# Geographic Problem Frames

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## Abstract

*We present a set of problem frames specialized to the area of geographic applications. Problem frames describe the elements of common problems, and help a specifier understand and decompose a complex problem into simpler subproblems for which a solution is often known. We provide an overview of the main issues in geographic applications, and present twelve frames that address many of the problems in the area.*

## 1. Introduction

A problem frame conveys the essence of a familiar class of problems. Each problem frame describes a relatively simple problem using a diagram. They help guide the analysis of a complex problem, and its decomposition into smaller, well understood problems. Problem frames also assist in describing the elements involved in the problem, since the frames clearly indicate its major components. Frames focus on describing the problems rather than the solutions, since problem analysis needs to be done and documented before a solution is considered.

Problem analysis, decomposition and description are challenging tasks in requirements engineering. Jackson in his recent book presents five general-purpose basic problem frames that guide the specifier during these tasks [2]. In this paper we present specialized problem frames that capture common problems in the area of geographic applications.

## 2. Geographic Applications

Solutions to common problems in the area of geographic applications are addressed by research in Geographic Information Systems (GISs) [1, 3]. However, there have been very few approaches to problem analysis in this area.

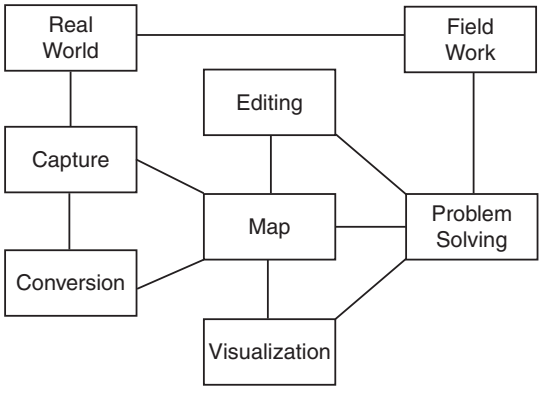


**Figure 1. A typical geographic application**

The diagram in Figure 1 shows a general view of a typical geographic application. A geographic application usually addresses a problem that deals with maps. In the diagram, this is referred to as a problem-solving task. Examples of problems dealing with maps include finding a route between two locations, analysis of farmland usage, and tracking bird migration patterns. However, in order to deal with the specific problem-solving task, there are a few other problems that need to be addressed. These problems relate to how the map is constructed, displayed, and manipulated.

Since a map is a representation of the real world it is necessary to capture data from that environment in order to build a map. In some cases, parts of the data already exist, but in different scales, projections, or reference systems such as lat-long or UTM. Data conversion is the process of transforming diverse data sets so that they are compatible with each other, and suitable for problem-solving tasks.

Most applications need to display the map and the results of the problem-solving task. These results may need to be added to the map. Some field work may also be required to ensure that the real world reflects the decisions made using the map.

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Note that in this diagram the person responsible for each task has been omitted, but it is clear that there are different people involved in the different tasks. For example, data from the real world is usually acquired by an individual, or by an automated system controlled by an individual. When a list of field-work tasks is produced, individuals are responsible for their completion.

The diagram shows common tasks of geographic applications. However, some of these tasks may not be necessary, depending on the specific problem-solving task at hand. For instance, if the data is already available from a library, data capture and conversion tasks can be eliminated.

Although this diagram gives a "big picture" of geographic applications, it is too generic to describe a specific application. However, the ideas presented here do allow us delineate and present a list of specialized geographic problem frames.

## 3. Geographic Problem Frames

Several frames deal with problem-solving tasks related directly to an existing map.

- **Proximity:** problems related to the concept of *distance*. The task is to find map entities that satisfy a distance requirement from a given entity or location. Examples of this frame involve finding nearest or farthest entities, or entities inside a bounding box.
- **Topology:** problems involving boundaries and interior parts of regions and their relationship with other regions. For example, determining whether two regions overlap, share a common border, or are adjacent, or if one region is inside the other.
- **Network:** problems concerned with a special case of topology involving node connectivity. Examples are found in the utility industry, which involves distribution and management requirements such as load flow, connectivity and routing.
- **Resource Location/Inventory:** problems involving the geographic position of resources in the map. These problems address questions of the form "Where is it?" and their counterparts of the form "What is at ...?"
- **Trend/Temporal:** problems related to time. The question "What has changed?" is captured by this frame, when comparing two maps of the same region from different time periods.
- **Site Selection:** problems that deal with selecting a region in the map that satisfies requirements of shape, size and orientation.
- **Map Integration:** problems that involve combining maps with diverse data sets to draw relationships between them. For example, find the relationship between weather and crop yield of a region.

The previous problem frames are specializations of the problem-solving task in the diagram. They all deal with an existing map. The following problems relate to the creation and manipulation of a map.

- **Data Capture:** problems that involve creating an accurate representation of the real world. The necessary data and method of acquisition both depend on the problem-solving task at hand.
- **Data Conversion:** problems using data sets with different scales, projections, reference systems, or representations (field vs. object, raster vs. vector). The task is to convert all data sets into a single compatible format.
- **Editing the Map:** problems involving changes to the map. This problem frame is similar to Jackson's *workpieces* frame.
- **Visualization:** problems involving the display of a map on a computer terminal or printer. The task also involves determining what information needs to be displayed, and how it should appear.
- **Field Work:** problems involving changes to the real world based on the decisions made using the map. The problems involve issuing orders and tracking their completion.

## 4. Work in progress

We are currently developing the diagrams for each problem frame presented here. This involves deciding which elements participate in each frame and how they interact through shared phenomena.

## References


[1] N. Chrisman. *Exploring Geographic Information Systems*. John Wiley & Sons, Inc., USA, 1997.

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[3] M. F. Worboys. *GIS: A Computing Perspective*. Taylor and Francis, London, UK, 1995.




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