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Differences in Feature Representation in Digital Map Databases

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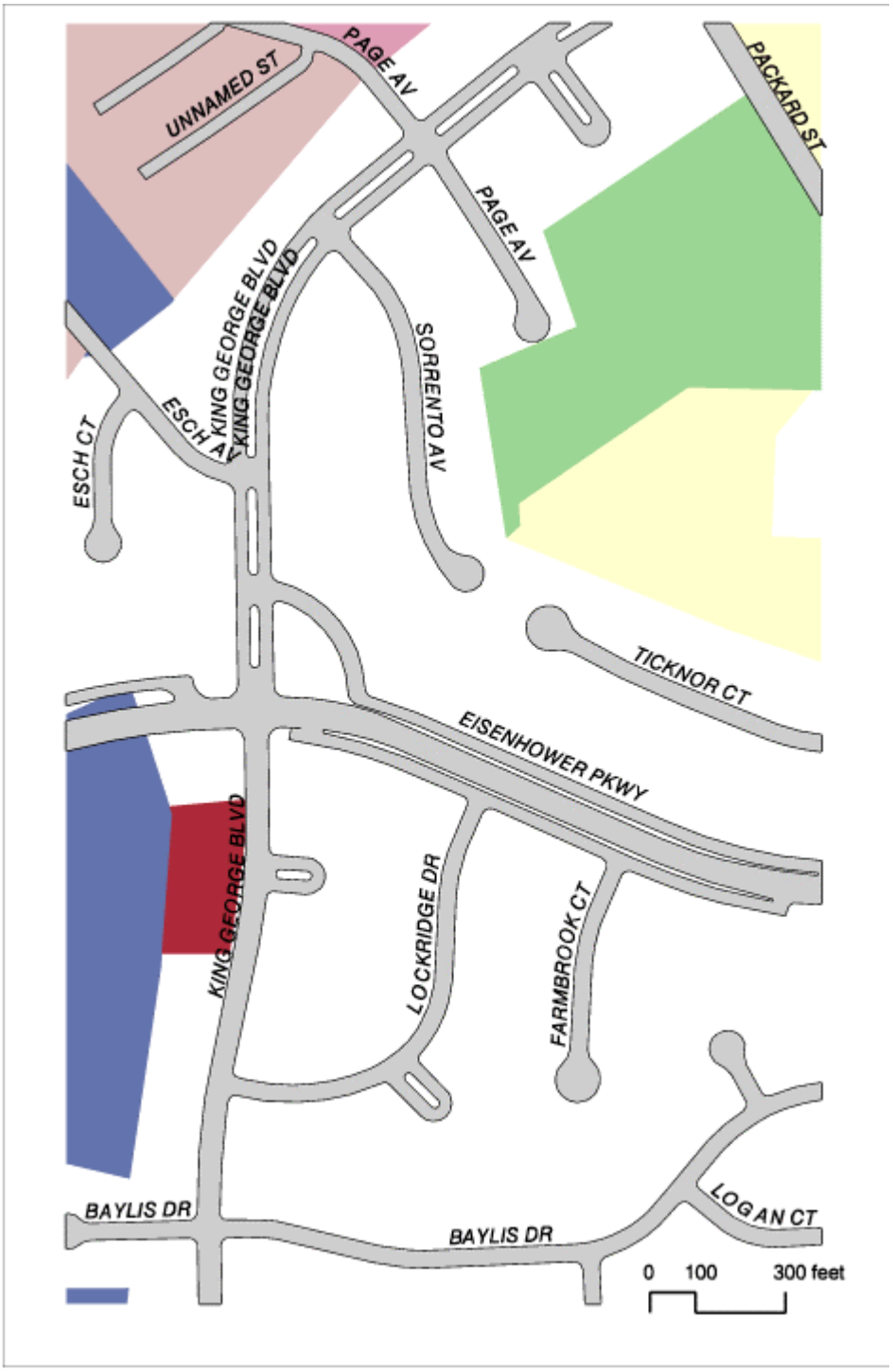
Abstract
Map databases are integral to many ITS (Intelligent Transportation Systems) applications in navigation, traffic forecasting, and route planning. With the increasing deployment of ITS technology demands for accurate and complete digital map databases of the nation's road network are surging. The development and maintenance of high quality digital map databases is expensive and time-consuming. Database sharing will be a sensible approach whenever possible in order to reduce cost. In the US map databases are being produced by a variety of public agencies and private vendors. Quality and levels of accuracy vary depending on data sources and production procedures. Verifying the quality and accuracy of map databases for purposes of navigation is a pragmatic and important concern. The Society of Automotive Engineers (SAE) has developed a Truth-in-Labeling Standard (SAE document J1663), the goal of which is to provide a consistent method for describing and comparing map databases. While the standard requires that database vendors provide a standardized label that lists basic database characteristics such as lineage, coverage, accuracy, content and scope of a database, there are currently no guidelines for feature representation (such as the layout of road intersections) in digital databases. Comparison of two different map databases reveals significant representational differences due to differences in precision of source material, data model and intended uses.

Problem
Current standards for data exchange are insufficient for unambiguous and successful transfer of information between digital map databases, in part because of semantic differences in feature representation. Real world entities are complex. Which faces of this

complexity are captured in the feature representation depend upon broader contexts and circumstances than can be reported in the metadata statements about the database. The examples presented here illustrate the dimensions of this problem.

Keypoints
Various reasons for the different representation of features in digital map databases exist. Four main reasons/sources of representational differences are distinguished. They are illustrated and discussed below.

1. Differences in Feature representation due to different interests. Agencies and companies focus on different types of geographic features. Municipal governments often take an area-oriented perspective, representing parcels and streets as polygons. Vendors of digital navigation maps use a network view with street addresses, street names and driver instructions.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0 100 300 feet

Figure 1a

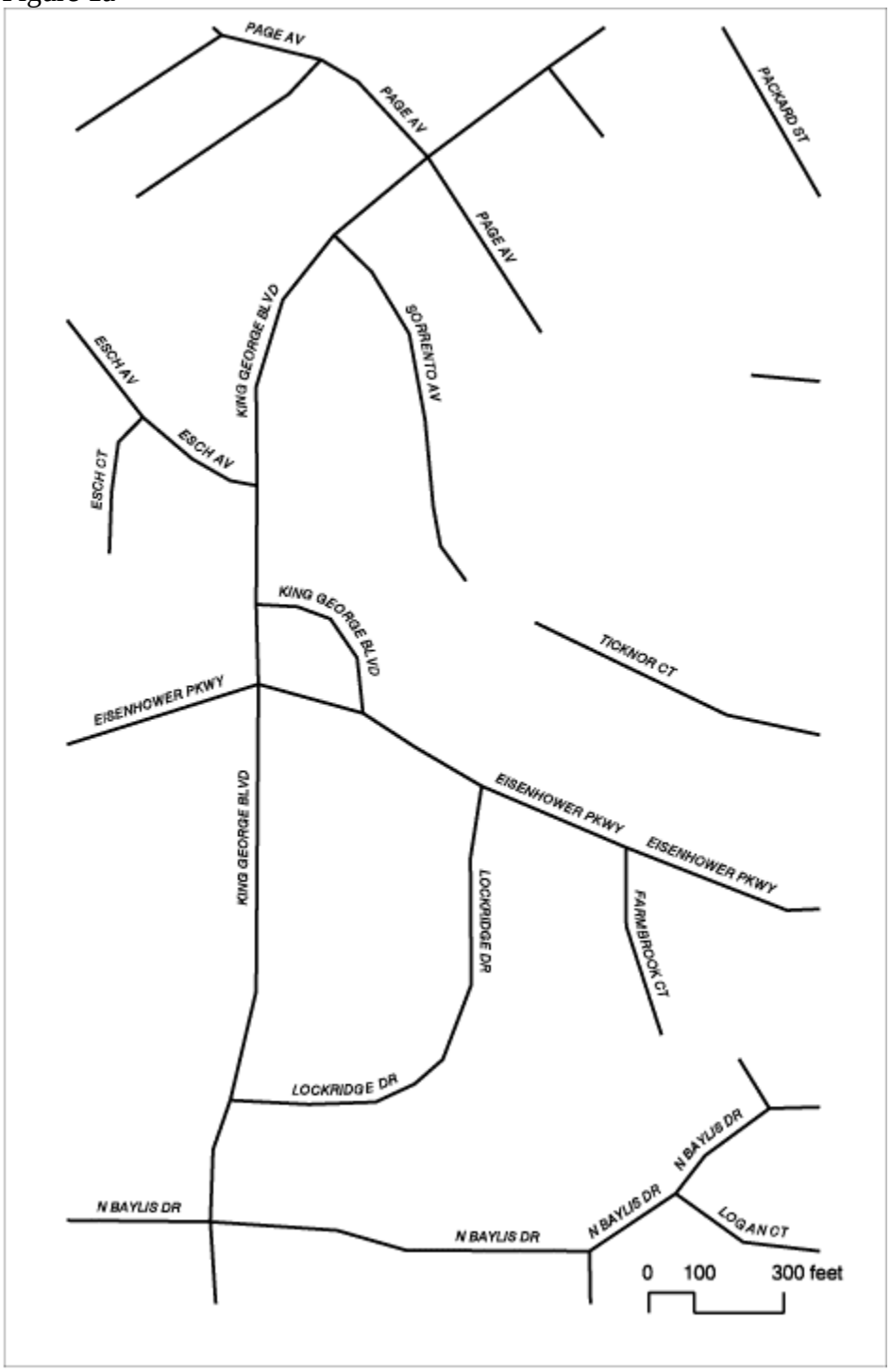


Figure 1b

2. Differences in feature representation due to underlying data model. There are many public and private sources for digital map data. Agencies and companies develop their own data models that may be proprietary. "Stone School Rd" crossing the Interstate

shows that one database uses a planar model (black arclines), whereas the other employs a non-planar model (blue arclines, no nodes).

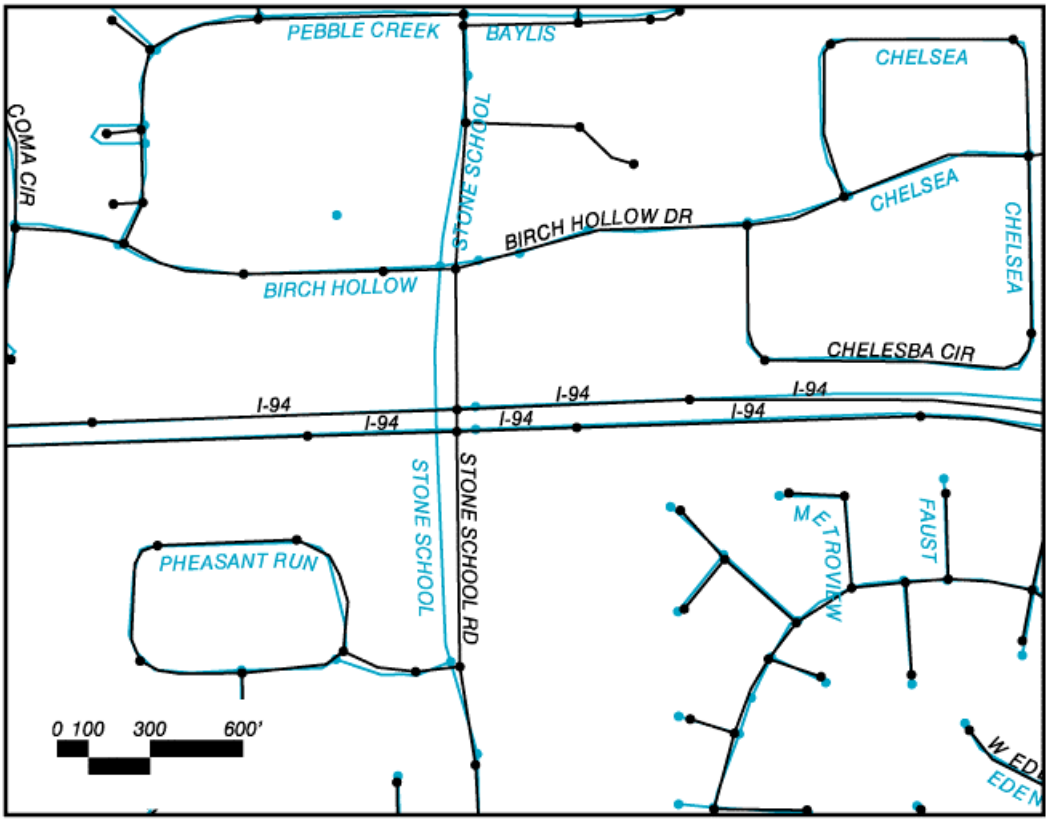
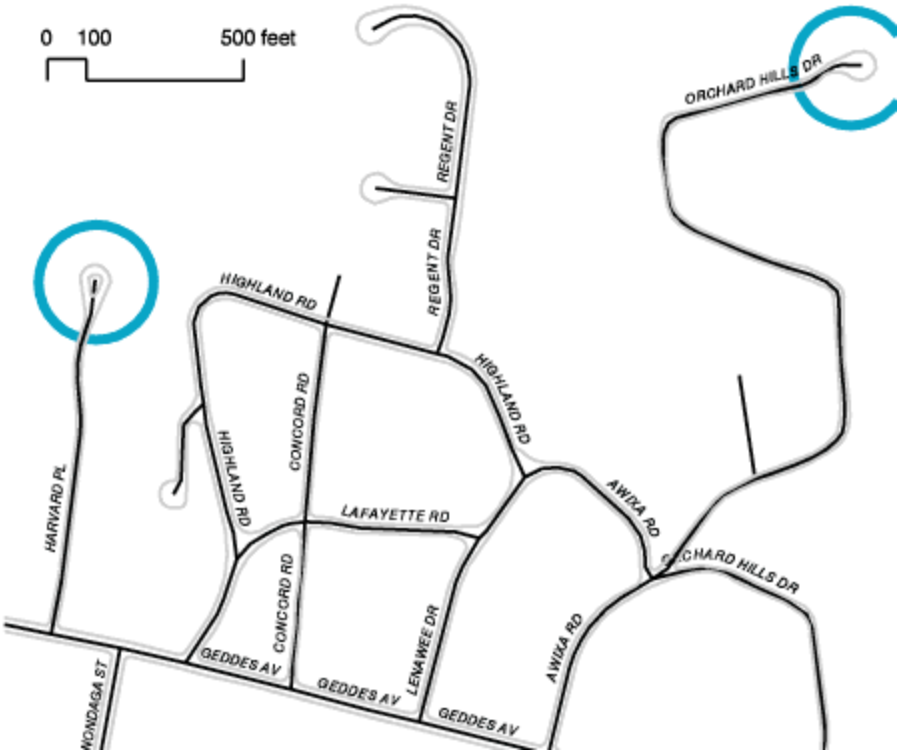


Figure 2

3. Differences in feature representation due to individual preferences. Operators who digitize maps may develop individual ways to represent features such as road intersections or dead end streets.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AWIXA RD
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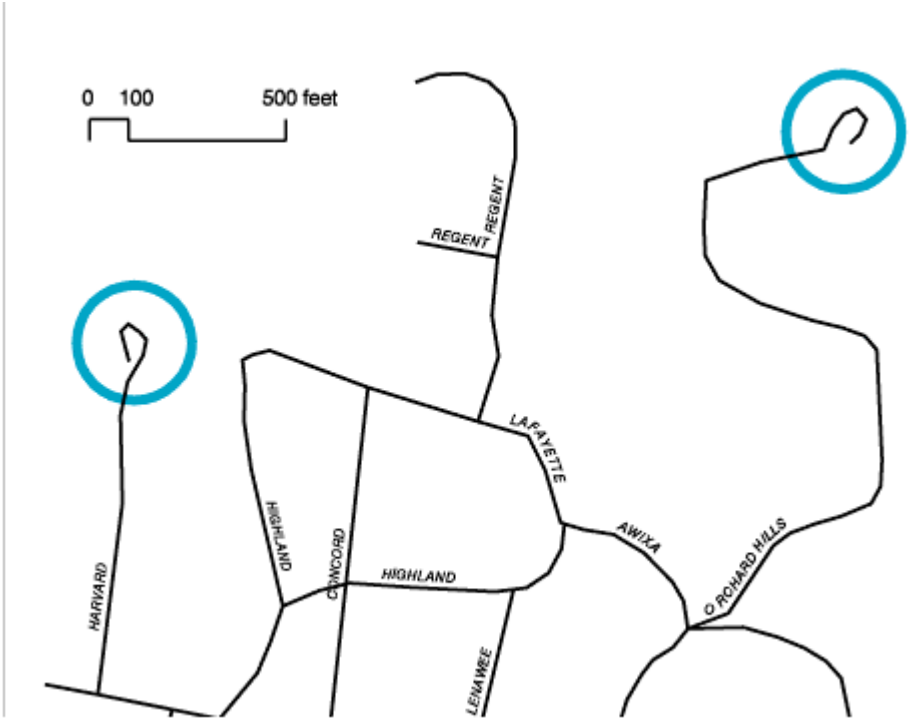
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HIGHLAND
HARVARD
LENAWEE

Figure3a

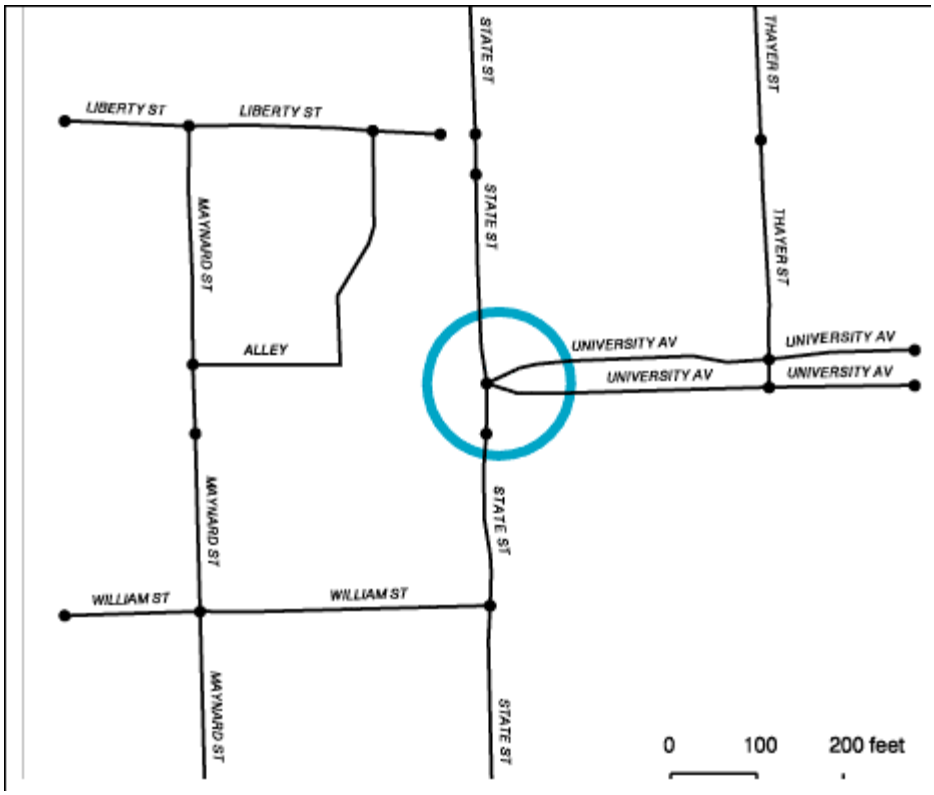
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Figure3b

Figure3c

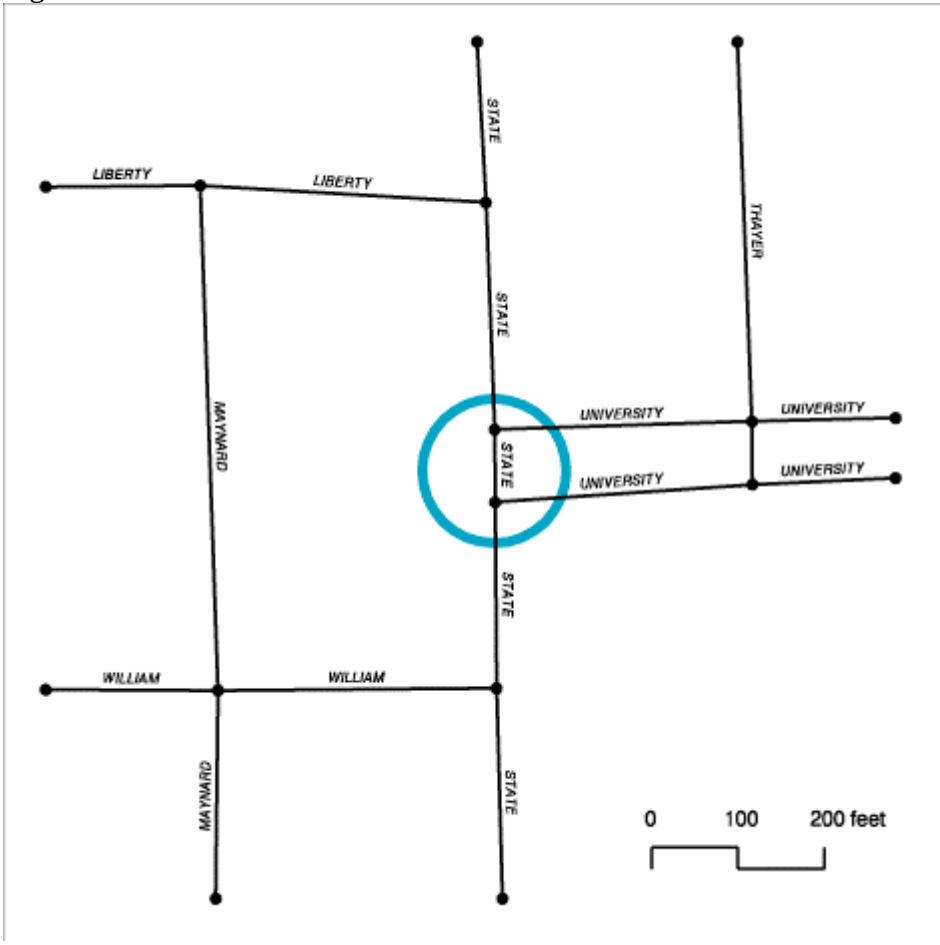

Figure3d

4. Difference in feature representation due to map scale and resolution. The larger the scale and finer the resolution of the original map, the more detail can be expected in features such as intersections.

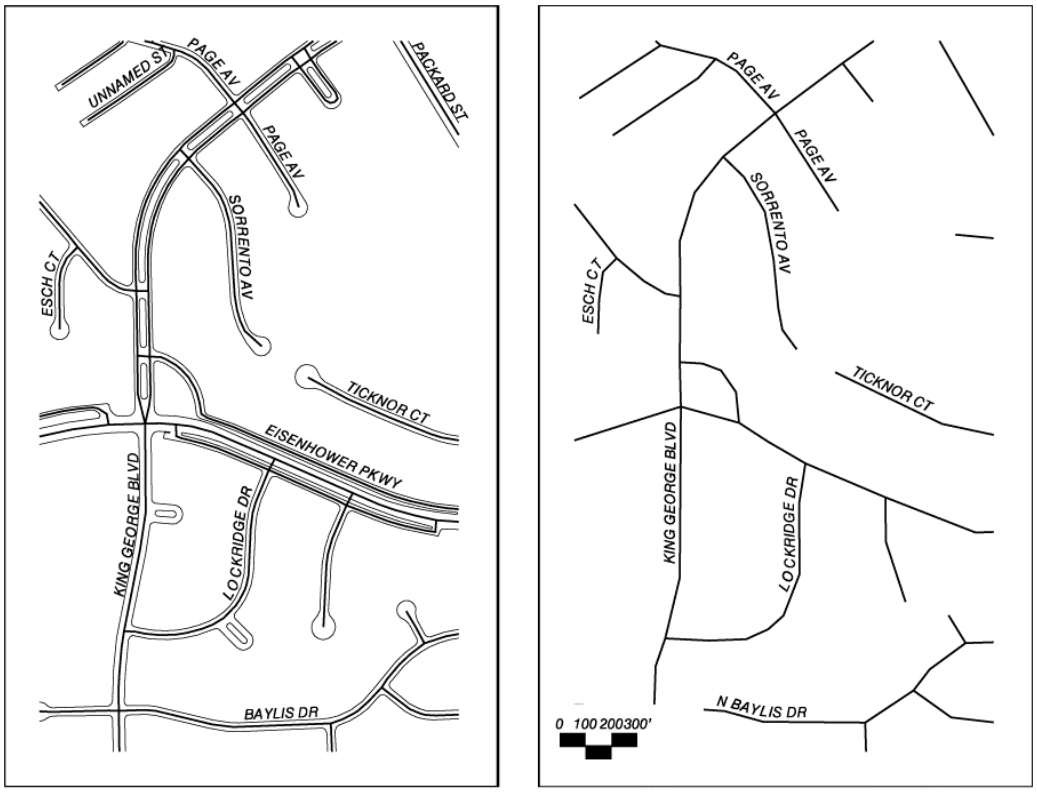

Figure 4

Discussion

One means to address standardization of feature representation is to provide detailed descriptions of the data set through metadata. While this is attempted in the new Truth-in-Labeling standard, it does not address feature representation. Metadata requirements are new. The Truth-in-labeling approach for standards applies to new datasets. Metadata for older dataset are hard to reconstruct; time depth and therefore change data simply may not be available. While standards provide a good start - the descriptive requirements may not be of sufficient detail for meaningful data sharing. Subtle data modeling differences create not so subtle differences in feature representations. Transportation data models may be planar or non-planar. An overpass of one road over another road in a planar model is generally represented by a node with four incident arcs. The node at the intersection has an associated attribute describing turn restrictions in order to convey the correct driver instructions (i.e. for route guidance). In a non-planar model of the same feature - no node exist since the arcs are unconnected in the 3-dimensional space. Thus, linking non-planar and planar databases is problematic.

Conclusion

The consequences of different feature representation are manifold. In terms of data exchange, data sharing and integration different feature representation leads to
- Lack of comparability (pattern matching)

- Lack of compatibility (data base/model anomalies)

Furthermore results from data analyses performed on different databases are likely to display different results. Differences in feature representation become an issue with increasing interest and need to exchange data. Generally there are two approaches to overcome the problem. 1. Descriptive and detailed metadata provision that includes information on feature representation is used to emphasize the different treatment of the features. 2. Standardization or formulation of conventions for feature representation which consider semantic differences.

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Nystuen, John D., Andrea I. Frank and Larry Frank, jr. "Assessing Topological Similarity of Spatial Networks." Paper presented at The International conference on Interoperating Geographic Information Systems INTEROP 97. Sponsored by The National Center for Geographic Infromation and analysis (NCGIA). December 3 – 4, 1997. Santa Barbara, CA – USA