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Informatics

Computer-Aided Design of the Information Ecosystem for Monitoring of the Black Sea Water Resources

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ABSTARACT: The present article considers problem of designing information system infrastructure for monitoring of water resources within the Black Sea basin of Georgia. Object-oriented, multimedia database technology was used as well as interface mobile communications using service-oriented architecture. Automated design of database server structure and reverse process (ORM <-> ERM) research for the ecosystem was carried out using CASE technology, in particular, using the object-role modeling (Natural ORM Architect) graphical-analytical instrument. System infrastructure for the eco-monitoring has been developed within integrated environment of MsVisual Studio .NETFramework 4.5 based on SQL Server database and Ms Sharepoint packages.

Key words: database, object-role modelling, ecology, monitoring system

One of the major challenges faced at the modern stage of human development is the necessity to achieve ecological sustainability [1,2]. Biosphere is conditionally divided into three subspheres: Aerobiosphere, Hydrosphere and Geobiosphere [1]. Within boundaries of these three environments we have the life environments of air, water and land. Earth biosphere comprises a diversity of ecosystems. An ecosystem is a combination of live organisms and their non-live environment. The diversity of living organisms creates a complex network of interactions that determines the sustainability of a certain ecosystem.

Climate changes taking place during the past years have led to changes in certain natural processes, among which is the increased risk frequency of flooding in river estuaries within the Black Sea basin. Estuaries of these rivers and their nearby areas often get flooded, erosion of the sea coastal line (abrasion) occurs, leading to negative ecological outcomes. In particular, we are dealing with the Black Sea within the boundaries of Georgia.

Considering the above, the scientific research of the environment in the area of the Black Sea ecology and prediction of its ecological parameters is of high importance, representing one of the country's strategic directions on the protection and retainment of land areas adjacent to the Black Sea is high priority of the

State [3]. The objectives of the scientific field research were: to determine areas of estuaries for the major rivers within the Black Sea basin in GPS coordinates and to do the mapping (Fig. 1), to identify temperature of the sea water and air, to take the sea water samples from the estuaries and vulnerable districts and to conduct laboratory research [4]

The field research for collecting various parameters using GPS coordinates would be much convenient if data entry could take place from a computer located at a distance. This way the parameters entered are remotely transferred to the web of the corporate portal and to the remote SQL Server database [5-7].

Name of the river and point coordinates	Genaeral view of the estuary on the digital map	Area of the estuary, km^2
I. River Chorokhi 1. X- 41602473,Y- 41571921; 2. X - 41600256,Y- 41570205; 3. X- 41604317, Y- 41561104; 4. X - 41618219, Y- 41539946; 5. X- 41628109, Y- 41.550019; 6. X- 41620934, Y- 41573706; 7. X - 41610627, Y- 41.569531; 8. X - 41604571, Y- 41573116		**5.465**
VI. River Rioni X- 42172443; Y- 41645811; X- 42173884; Y- 41629814; X- 42194850; Y- 41.593968; X- 42234461; Y- 41609054; X- 42261137; Y- 41626465; X- 42244261; Y- 41632567; X- 42216245; Y- 41631737;		**14.551**

Fig. 1. GPS coordinates of the rivers within the Black Sea basin: Chorokhi and Rioni.

Experts from the monitoring service take water samples from the above shown control points for analysis and once analysis is done, results are transferred to the major server of the system using mobile gadgets [6]. Fig.2 represents a Table which shows the values of ecological parameters entered from those control points. Exact time when the data are entered is automatically fixed.

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asaxeleba, GPS_X, GPS_Y, Temp, Mjavianoba, Marilianoba, GETDATE() AS Dro, Tanamshromeli_ID

dasaxeleba	GPS_X	GPS_Y	Temp	Mjavianoba	Marilianoba	Dro	Tanams
sarfi	41526956	41548731	45.90	67.89	45.78	2016-06-22 06:24:58	NULL
kvariati_1	41545542	41561587	67.00	67.00	34.00	2016-06-22 06:25:00	1
kvariati_2	41554651	41563841	NULL	NULL	NULL	2016-06-23 08:10:11	NULL
gonio	41574588	41565589	NULL	NULL	NULL	2016-06-23 08:10:10	NULL
NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL

Fig. 2. Table with sea ecological parameters.

Designing Conceptual ORM Model for the Black Sea Ecological Parameters

Our objective is to design database and develop software for the Black Sea ecology computer system. At an initial stage, we need to define objects describing main parameters of the sea ecosystem in terms of syntax and semantics. System analysis has been conducted resulting in the following objects:

Sea (SeaID, Name, Length_EastWest, Length_NorthSouth, Area, Water_volume, Average_depth, Max_depth);

River (RiverID, River_Name, Catchment_pool_area, km2, Absolute_mark, m, River_length, km, Average_inclination, i, Average_height_of_basin_section, m, Average_runoff_module, L/sec.km2, Average_annual_cost m3/sec);

Estuary (EstuarID, RiverID, CoordGPSx, CoordGPSy, Area,);

Vulnerable_district(Vulnerable_districtsID,CoordGPSx, CoordGPSy, Area, T1/T2, pH, TDS);

GPS_coordinates (CoordGPSx, CoordGPSy);

Sensitive_area (SensitiveAreasID, CoordGPSx, CoordGPSy)

District (DistrictID, Name, CoordGPSx, CoordGPSy, Area, T1/T2, pH, TDS);

Water_test_factors(WaterTestID, WaterT1, AirT2, Water_acidityPH, WaterSalinityTDS) etc.

Database was designed using an object-role modeling instrument and its principles. [8,9]. As an instrument we used Natural ORM Architect (NORMA) package which is compatible with integrated system of Visual Studio.NET Framework [8].

Conceptual model (ORM) or a schema is a unity of main terminology found in the problem area and related links among them, describing business processes and rules of the given research area. In theory, it jointly used categorical approach (Grammar rules of a language) and math logic (algebra) [10,11].

Using the NORMA instrument interface, knowledge from users related to objects to be designed is transferred to the system in the descriptive, textual form of objects, their attributes and predicates (binary, … , n). Later on, NORMA system itself provides us with an integrated conceptual model which is shown in Fig.3:

To illustrate, we described four objects: River, estuary, estuarCountur and district. Connections among these objects are constructed using “has”, “is”, “works”, etc. predicates. Predicates are facts, for instance: f1: River has RiverName; f2: River has RiverLength; f3: River has Estuar; f4: Estuar has River ; etc., f15: District has Category; f16: District_Category is Normal or Sensitive or Vulnerable and so on.

Object “District” has a parameter “district_category” which represents a value from a set {normal, sensitive, vulnerable}, determined by values of its ecological parameters. It is possible that results might contain inaccuracies, correction of which is possible easily under network modification regime by the user itself any time before the final conceptual model is designed (shown in Fig. 4 with realistic tables and database attributes). Fig. 4 gives primary (PrimaryKey) and secondary (ForeignKey) keys, using of which connections among data were carried out.

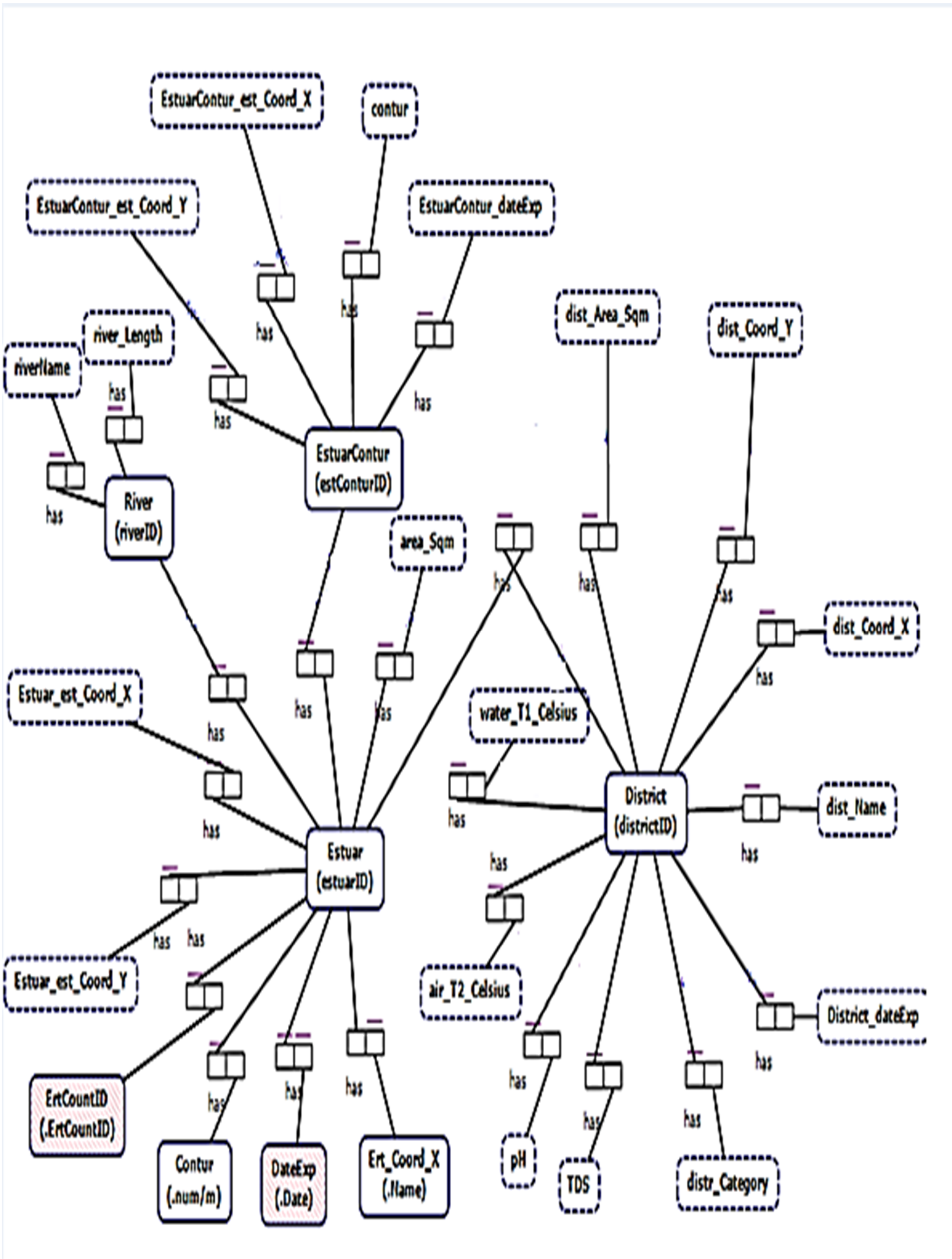

Fig. 3. Fragment of ORM schema of the Black Sea ecology monitoring system.

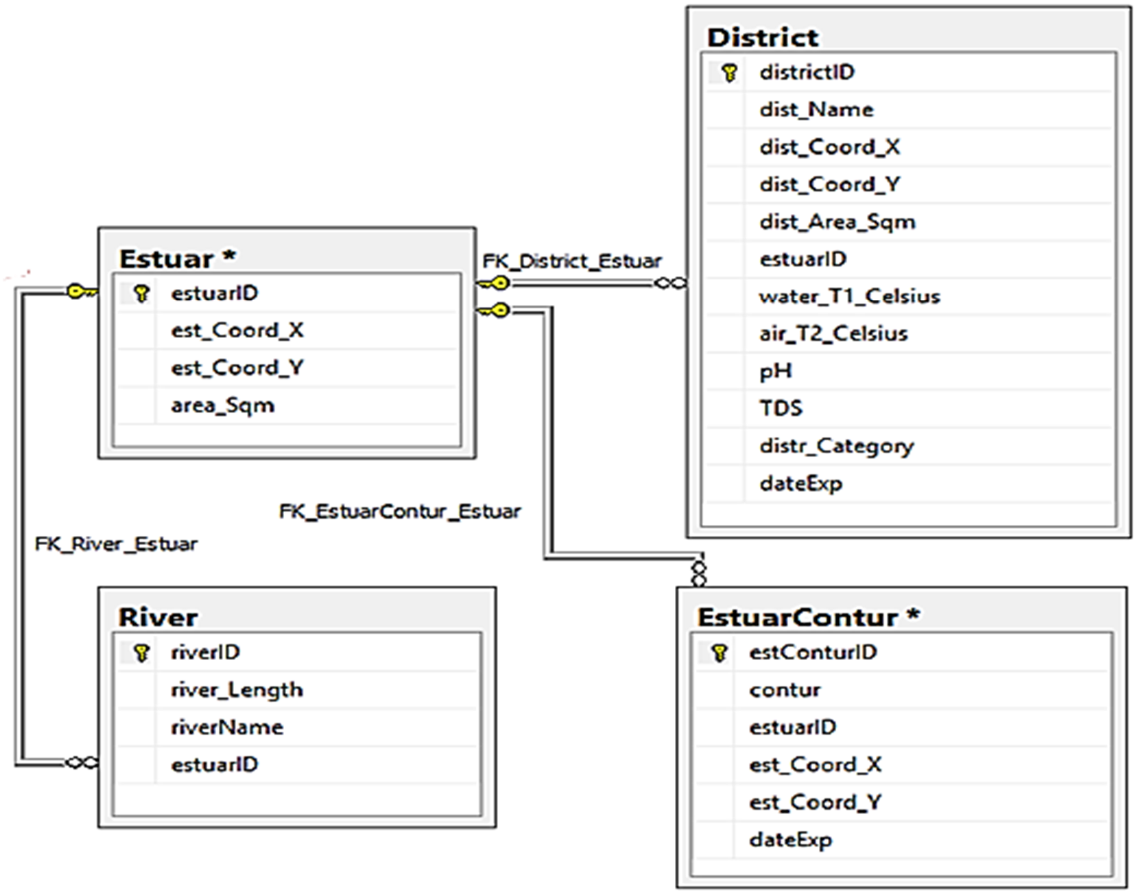

Fig. 4. ERM- Conceptual Model.

Developing Web-Service for the Black Sea River Estuary Monitoring System

Web portal has been developed on the basis of Ms SharePoint Server which provides flexible possibilities of using cooperation and group services. In particular, it is possible to quickly create web-based services for groupwork [12]. At next stage, it is necessary to connect MsSQL Server database with the web portal. To solve this, we used Sharepoint Designer. Fig. 5 presents Table with measurement values taken at control points as shown on the organization's web portal.

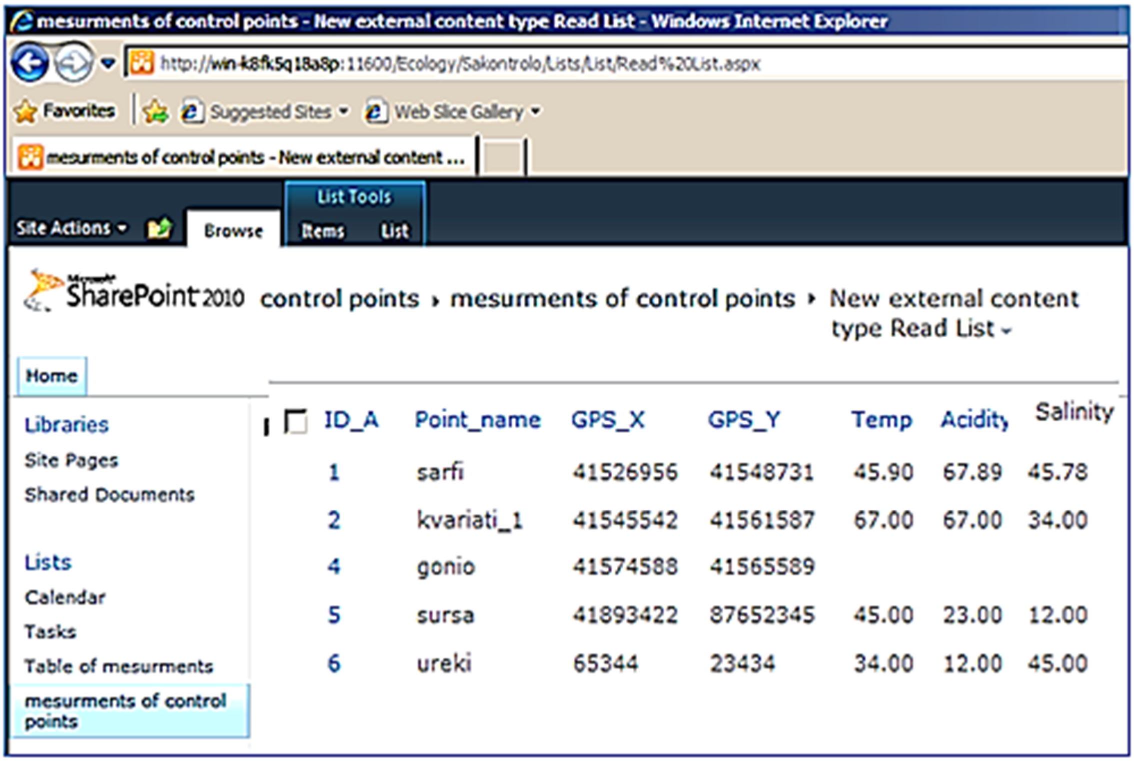

Fig. 5. Measurement values taken at control points.

Thus, taking various measurements according to GPS coordinates can be carried out from a remote computer or mobile phone. Efficient data entry right at the point of research does not require the use and maintainance of a paper register. Values are depicted on the corporate web portal at the moment of entry in the remotely located SQL Server database.

Conclusion

The constructed experimental monitoring system is capable of identifying new vulnerable districts of the coastal line with respective areas according to GPS coordinates. The system was developed using dynamic forms of Ms SharePoint Server, Business Data Connectivity and Infopath. Thus, all of the above mentioned will allow us to conduct complex assessment of current ecology problems for the Black Sea and correspondingly, further plan the necessary security measures for the coastal line and nearby areas.

ინფორმატიკა

საინფორმაციო ეკოსისტემის ავტომატიზებული დაპროექტება შავი ზღვის წყლის რესურსების მონიტორინგისათვის

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სტატიაში განხილულია შავი ზღვის საქართველოს აკვატორიაში წყლის რესურსების ეკოლოგიური მონიტორინგის საინფორმაციო სისტემის ინფრასტრუქტურის დამუშავების ამოცანა. გამოყენებულია მონაცემთა ობიექტ-ორიენტირებული, მულტიმედიური ბაზების ტექნოლოგია, ინტერფეისის მობილური კომუნიკაციები სერვის-ორიენტირებული არქიტექ-ტურით. განხორციელებულია ეკოსისტემის მონაცემთა ბაზის სერვერის კონცეპტუალური სტრუქტურის ავტომატიზებული დაპროექტება და რევერსული (**ORM <-> ERM**) პროცესის კვლევა **CASE** ტექნოლოგიით, კერძოდ, ობიექტ-როლური მოდელირების (**Natural ORM Architect**) გრაფულ-ანალიზური ინსტრუმენტით. ეკომონიტორინგის სისტემის ინფრა-სტრუქტურა რეალიზებულია **MsVisual Studio .NET Framework 4.5** ინტეგრირებულ გარემოში **SQL Server** ბაზის და **Ms Sharepoint** პაკეტების საფუძველზე.

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