Simple GIS Simulation with the Schematic Processor

Synopsis of Class 16, GIS in Water Resources, Fall 2011

By now you've gained experience in working with GIS features such as polylines representing a stream network and polygons representing catchments. As you might imagine, there are numerous hydrologic features one could represent in GIS. But what should the features be called? How should they be represented? What attributes should they have? If I share my data with someone else, how will be able to interpret my data? The *Arc Hydro* data model addresses all of these questions.

Arc Hydro consists of a data model and tools for working with hydrologic data in GIS. A *data model* is like a blueprint defining how data should be represented. For example, in Arc Hydro, stream networks are represented as polylines called HydroEdges, while the connections between HydroEdges are point features called HydroJunctions. All features in Arc Hydro have an attribute called *HydroID*, and this attribute is used to establish *relationships* hydrologic features. For example, a Watershed feature will keep track of the HydroID of the HydroJunction which serves as its outlet.

One way of displaying hydrologic features and the relationships between them is with an interconnected schematic network of *links* and *nodes*. Schematic networks can be created using tools such as the Arc Hydro Tools. In Arc Hydro, schematic networks consist of *SchematicNode* and *SchematicLink* features. SchematicLink features include *FromNodeID* and *ToNodeID*, which store the HydroID of the SchematicNode at the upstream end of a link and the HydroID of the SchematicNode at the downstream end of a link, respectively. SchematicNode features include a numerical *SrcType* field to indicate the type of feature the node represents, while SchematicLink features include a numerical *LinkType* field to indicate the type of connection the link represents.

For example, consider a stream network with watersheds delineated that drain to those streams. When using an Arc Hydro schematic network, the endpoints of stream segments would be represented as nodes and the streams themselves would be represented as links connecting the nodes. Watersheds could also be represented as nodes, and links could connect those watershed nodes with stream endpoint nodes to represent the movement of water from the watershed into the stream network. These links and nodes would consist of these types:

SchematicNode:

SrcType = 1 – Represents watersheds
SrcType = 2 – Represents endpoints of stream segments (one on upstream end and one on downstream end)

SchematicLink:

LinkType = 1 – Connects watershed nodes to stream nodes
LinkType = 2 – Connects stream endpoint nodes (represents the river network)

These SrcType and LinkType values are just examples. You could have any number of values to represent as many types of features as you desire.

Not just limited to a pretty display, these schematic links and nodes have the potential to serve as the elements at which processes occur in a simulation of some phenomenon. The *Schematic Processor* unlocks this potential.

The Schematic Processor is a set of ArcGIS geoprocessing script tools for processing Arc Hydro schematic networks. The tools give you the ability to associate behavior with schematic features. For example, if you are simulating the movement of bacteria through a stream network, the schematic processor can decay the bacteria as they move along schematic links representing stream segments.

The behaviors assigned to schematic features are implemented with snippets of Python code called *processing ops*. A few ops for handling tasks such as simple accumulation of values downstream and first order decay are included with the Schematic Processor. You can also write your own ops to simulate whatever behavior is desired.

For example, consider the case of computing mean annual bacterial load for the outlet of a river basin. Suppose you've computed mean annual load produced by nonpoint sources in the watersheds of the basin. You'd like to move that load through the stream network, accumulating the values downstream until you arrive at a total value at the basin outlet. Since bacteria typically decay as they move through natural systems, you'd also like to consider this decay as the bacteria move downstream.

The accumulation of upstream loads and the decay of bacteria are behaviors that schematic nodes and links exhibit. Adding up loads received from upstream features is a *RECEIVE* behavior, while decaying bacteria before passing the load to the next downstream feature is a *PASS* behavior.

To continue the example above, the following ops could be created to perform the computation of mean annual bacterial load, given that the values on watershed nodes represent mean annual load contributed by each watershed.

SchematicNode:

- SrcType 1 (watershed) – RECEIVE – N/A (these are the most upstream features in the network)
- SrcType 1 (watershed) – PASS – Send value unmodified downstream
- SrcType 2 (stream node) – RECEIVE – Sum all received values
- SrcType 2 (stream node) – PASS – Send value unmodified downstream

SchematicLink:

- LinkType 1 (watershed to stream) – RECEIVE – Sum all received values
- LinkType 1 (watershed to stream) – PASS – Send value unmodified downstream
- LinkType 2 (stream) – RECEIVE – Sum all received values
- LinkType 2 (stream) – PASS – Apply bacterial decay and send result downstream

The task of summing values and sending values unmodified downstream is so common that a processing op to perform this task is provided with the schematic processor. Other tasks can be handled by programming small Python scripts, which you will have a chance to do in the next exercise!

For more information on Arc Hydro, visit http://resources.arcgis.com/content/hydro/. To download the Schematic Processor, visit http://tools.crwr.utexas.edu/.