solar, wind, hydro, biomass, geothermal, ocean energies)
- ❖ safe drinking water
- ❖ hunger & poverty
  - ➢ food production and distribution
- ❖ population growth ++
- ❖ income distribution (the gap between rich and poor)
- ❖ resource depletion
  - ➢ deforestation
  - ➢ desertification
  - ➢ topsoil loss
  - ➢ aquifer depletion
  - ➢ energy resource depletion
- ❖ pollution (air, water, land) +
  - ➢ toxics, chemicals, and nuclear
- ❖ loss of fisheries
- ❖ global climate change +
- ❖ illiteracy
- ❖ mega-cities in developing world ++
- ❖ human health +

Layers we are displaying right now:
(+partial   ++complete)

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[1] For more information:
http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=List_of_supported_map_projections

[2] For more information:
http://www.geni.org/globalenergy/library/buckminster_fuller/dymaxion_map/dymaxion_projection.shtml and
http://www.bfi.org

There are layers that one can't classify into only *one* specific issue. For example, the "Earth-At-Night" layer shows both information about electricity supply and also information about settlement locations.

We can display layers that show information *indirectly*. For example a layer about the issue "groundwater" gives information about the soil, water supply, plant growth, and so on.
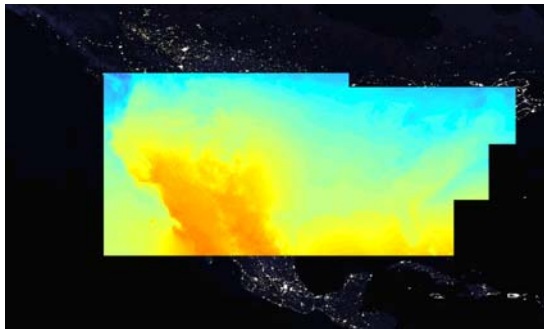As a GIS user, we relied on data that is available online, because we did not create any *new* data.

Figure 1
Partial Solar Radiation Data From NREL (North America).

5. Methods of Displaying Data for Current Projects

5.1 Locating and Collecting GIS Data and Statistical Data

To visualize the named issues in a GIS, we first required data. These data originated from various sources: authorities (e.g. National Renewable Energy Laboratory[3]), NGO (e.g. World Wildlife Fund[4]), firms (e.g. Platts[5]) and others (e.g. Map Ability[6]). The most important means to access data used for this work has been the Internet.

5.2 Data Management

All data was arranged in an appropriate structure on a local hard disk. Through this structure, the developer was provided with fast access to the data. For every record we used later, a Readme file with the exact download address of the record was designed and saved within the structure.

5.3 Formatting, preparation and colorization of data

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[3] Website: http://www.nrel.gov/
[4] Website: http://www.worldwildlife.org/
[5] Website: http://www.platts.com/
[6] Website: http://www.mapability.com/

Many data are already published in GIS-suitable formats on the Internet (e.g. Shapefiles, Geotifs etc.). Others are available in different formats (e.g. Databases, Excel Files) and must be connected with geographic information.

An important process of this project is the Colorization and/or Visualization of the data. This resulted in the current color schemes used by the resulting Flash visualization and WMS server presentations mentioned below.

5.4 Methods of comparing data for decision-making

Data can be presented in many different manners. Next to static maps (printed or digitally), we have demonstrated time animations for certain trends (e.g. CO_2 emissions of the last 25 years, or the USA's solar radiation monthly loop for one year), when the appropriate raw data are available. Other methods of displaying data are used as required to illuminate the issues discussed in a compelling manner.

It is important to use a common color scheme for data when visualizing them. In ArcGIS, we have a huge choice of colors and color schemes. But, because we want to compare data (like total CO2-emissions and CO2-emissions per capita) it is useful to select one color scheme for all data (at least for all data that are generated out of statistical data and have a "country by country" resolution; that means every country has one color that represents the specific statistical value). Legends should be easy to understand and not confusing. Therefore, we avoided long decimal places.
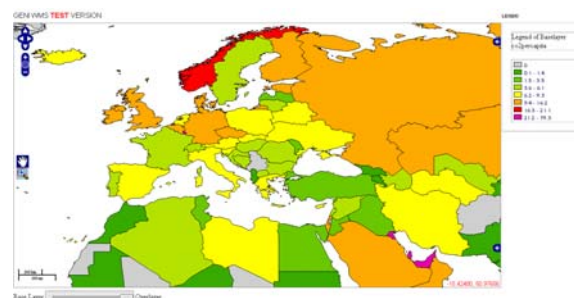

Figure 2
CO2 Emissions Per Capita. "Country by country" Resolution

5.5 Making Statistical Data Available in GIS Format & GIS Software

Statistical data that already exists (for example in Excel Spreadsheets) can be connected with

geographic information. We used a Shapefile[7] with geographic information of every country in the world. Most statistical data have a specific area they are attached to. In the case of statistical data for countries, the connected area is, of course, the country itself.

Because the spelling of the countries name in the statistical data is not always 100% the same as the Shapefile name, we used a numeric identifier for each country. With the "JOIN" function in ArcGIS and the numeric identifier used in each spreadsheet it is simple to connect the geographic information from the Shapefile with the statistical data from a spreadsheet.

With this method we made many purely statistical reports' data available via ArcGIS. We targeted about 25 issues of global concern based on data of the "Human Development Report" (United Nations Development Program) as well as data in the "International Energy Annual 2005" from the Energy Information Administration (EIA)

5.6 Animation of data over time

Based on this method, We developed some animations over time. This is possible when there are statistical data available over a certain time period. Animations of this kind are relatively uncommon in GIS, because the function is relatively new. We can use animations like this for more timely and effective decision making. Animations over time are able to show certain trends, like the increase of CO_2-emissions in the world in the last 25 years.
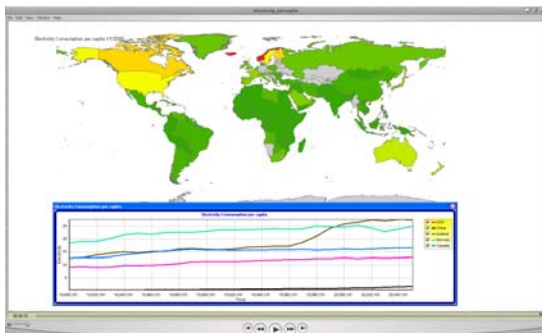

Figure 3
Animation Over Time. Issue: Electricity Consumption Per Capita Over 25 Years (1980 – 2005).
Created out of statistical data and exported in *.mov-file format from ACRGIS 9.2

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[7] The **ESRI Shapefile** or simply a **shapefile** is a popular geospatial vector data format for geographic information systems software (Wikipedia).

6. Software Tools Used

6.1 ArcGIS 9.2

ArcGIS is an extensive GIS software program. Among other things, it enables the visualization and preparation of GIS data. The software is commercial, and we used a Trial Version. Jens chose ArcGIS because he had taken a one-year course in ArcGIS during his study at the University of Applied Sciences in Eberswalde, Germany. He wrote His thesis in the field of GIS (Geodata management, generating and visualizing based on a cloud forest project in Puebla, Mexico).

As mentioned before, the tool to develop time based animations is relatively new and in an early state of development. Depending on how extensive the data are that you want to use for animations, it could take a lot of processing time to develop the animation. Of course this depends on the computer you use, too. With our computer, the "solar radiation animation" took about 12 hours of processing time to render. This is much like rendering high-end graphics for an animated feature movie that you may see in a theater.

ArcGIS is not a tool you can use to make predictions or forecasts of the future. ArcGIS can only help you visualize *existing* historical data.

6.2 Quantum GIS (open source)

Quantum GIS is an efficient GIS software program. An advantage of Quantum GIS is that it is open source and therefore freely available. We used Quantum GIS primarily to test the MapFile of our Mapserver[8] and the Web Map Service. MapFiles are the basic configuration mechanism for MapServer.

6.3 Microsoft Excel & Access

Microsoft Excel & Access were used to process data available in spreadsheets and other statistical data. ArcGIS is able to import data in *.xls-file format, but there are lot's of limitations when processing *.xls-files in ArcGIS[9].
As mentioned before, to connect statistical

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[8] MapServer is an Open Source development environment for building spatially-enabled internet applications. MapServer excels at rendering spatial data (maps, images, and vector data) for the web.
[9] For more information see:
http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Working_with_Microsoft_Excel_files_in_ArcGIS

data with geographic information, we used the "JOIN" function of ArcGIS and the following process:

- First, you delete all unnecessary information in the raw data *.xls-file from the UNEP (like unnecessary spaces, columns, headlines and so on) in Microsoft Excel
- The Result is a *.xls-file that has only the name of the country and the value of the specific issue (like CO_2-Emissions in the year 2005) included
- Then match the numeric identifiers with the ID from the Shapefile
- Next convert the raw data (which are available in *.xls-file format) with Microsoft Access into *.dbf-file format.
- Finally import the statistical data in *.dbf-file format (from Access databases) into ArcGIS, because *.dbf-files can easily join with the table of attributes of a Shapefile (which is also in *.dbf-file format).

6.5 Adobe Flash

Adobe FLASH was used by Silvio Rabe, another intern at GENI, to represent some data in an online interactive animation. High resolution graphical images were exported out of ArcGIS and scaled to fit in the FLASH animation. With those images, he created a FLASH animation, where you can slide between different issues and zoom for better visibility and clarity. There is a menu available with that visualization where you can navigate through the different issues and explore (compare and contrast) them via your choice of web browser[10].

Because we used only exported, static "pictures" of the actual maps' respective data, there is only a limited interactivity in this FLASH animation. Views and features like legends are not created dynamically.

An advantage of a FLASH animation is that it is relatively simple to develop and design.

6.7 Workstations Used

The machine that was used for ArcGIS, Excel, Access and rendering was:
Custom-fabricated GIS workstation, including Windows XP Pro operating system

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[10] Web Browser: any a number of software programs that allow viewing of information posted on an Internet site.

Hardware details:
    Intel Pentium 4, CPU 3.00 GHz, 4 GB of
    RAM, 250GB Hard Disk Drive

The machine that was used for Internet research, integration, testing, and study was: Macintosh Operating System OS 10.4 (Tiger) Notebook computer
Hardware details
    Intel Core 2 Duo, CPU 2.16 GHz, 2 GB of RAM, 320 GB Hard Disk Drive

7. WMS – Web Map Service

With the help of John Graham, who made available the corresponding WMS server, it is possible to store the Geodata[11] on a MapServer. With the server in place, it is possible to operate a Web Map Service (WMS). To display this data on the Internet we used the Web Map Client/Viewer "OpenLayers". This is an open source Javascript library.

§   *The MapServer is provided by John Graham at the SDSU IT Visualization Laboratory -*

These are the specifications of the hardware the MapServer is running on:

    Intel Dual Woodcrest, 4 GB RAM from
    supermicro, sponsored from Intel

OpenLayers allows us to implement a couple of interesting features (e.g. Slider-function, Zoom etc.). It is highly user interactive and creates the views (e.g. when zoomed) and legends automatically out of the selected files. This means once set up and configured, it is easy and comfortable to implement more layers.

It is possible to use other Web Map Services (e.g. from NASA) that supply large amounts of data, which are impossible to distribute/serve for a NGO like GENI.

8. Data Sources

The following table is a list of Layers and their source of data that was used to create the GENI Web Map Viewer:

Layer	Solar Radiation
Name of File	soam.shp, africa.shp, asia.shp
Link to Datasource	http://swera.unep.net/index.php?id=35&idx=337
Citation	Author or developer (Originator): U.S. National Renewable Energy Laboratory (NREL) Name or title (Title): Solar: monthly and annual average direct normal (DNI), global horizontal (GHI), latitude tilt, and diffuse data and GIS data at 40km resolution for South America from NREL Publication or Release Date (Publication Date): 2006-Jul

Layer	Cities
Name of File	glpv1.shp
Link to Datasource	http://sedac.ciesin.columbia.edu/gpw/global.jsp

Layer	Transmission Grid
Name of File	trans_eu.shp, trans_na.shp, trans_asia_aus.shp, trans_saa.shp
Link to Datasource	http://www.mapability.com/index1.html?http&&&www.mapability.com/info/vmap0_index.html
Citation	a. "this product was developed using materials from the United States National Imagery and Mapping Agency and are reproduced with permission", b. "this product has neither been endorsed nor authorized by the United States National Imagery and Mapping Agency or the United States Department of Defense"

Layer	Earth At Night
Name of File	soam.shp earth_city_lights_5km.tif
Link to Datasource	http://visibleearth.nasa.gov/view_detail.php?id=1438
Citation	

Layer	Blue Marble
Name of File	(WMS)
Link to Datasource	http://wms.telascience.org/cgi-bin/ngBM_wms?STYLES=&TIME=2004-09
Citation	

Layer	NASA Global Mosaic
Name of File	(WMS)
Link to Datasource	http://t1.hypercube.telascience.org/cgi-bin/landsat7
Citation	

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Layer(s)	➢ Coal ➢ CO_2(total), CO_2(per capita) ➢ Population(urban), Population(total) ➢ Improved Water Sanitation, Improved Water Source ➢ Economic GDP, Economic GDP(per capita)
Name of File	coal.shp, co2total.shp, co2percapita.shp, popurban.shp, poptotal.shp, imp_water_sanitation.shp, imp_water_source.shp, eco_gdp.shp, eco_gdp_percapita.shp
Link to Datasource	Datasource of statistical data: http://hdrstats.undp.org/indicators/
Citation	maps based on statistical data from UNDP; development of maps & colorization "Global Energy Network Institute"
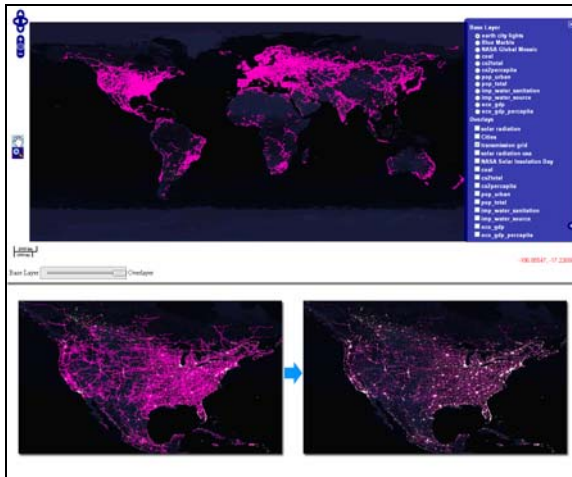
Figure 4
Picture on top: Screenshot of our Web Map Viewer
(OpenLayers);
Selected layers are:
- the "Earth City Lights" layer and
- a layer displaying the transmission lines as an
  overlay

Pictures on the bottom:
This shows the effects of the Zoom function and the Slider
function

8.1 Open Data and Open Source Data

Open Data is a philosophy and practice
requiring that certain data are freely available
to everyone, without restrictions from
copyright, patents or other mechanisms of
control. It has a similar ethos to a number of
other "Open" movements and communities
such as open source[12] and open access.

8.2 Copyright Issues for GIS data

Often, freely available data is copyrighted, but
it allows you to use (and sometimes change)
the data[13].

8.3 Pay-for-Use data

There is a huge variety of Pay-for-Use GIS
data available on the Internet. The advantage
of Pay-for-Use data is that they are often more
accurate than Open Source data. One
disadvantage is the high price and often the
restricted copyright rules. Here are some

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[12] For more information about open source:
http://opensource.org/docs/osd
[13] A good example for this type of data are data from
NREL. This is a short quote from their copyright
statement: "The user is granted the right, without any fee
or cost, to use, copy, modify, alter, enhance and distribute
this data for any purpose whatsoever, provided that this
entire notice appears in all copies of the data. Further, the
user of this data agrees to credit NREL in any publications
or software that incorporate or use the data."

Internet sites that provide energy-related Pay-
for-Use GIS data:

http://www.solemi.com/order.html

http://www.petroleum-economist.com/

http://www.platts.com

http://www.rextagstrategies.com

9. Summary

The results of this project so far are:
- We displayed some layers of the GENI
  Visualization on the Internet. Some of
  them are created out of statistical data
  and, therefore, may be new in a Web
  Map Service.
- The approach of displaying all the
  issues is a very extensive one. It could
  show the public how coherent these
  issues really are and in a more
  understandable way.
- The interactivity (e.g. the slider-function)
  is an appropriate way to recognize
  connections between global concerns.
- Animations are a good way to display
  time-dependent trends.

The next step that is planned is:
- Implement a better menu for
  OpenLayers

The opportunities for enhancing this project's
results are:
- Implement more layers
- Improve the functions and features of
  the Web Map Viewer (e.g. get feature
  request options, menu that does >>>)
- Convert more data from statistical data
  (e.g. with higher resolution (state level,
  province level) and/or with the time
  series available for comparisons)
- Cooperate with institutions that could
  provide GENI with unique, exclusive
  data (e.g. forecasts of population
  development)
- Create an all-in-all presentation (maybe
  on a DVD) that features:
  - animations (FLASH movies
    that highlight specific ideas);
  - an online Web Map Viewer
    with commentaries from
    Experts;
  - other animation / movies

10. Links

10.1 Link to extensive collapsible list of links on global issues

10.2 Link to extensive collapsible list of links on GIS data

10.3 Links to other online resources that John Graham suggested that were used, including ways to display the work

10.4 Links to other online resources found as a result of this work

11. References

Dymaxion projection
http://www.geni.org/globalenergy/library/buckminster_fuller/dymaxion_map/dymaxion_projection.shtml

UMN – MapServer
http://mapserver.gis.umn.edu/

OpenLayers
http://openlayers.org/

12.   Bibliography
http://mapserver.gis.umn.edu/
http://openlayers.org/
http://de.selfhtml.org/
http://www.google.com

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13.   About the Authors

13.1   Jens Klawitter
Jens Klawitter is from Berlin, Germany. He has a Certificate in "Landscape Use and Nature Conservation" (BS). He is studying "Global Change Management" (MS) in Eberswalde, Germany, while performing his research at GENI's office in San Diego, California. His specialization is Geographic Information Systems (GIS), which was the focus of his thesis ("Geodata management, generating and visualizing based on a cloud forest project in Puebla, Mexico"). You can contact Jens via email at: JENS @ wirreswirken.de or MCJK @ gmx.net.

13.2   Paul-Michael Dekker
Paul-Michael Dekker lives in San Diego, California. He received a Bachelor of Applied Science (Systems Design Engineering) from the University of Waterloo, Waterloo, Ontario, Canada, in 1980. He is currently the IT Director for GENI. Paul-Michael has written previously on *The GENI Model* (http://www.geni.org/globalenergy/library/geni/simulation/the-GENI-model.shtml).
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13.3   Peter Meisen
Peter lives in San Diego, California. He graduated from the University of California, San Diego with an Applied Mechanics and Engineering Sciences degree in 1976. Peter Meisen is currently the President of GENI. Peter has written extensively about *The GENI Initiative*.
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13.4   John Graham
John lives in San Diego, California. John is the Chief Scientist for SDSU's it^2 Visualization Center. His extensive background can be found at http://www.telascience.org/Members/johng/.
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Flash Visualization:
http://www.geni.org/globalenergy/multimedia/animations/global-viz-comparisons/flash-presentation/webtest.swf

WMS Visualization:
http://hypersphere.telascience.org/~jubai/test_wms.html