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GEODATABASE DESIGN FOR THE MUREŞ RIVER, THE PETRIŞ-PĂULIŞ SECTION

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Abstract. Proiectarea unei geodatabase pentru râul Mureş, sectorul Petriş-Păuliş. Modelul de date Arc Hydro oferă o modalitate standard de descriere a datelor temporale şi geospaţiale pentru resursele de apă. Datele sunt grupate în patru seturi de date: Hydrography, Drainage, Channel şi Network, împreună cu un set de obiecte tabel precum Time Series. Acest articol abordează modul în care se proiectează o geodatabase pentru râul Mureş, pe porţiunea din Culoarul Inferior, între Petriş şi Păuliş. Pentru a facilita studiul s-a implementat template-ul Modelului de date numit Arc Hydro Framework.

Keywords: Arc Hydro Data Model, ArcObjects, Geodatabase, Unified Modeling Language

INTRODUCTION

Arc Hydro is an ArcGIS extension for water resources that focuses on the description of surface water hydrology and hydrography. It uses one of the most modern data storage systems - the object relational database format, and provides a standardized way of describing the geospatial and temporal data of a water system. As a part of the ArcGIS development, ESRI made efforts to customize ArcGIS for particular applications using designed data models. Therefore, regarding the applications for water resources, this effort led to the creation of the Arc Hydro Data Model.

MATERIAL AND METHOD

This article focuses on the process of building the Arc Hydro geodatabase for the Mureş River on the Petriş-Păuliş section in Arad County, Romania. The design of this database is done while bearing the UML for ArcObjects diagram in mind, since contrary to a standard database, the geodatabase is not a simple collection of tables and relationships (like a traditional oracle database) but a collection of classes with attributes and functions that hold data.

The Petriş-Păuliş section is relatively isolated from the big cities, Arad, the administrative city of the county, or Deva in the neighboring Hunedoara County.

The area has only towns and a lot of villages. Regarding the land use, agriculture is practiced in the flood plains and terraces of the Mureş and deciduous forests cover the hills and the mountains.

RESULTS AND DISCUSSIONS

An ArcGIS database is named ***geodatabase*** as it stores data describing geospatial objects in a relational database format.

Relational databases store data in a set of tables linked by relationships, the associations between records in connected tables through values in key fields that the tables share.

Arc Hydro makes use of the geodatabase storing system, a special form of relational databases. Geodatabases allow geospatial coordinates of a GIS layer to be stored just in one field in a relational data table and no longer be held separately from the attribute data as in ArcInfo. Arc Hydro also integrates the behavioral and the inventory data model paradigm, as well as an integrated networked database structure.

Essentially the Arc Hydro Data Model is a framework of defined tables and relationships (i.e. the names, relationships and structure are inherent for the model). Changing this model (changing a name, relationships, value types etc.) leads to the inability of the Arc Hydro extension to interpret, store or calculate values from or in the model. Hence, it always needs to successfully complete a validation check (if the user works with ArcHydro methods only, data will always be correct since the program won't allow input that does not comply with the model).

Arc Hydro is a connected set of objects and features built on a generic set of objects and features named ArcObjects. The ArcObjects in the database are arranged in a hierarchy defined through the use of the Unified Modeling Language (UML) as illustrated in figure 1.

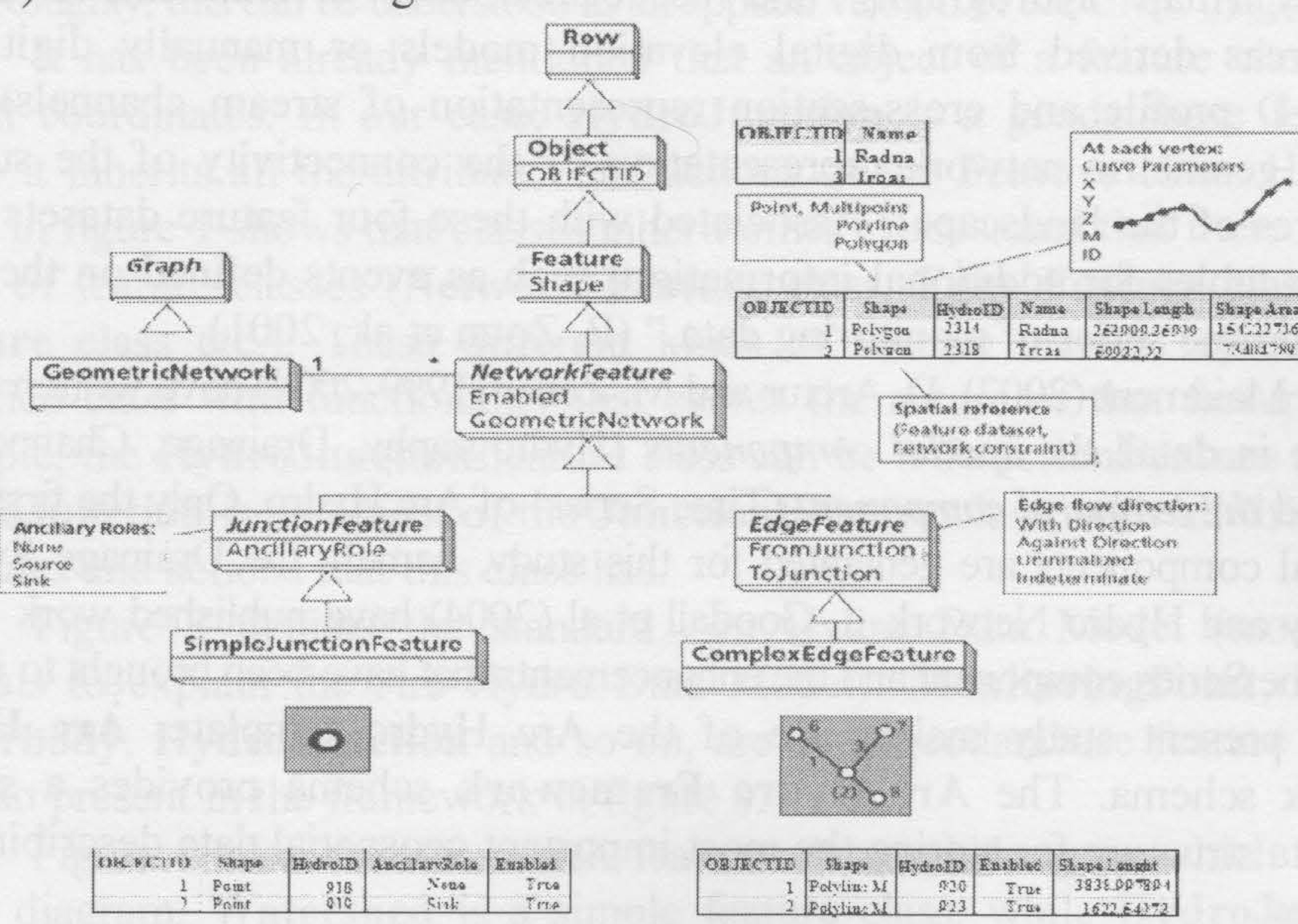

Fig 1. ArcObjects defined in a Unified Modeling Language hierarchy (Maidment D.R. 2002)

It shows the essential classes for building an Arc Hydro geodatabase. These classes (**Object**, **Feature**, **NetworkFeature**, **EdgeFeature**, etc.) are blueprints for objects and supply them attributes (that describe the object) and actions (what can an object perform). Classes can contain other classes, or more correctly, an object of one class can contain objects of another class and inherit their attributes and actions.

In this model for example, an object of the **Feature** class can have an object of the **Object** class and use through this object its attributes and actions. An object of the **Object** class can then own an object of the **Row** class.

The UML model illustrates this as the class **Object** is designed only to store attributes, the **Feature** class stores spatial coordinates, but since every **Feature** object has an **Object** object, it also has attributes. A **Network Feature** object subsequently has attributes and spatial coordinates as information, as well as points and lines of interest called **Junctions** and **Edges**.

The **NetworkFeature** class is a special class (abstract class) which can be divided in the **SimpleNetworkFeature** class and the **ComplexNetworkFeature** class.

ArcObjects were customized for hydrology. All features in Arc Hydro are hydro features and carry the **HydroID** and **HydroCode** attributes .

The **HydroID** is an integer identifier for features and it is used for internal management of information within an Arc Hydro geodatabase. The **HydroCode** is the permanent public identifier of a feature, a text attribute linking Arc Hydro to external sources of information about the feature stored in other information systems. In this way, Arc Hydro can be linked with other information systems in order to automatically acquire data needed for hydrologic studies.

"The ArcGIS Hydro Data Model stores data in four feature datasets (…): Hydrography (map hydrography and associated data inventories), Drainage (drainage areas derived from digital elevation models or manually digitized), Channel (3-D profile and cross-section representation of stream channels), and Network (a geometric network representation of the connectivity of the surface water features of the landscape). Associated with these four feature datasets are a set of object tables for additional information, such as events defined on the river network, and time series of monitoring data." (R. Zoun et al., 2001)

D.R. Maidment (2002), D. Arctur and M. Zeiler (1999-2004) have written works that describe in detail the ***spatial components*** (Hydrography, Drainage, Channel and Network) and ***the temporal component*** (Time Series) of Arc Hydro. Only the first three of the spatial components are generated for this study, namely the Drainage System, Hydrography and Hydro Network. J. Goodall et al (2004) have published work discussing the Time Series component and the enhancements that have been brought to it.

The present study makes use of the Arc Hydro template: **Arc Hydro Framework** schema. The **Arc Hydro Framework** schema provides a simple compact data structure for storing the most important geospatial data describing the water system.

The UML diagram in figure 1 shows how ArcGIS handles the data input within the Arc Hydro Data Model. It establishes for every class the data it will handle, the attributes of the classes and how they will be used by the program. For the geodatabase design of the Mureş River on the Petriş-Păuliş section is essential to know the structure in order to insert relevant data.

As explained before, data inserted into the database needs to be valid and logic to be sure that no unexpected results occur. Therefore, during certain stages of the project, when our knowledge about this diagram was insufficient, certain layers of information missed and watersheds were not calculated correctly.

Upon loading, all the geodatabase elements are completely empty, as this is, just like the name suggests it, a framework the user can work with (fig.2).

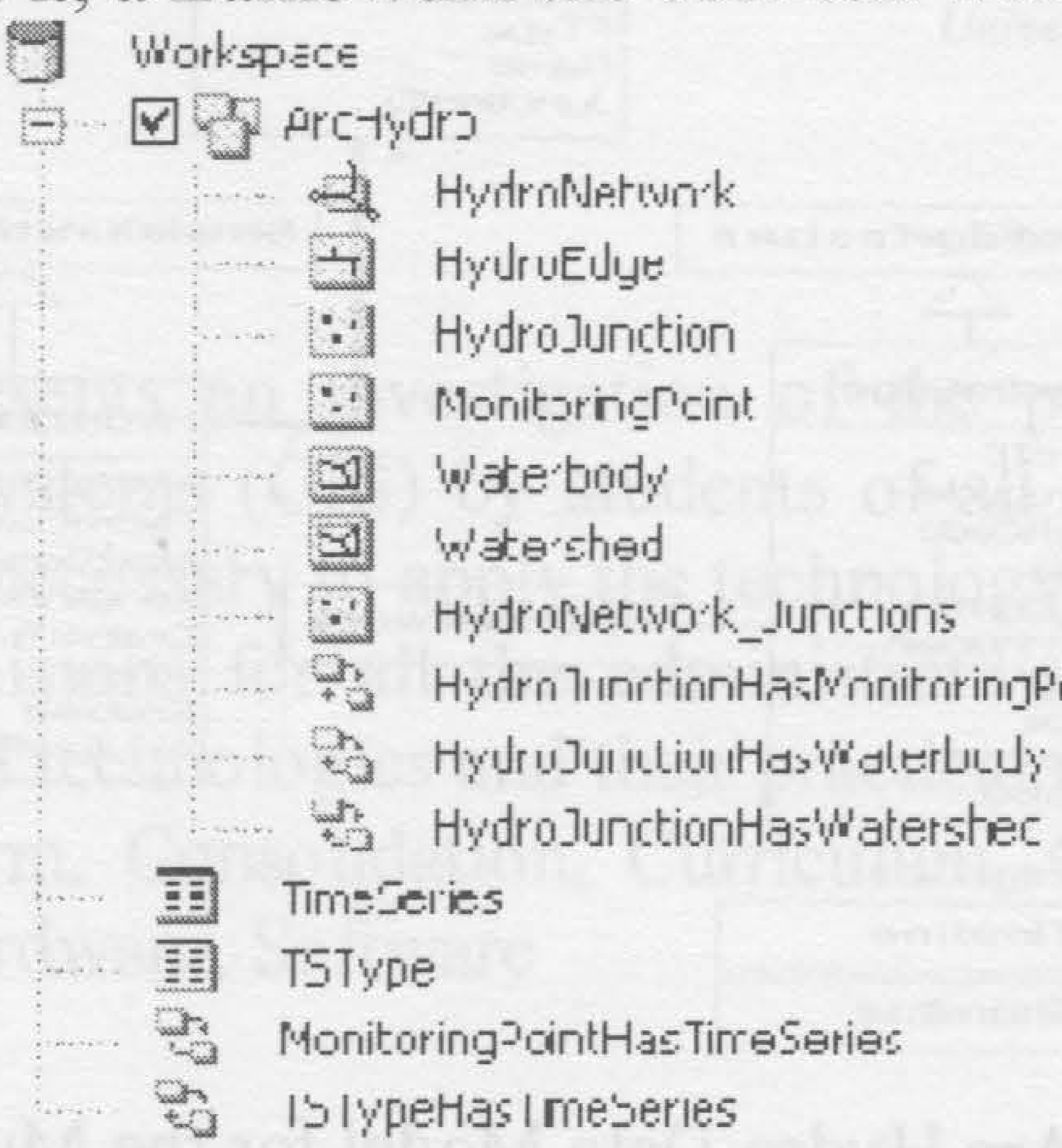

Fig 2. The loaded Arc Hydro with Time Series Framework

The framework has several feature classes (ex: **HydroEdge, HydroJunction** etc.) and relationships between those feature classes (**HydroJunctionHasMonitoringPoint** etc.). Roughly, this can be understood as an applied version of the UML diagram.

It has been already mentioned that an object of a feature class holds the spatial coordinates. In our case, **HydroJunction** is a geodatabase feature class, hence it inherits all the attributes and actions of the **Feature** class. However, the UML in figure 1 shows that classes inherit other classes, and that there are multiple kinds of feature classes (**Network Feature** class, **Edge Feature** class, **Junction Feature** class etc.). These different kinds of feature classes represent a more specified class with functionality that serves the nature of that feature class. For example, the **HydroJunction** feature class can be a **JunctionFeature** class, hence **HydroJunction** is an object of the **JunctionFeature** class, with all the specialized attributes and actions that this class has.

Figure 3 depicts the standard Arc Hydro Data Model (model used in tutorials to explain the Arc Hydro Data Model). **MonitoringPoint, Watershed, Waterbody**, **HydroJunction** and so on, are each geodatabase feature classes that are also present in the framework in figure 3.

Figure 3 also denotes which feature classes belong to which class in the UML diagram. **Watershed** is a simple feature class, while **HydroJunction** is a **SimpleJunctionFeature** class. With this knowledge, classes have been created for the Mureş River and Petriş-Păuliş section. For the project the standard data model was basically kept, removing nevertheless the **Waterbody** feature class.

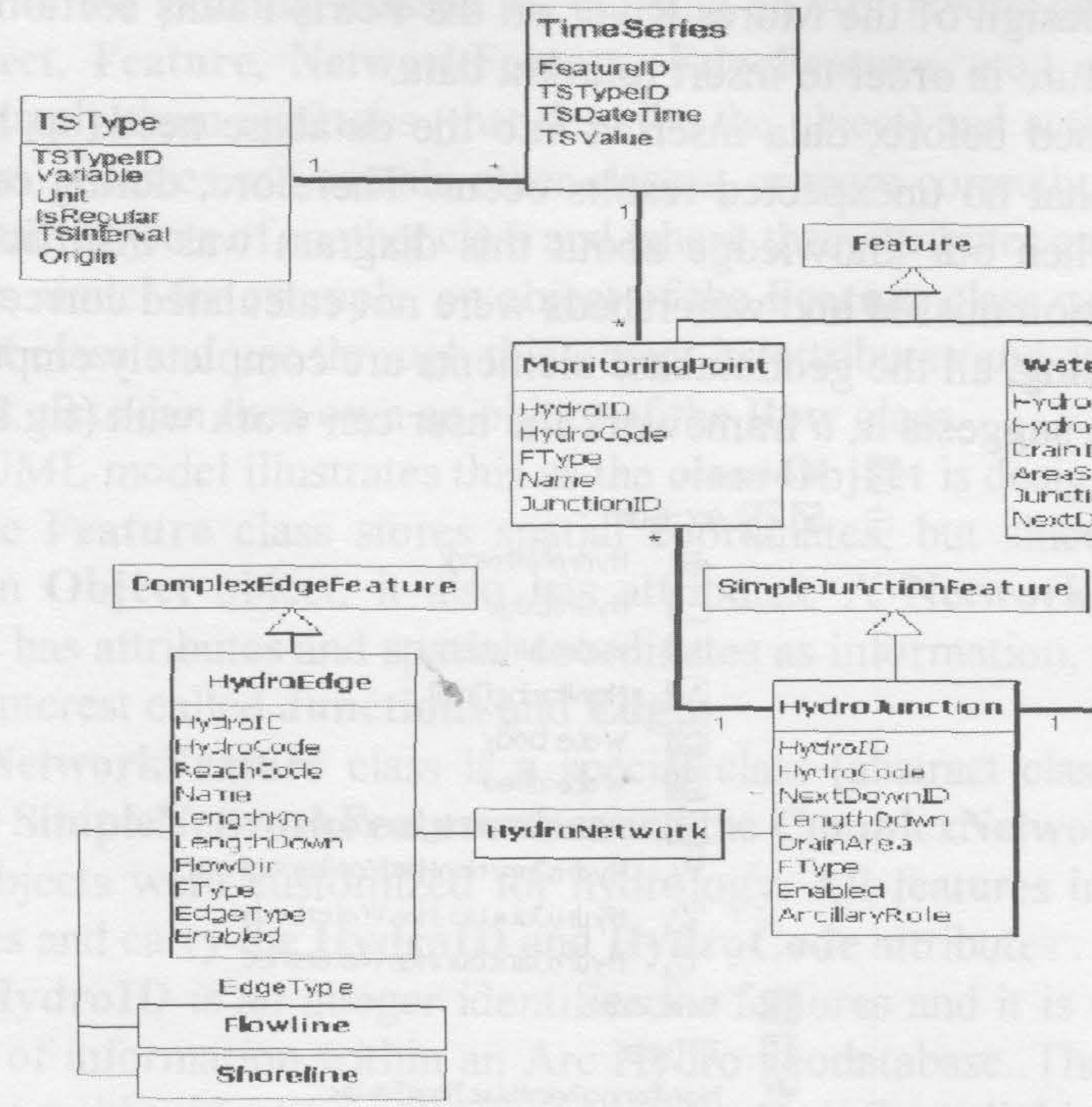

Fig 3. Arc Hydro Data Model for the Mureş River

The **Time Series** are two different feature classes not specified in the UML diagram and hence go beyond the scope of this article. **Time Series** feature class however do belong to the standard Arc Hydro Data Model and are included within the **Arc Hydro Framework With Time Series.**

CONCLUSION

The article began with a pencil drawn UML diagram and concludes with the possibility of specifying a class according to the UML diagram and supply it with attributes and functionality. It is through the use of the data model that we know how it is exactly that we should name and typecast our classes.

This is, however, only the start of the project. The article explains how the project is loaded and how the multiple feature classes are created. For the Mureş River a specific framework was loaded, no feature class having any value. As long as no data has been inputted into the geodatabase feature class, there is nothing that the Arc Hydro extension can interpret.

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