Innovative Infrastructure Management through GIS:Australian Perspective

Ashish Shah[1] and Kanan Saraiya[2]

1. Asset Engineer Citiworks, Townsville City Council Australia

2. Infrastructure Planning Officer Planning & Development Townsville City Council Australia

Abstract

In most developed and developing economies, Civil Infrastructure assets make up the social and economic infrastructure, which facilitate the essential services to public and business. The management strategies of publicly funded civil infrastructure assets drive the efficiency and comfort level of expected and actual living standards of its stakeholders.

The goal of Infrastructure Management is to meet required level of service, in most cost effective manner, through the management of assets for present and future customers. As any infrastructure assets; data and its derivatives (Information, Knowledge and Wisdom) representing those assets are valuable. Efficient, reliable, portable but time and cost effective data are the essence of success of any infrastructure management regime. Geographical Information System (GIS) has been and being proved to be one of the most prominent technology assisting to churn the data into information, knowledge and at some extent wisdom.

Efficiency and improvement in Infrastructure Management practices have been achieved through existence and use of GIS applications since number of years. GIS applications are in heart of number of infrastructure management aspects including development of asset register, condition audits of assets, preventing damage to underground assets, ease of asset identification, infrastructure planning, sharing of asset information across Government and land management etc.

Case studies of GIS based (spatial) video based system for linear assets; GIS handheld based system for linear and non-linear assets; prevention of damage to underground services; infrastructure planning and features of other local government applications have been discussed in details.

A typical spatial video based system links digital video footage, line scan images and visual inspection data on global positioning system (GPS) to provide a metre-by-metre view and analysis of asset condition and assets inventory. A handheld computer based spatial system comprising GPS receiver, digital camera, laser distance meter, digital compass and inclinometer. GIS representation of development and growth of region, infrastructure need and trunk infrastructure is practiced in infrastructure planning. A typical "dial before you dig service" have real time GIS information on underground assets. A feature of local government GIS application includes sharing accurate and up to date asset information across departments and to general public.

The paper demonstrates features, practical use and benefit gains from some of the GIS based applications currently implemented in Australia for Infrastructure Management.

Keywords: *Asset Management, GIS, Geographical Information System, Data acquisition, Asset Inventory, Infrastructure Management, Infrastructure Planning*

Introduction

In most developed and developing economies, Civil Infrastructure assets make up the social and economic infrastructure, which facilitate the essential services to public and business. The management strategies of publicly funded civil infrastructure assets drive the efficiency and comfort level of expected and actual living standards of its stakeholders.

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Wisdom) representing those assets are valuable. Efficient, reliable, portable but time and cost effective data are the essence of success of any infrastructure management regime. Geographical Information System (GIS) has been and being proved to be one of the most prominent technology assisting to churn the data into information, knowledge and at some extent wisdom.

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A significant part of an Infrastructure Asset Management system consists of acquiring data, churning them into useful information, digging out the knowledge and extracting the wisdom. These data and their derivatives are useful only if acquired correctly, stored correctly, their life is managed and their usefulness is monitored. Hence to its basics; efficient, reliable, portable but time and cost effective data acquisition practices are the essence of success of any Infrastructure Management regime.

We are evolving from the early days of laborious paper-based exercises taking hours, with little in the way of audit ability and being both difficult and costly to accurately repeat if needed, to the digital systems in which information can be instantaneously distributed, analysed, and cross-referenced. The ability of computers to both automate laborious processes, and retrieve and display information, permits what would be better but previously prohibitively expensive exercises to now be practical. These digital revolutions have been presenting ever-increasing opportunities to reduce costs, increase productivity, and more easily satisfy legislative requirements.

The field of asset information capture in particular has benefited greatly from the recent advances. Whereas previously teams on foot with pads of paper in hand slowly walked the network, and then additional teams were sent out to audit the first team, today personal computers have displaced the paper and GPS systems have been widely embraced. Today, it is now a reality that many cases

the need to continually send teams out into the field can be completely removed.

The next phases of paper describe some selected GIS applications with features, benefits and practical case studies being currently used in Infrastructure Management in Australia.

Asset Information Acquisition Systems

To keep in the forefront in development of today's advanced infrastructure management tools, spatially registered video system of asset information acquisition for linear assets and GIS enabled handheld based system for linear and non-linear assets have been developed.

A typical spatially registered video system takes advantage of the advances in global-positioning, digital cameras, GIS, digital storage, video compression, interfaces and display technology, to deliver higher-quality and more-accurate information quickly and cost effective than field-survey. The system is the practical realisation of the idea of minimising field-work as much as possible by being able to drive a road network virtually, 'from the office', using previously-captured video footage from running vehicle.

A vehicle travelling at normal road speed captures video and spatial data, which once processed, permits the user to click on the map anywhere along a road to bring up video recorded at that spot, and then to play that video in any direction. The video forms a permanent record, which can be retrieved at any time without undue delay. In addition, the video is fully integrated with a database and a geographic information system, permitting assets to be located and mapped with their attribute information entered into a database. The current technological advancements enable the user to undertake their tasks faster, more reliably, and more accurately than ever before.

Assets information which generally can be picked from running vehicle include roadways, pavements, kerb and channel, traffic signs and signals, parking systems, pavement and kerb markings, streetlights, parks and trees, bus stops and street furniture etc. This system can also be used for railways, tramways, footpaths, bikeways etc. Other assets which require closer scrutiny and where information is imperfect or difficult to achieve from running vehicle video include bridges, culverts, footpath, kerb & channel, traffic signs and tree

surveys. Handheld based GIS field survey tool is used for these assets.

A few of spatially registered video systems with varied functionalities and features are available in Australian market. Following is the summary of benefits of GIS enabled- Line Scan (Pavement View) and Area Scan (Asset View) video system which provide a metre-by-metre view and analysis of asset condition and on-road and off-carriageway assets.

Accurate: *The assessors have the ability to:*

- Stop, reverse, pause and replay the video image until the *assessor* is satisfied they have correctly logged the fault or asset item.

- To identify and log all assets from the comfort and safety of the office.

- Increase accuracy because the *assessor* is not distracted by traffic, noise or weather, heat/cold, need for toilet stops.

Record of exact condition with GPS: Represents a defensible record of the condition of the network at that time for duty of care responsibility issues that may arise up to several years later.

Measuring and Asset Creation Tools: The *assessor* can use 'in-built' asset creation and measurement tools to create, verify locations, extents, height etc off the video screens. For example one can create linear and points assets and measure their width, height, or the distance of an asset from the edge of the roadway etc.

Single Pass and Verifiable: It is a 'one pass once' operation eliminating data matching and miss matched sections. It is easy to revisit or replay a particular section if a supervisor or QA auditor wishes to verify the type, density or location of collected items.

Multiple-uses: Allows the post processing at a future date of other items that maybe of interest to other departments including

- road safety surveys,

- development of asset register (i.e. creation of assets of the video)

- to identify, verify or record attributes of

- pavements, shoulders

- power-poles, signs, medians, intersections, roundabouts,

- line marking, pedestrian crossings, kerb & channel,

- bikeways, street lights & traffic signals, safety barriers, guard rails etc

- ther local area traffic management assets

Safe: Removes the *assessor* from potential harm by not requiring them to be on the road surface.

Detail description of one of such system called Digital Road Inventory Video Environment (DRIVE) is given here as authors were directly involved with the system.

Data Collection Process

The DRIVE system involves both software, and the use of a specially equipped vehicle operated by a single person, which travels the road at normal road-speed (up to 110km/hr). The vehicle contains a differentially corrected GPS, video cameras, computers, and hard disks onto which the raw information is stored. The system is portable, and can be dismounted and installed on another vehicle as required.

Fig. 1: DRIVE vehicle set-up image

The raw information captured by the vehicle is processed back in the office, in a mostly automated process. Firstly, the GPS information is corrected for drift and dropouts. Each frame of video then has positional information calculated for it. The video data is then processed to enhance quality, and recompressed to achieve a better size versus quality trade-off.

As the vehicle can travel at normal road speeds, over 400km of road lanes per day can be captured. The frames of video captured in the field are taken a set distance apart; typically a value of 4-8 meters is chosen to provide sufficient overlap. The video cameras are usually configured to provide a 180-degree field-of-view, however other configurations, such as a backwards-facing camera, a camera facing

upwards, to capture tree canopies, a camera facing pavement view to assess pavement defects and camera configuration on left side to view kerb and channel assessment also find application. The advances in storage technology have made the storage requirements fairly modest by today's standards: a single (optionally removable) hard-disk costing less than AUS $200 usually suffices to store an entire local road network of approx 1000 km, each road driven in both directions.

After these steps have been completed, the processed data is immediately available for use by the DRIVE asset inventory and video viewing software. The video footage can also be placed on a local area network, to permit viewing from any computer in the office; and a web interface is also possible. The positional accuracy achieved for locating items from the video is typically +/-2m.

DRIVE Features

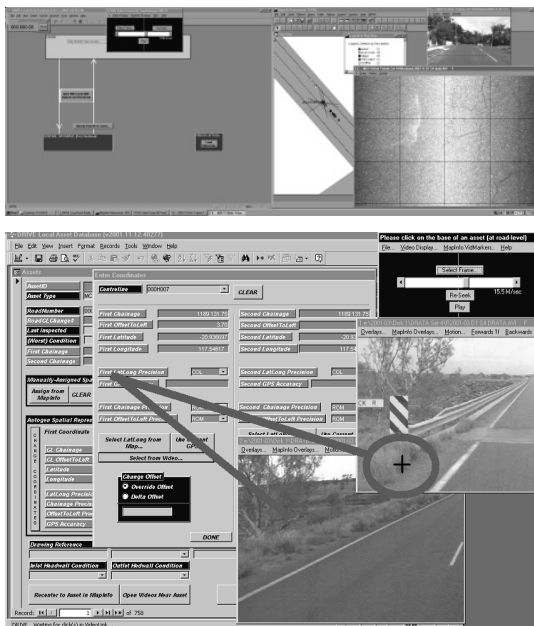The DRIVE system permits a user to drive a road network 'in the office', avoiding time-

Fig. 2 DRIVE PC set-up images:

consuming, costly and less-comfortable fieldwork. The video representing particular location can be opened by simply clicking on that part of the road section. More than one camera's video can be displayed concurrently. The video footage can be viewed and played at any speed, from single-frames up to hundreds of kilometres per hour, and in either

the forwards or backwards direction. The images below show snapshots of DRIVE set-up.

Data-Entry of Items

The key feature of DRIVE is that one can not only view assets using the video, but one can also geographically locate and create new items into a database (or relocate existing items) both quickly and easily by either clicking on the map or clicking on the video. Alternatively, the user can trace along or around the outline of the item on the video from which lengths and areas of those assets can also be calculated directly on GIS platform (such as MapInfo Professional or ESRI ArcView). DRIVE can store both assets (signs, trees, etc) from assets view cameras and defects (kerb and channel defects, potholes, graffiti, cracking, and patches etc) from pavement view camera.

Attributes can be entered based on the video for the new item, and optionally a chosen video-frame can be linked to each item, to represent it visually. The underlaying of aerial photography during data-capture is often advantageous, as it adds an additional 'birds-eye' view to DRIVE's 'cars-eye' view, and can be used for tree canopy widths, noise walls, crash barriers, bridges and toll plazas etc.

The item has both its latitude-longitude and chainage calculated automatically by DRIVE, once it has been located from the simple click on the video or map.

One particularly useful feature of the system is being able to click on a piece of inventory on the video to bring up the database records associated with that item. This permits extremely rapid auditing of data previously entered into the system. In addition, the selected frame of video chosen to best-portray the item can also be brought up, and the video stepped forwards or backwards as required.

Finally, as DRIVE is built from off-the-shelf database and GIS, these can be used to perform powerful querying analysis and reporting and ad-hoc mapping functions in addition to that which DRIVE itself provides.

Typical Uses

The majority of uses of the DRIVE system to date has been for asset inventory creation, eg the collection of both on- and off-road assets including pavement and seals, line-marking, culverts, kerb and

guttering, gully-pits, street furniture, guard-rails; and especially signage- not only merely the location, but also type, width and height plus condition. Defects such as potholes, graffiti, damage, vegetation-encroachment or simply age-related failure to meet standards can also be picked up from the video and entered into a database and GIS.

DRIVE can also be utilised to track changes to assets over time, i.e. be used to track deterioration, detect damage, and chart the growth of defects. One very powerful and novel aspect of the system is the ability to play video from two different times (eg this year and last year) side by side, in near-perfect synchrony. Being able to do this makes the process of detecting changes which have occurred over time highly reliable, repeatable, and quick.

For example, councils have requested video to be taken of their networks before their use by military or construction equipment, to act as evidence of the roads prior condition and to determine the extent of any damage done. Similarly, contractors can find videoing the roads useful as proof that any damage along the travelled route were pre-existing.

Councils also use the video as proof of existence of road inventory, or of existence or otherwise of defects, to disclaim or reduce legal liability. In addition, having customer-service staff being able to see on their screen what the customer wants to discuss, be it a pot-hole or a tree, is also highly advantageous.

Apart from its above-explained uses, further information can always be captured off the video at any later stage. Hence a local authority may capture video intending to use it to produce a sign inventory; but later may use the same video to pick up lane markings, or street trees, or drainage assets, or advertising, etcetera. This entails significant cost-savings for the client, as a single video-capture pass can be used for numerous diverse purposes.

In summary, number of local government organisations have benefited from DRIVE type data acquisition technology for development of roadway related asset registers, condition surveys, for reporting deterioration and valuations. This has added benefits in the remote areas and very busy roads.

Same vehicle collecting video and GPS information is normally equipped with multi laser profilometer to collect other useful road condition information such as Roughness, Rutting etc. We at

Townsville city council are exploring the feasibility to build our own vehicle based spatially registered video system for road condition survey.

Footpath Scenario

Currently, our asset inspectors walk across the footpaths and bikeways for condition assessment and hazard identification. It takes longer time and no data verification is easily possible and it is time consuming.

Author is negotiating with senior management to introduce footpath inspections using spatial video based system (video camera and GPS to be mounted on golf buggy type of vehicle i.e. approx 1 m wide) being developed.

With Video technology's capabilities, some of the major benefits include:

- All video, GPS, identification, measurement, condition audit, hazard identification of footpath, identification of driveways etc benefits;

- Insurance companies –in the incidents of claims, very good evidence from Council side;

- More than normal inspection program: data accuracy and verification;

- Unskilled staff member can drive across the network;

- After video processing it can be rated in office later;

- Other issues get attention off the video; asset register gets up to date etc.;

- Ease in identification of work priorities and better management of available resources; and

- Citiworks' (Business unit of Townsville City Council) innovative, proactive and enhanced commitment to fulfilment of duty of care

Any work in this area will have potential with other councils and departments with larger footpath and bikeway networks (Requiring inspections biannually or otherwise, mainly on Risk and Claims basis due to accidents etc on top of Condition rating aspect)

Handheld GIS based System

Not all required information can be determined from the video alone; and in some cases the item of interest may not even be visible from the video data

collected. In such circumstances additional fieldwork is required. With the DRIVE system the number of items requiring field-capture is greatly reduced and where possible their locations pre-identified, making any field-capture a more efficient exercise. A leading-edge field data-collection system taking advantages of technological changes to greatly increase speed of data-entry is highly desirable. Numbers of handheld devices are now available in market with various features.

One of such system IKE™ which author was involved is described here. IKE™ is fully integrated personal data-entry system which is fully compatible with DRIVE and may be easily configurable for other video systems.

IKE™ is a handheld device consisting of GPS receiver, digital camera, laser distance meter, digital compass and inclinometer. It is being used for "difficult to get straight form running vehicle" type of assets as well as for bridges, culverts, kerb and channel, traffic signs and tree surveys etc. An interface with desktop computer and GIS for data collection and next phase of processing and analysis is available.

From up to 100 m distance, assets can be targeted; IKE™ can capture GPS information at asset or at inspector position. One or more digital photograph of asset can be taken with this GPS and other information. Linear assets can also be created
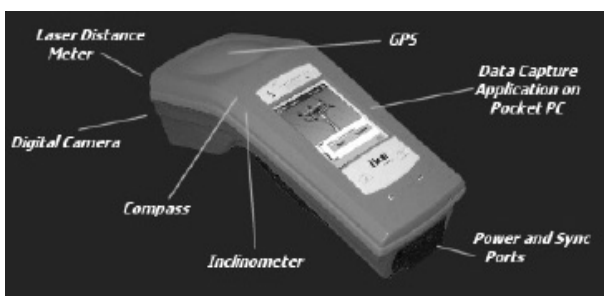

Fig. 3 IKE image:

or measured by creating number of points from inspector and at asset position. After creating or identifying previously created assets attribute information including condition, type, material etc can be inserted straight into pre-developed asset forms' dropdown or text fields for handheld. All this information related to assets including photographs linked to assets can be transferred back to laptop or office computer using simple synchronisation techniques and asset information system gets updated.

Image from http://www.surveylab.co.nz/Who_is_ike~qu.html

Alike DRIVE type system, number of Councils have adopted and used handheld based GIS enabled inspection system for collecting asset inventories, condition assessment, reporting for roadway, park, building and other infrastructure.

Infrastructure Planning, few Other Applications

Infrastructure Planning and Flood Study

For a local government, Infrastructure Planning is essential to meet the requirements of growth on or before time. Growth analysis is performed for the local government area through data collection of population, commercial, retail, industrial and community aspects. All these factors are integrated into a GIS model (mapping system) and the areas expecting varied levels of growth can be identified. These highlight infrastructure requirements in the short and long term future and allow effective infrastructure planning. The mapping system is integrated with land information system and can be used for number of other planning applications including property search, development assessment (green field or change in density), inter-governmental planning, designing environmental solutions, etc. These applications are available for public on request. The wide and numerous usage of this land information system make it an essential part of any local government. Various Government agencies for Road, Water and Transport are having extensive usage of GIS platforms e.g. ESRI Arcview or MapInfo Professional, in their forward planning as well as maintaining existing infrastructure.

The environmental application in local government is for Drainage Management Plan in the wetland area (next to national park) of the tropical city. To make this plan, various aspects of environment are considered including soil types, future wetland development and underground water level. These data for existing and future conditions are acquired through GIS and various solutions are designed to achieve desired standards.

In tropical cities, to mitigate natural disasters like flooding, rigorous GIS flood mapping is undertaken as part of preventive disaster management plan or strategy. Risks analysis and mitigation actions taken can assist in identification of infrastructure

upgrades or additional infrastructure. This study assists in prioritisation of new capital, maintenance or rehabilitation works. This results in optimised alleviation of flood impacts in the areas of extreme need.

Development of Priority Infrastructure Plan

In Australia particularly in Queensland State, it is legislative requirement to have Priority Infrastructure Planning for major local governments. Priority infrastructure plan determines the growth for 15 years time horizon based on growth analysis. The growth is analysed considering population, commercial, retail, industrial and community aspects. The resultant is to identify areas with high growth, medium growth and low growth. This is possible with the help of growth modelling developed using GIS. In this priority infrastructure area, infrastructure is planned, designed and implemented as requirement identified in various timeframes. For infrastructure planning, maps of existing and proposed future infrastructure are prepared in GIS which are very convenient tool to communicate and consult various inter and intra government departments and interact with development industry and public. Public consultations are also easily handled with the GIS maps as they are quite easily understandable compared to text, when complex system of various infrastructures is to be discussed.

Priority infrastructure plan is a legislative replacement of interim infrastructure headworks charging policy. It facilitates charging to developers for the existing and future trunk infrastructure as per their fair and equitable share. These charges, as received by local government, are obliged to be spent on new trunk infrastructure and provide desired standard of service back to the users and community. This leads local government to manage infrastructure effectively and most efficiently.

Property Search and Sharing of Corporate Information

GIS based asset information system is widely used to share up-to-date data with lowest possibility of errors. Central repository of asset data in GIS form for corporate use and ease in auditing and quality assurance is common in Australian local government environment. Townsville Intranet Mapping is in-house developed view only GIS system at Townsville City Council.

A typical example of property search consists of a request from public to have a search of one's block of land. The intention might be to buy that particular land or to change the building plan or increase the density. Search includes all features of that land parcel including various existing or future infrastructure position, flood level, exact dimensions of land parcel, neighbourhood details, aerial photograph, soil characteristics, land parcel located in which geographical boundaries such as suburb, district, statistical area etc through GIS. These can help the owner or prospective buyer of that land parcel to make informed decisions. Also these features help land and property valuers to make better decisions. The reports from valuers are considered one of the basic requirements for approving home loans.

Dial Before You Dig, Australia

Excavators may be held financially responsible by the asset owner should they damage underground assets. GIS has helped in minimise waste and eliminate accidental damage to underground assets.

Dial before you dig is national service where either one can call or on web based GIS system one can show/identify point/area which needs excavation. It is easy to use and one can view all the related information online. Once request is made, relevant service provider participant of the program will send necessary GIS maps/plan for your information in agreed time frame.

Here is some important information about the Dial Before You Dig Service [1]

· Dialing Before You Dig helps prevent damage and disruption to Australia's vast underground pipe and cable network which carries many essential services, including our electricity, gas, communications and water.

· Neglecting to dial before excavating can lead to costly disruption to essential services, and injury or death to workers and the general public. It can also lead to heavy financial penalties.

· Dialing Before You Dig is the most efficient way to obtain information on underground networks at your excavation site.

· Dial Before You Dig is a unique partnership between most of Australia's communications, gas, water and electricity providers. By joining forces, these organizations are able to offer a one-stop

shop for underground network GIS maps/ plans so excavators no longer have to contact each of them individually.

· If your proposed excavation site has underground networks, all relevant GIS maps/ plans showing their location should be provided to you within two working days.

· Dial Before You Dig is a national service and 1100 can be called from anywhere in Australia to access plans for anywhere in Australia to minimize one's risk.

· A single cable or pipe cut can leave an entire community without essential services such as communications, electricity, gas and water.

As all constructors have a Duty of Care to observe with regard to underground pipes and cables when digging or excavating. This type of GIS based application has been proven to save time, money and potentially, lives.

Summary

Accurate asset information and condition data are in the base of infrastructure planning and management. Advancement in GIS and other technologies have facilitated more informed infrastructure investment decisions through assistance in prioritisation of works and optimisation of funds at considerable extent. In this paper, authors have described some selected GIS applications, which they are closely associated in Infrastructure Management in Australian environment.

References

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About Author

Mr. Ashish Shah is an Asset Management Engineer of civil infrastructure. He has done his post graduation in information technology with distinction from RMIT University, Australia and graduation in civil engineering from Nirma institute of technology, Gujarat. He has a vast experience in research and project management. His key skills include GIS and its applications, civil infrastructure management, data acquisition and analysis. He has published many papers in national and international journals. He is a member of many national and international societies.

Semantic Interoperability Based on Geospatial Ontologies

Sumit Sen

University of Münster, Robert Koch Str 26, 48149 Münster, Germany

sumitsen@uni-muenster.de

Abstract

Geospatial data and services are built with certain semantics in mind. These semantics are mostly implied and sometimes specified by the application designers and data providers in the form of documents and meta-data. Geospatial ontologies help to specify such semantics in a formal language. We discuss the role of semantics in the overall interoperability of geospatial data and that such ontologies are the key to ensure semantic interoperability of geographical information systems. This paper explores various approaches in geospatial ontology specifications. Specifications which treat functions of geospatial entities as important constituents are argued to be more useful than those which do not. We illustrate our hypothesis with examples from road network ontologies based on algebraic specifications as well as Bayesian Network based specifications. Our experiments have shown that translations of geospatial data based on ontology mappings can provide mechanism to improve semantic interoperability.

Keywords: *Semantics, ontologies, geospatial entities, interoperability*

Introduction

Users of geospatial data and services are drawn from across domains. With the advent of internet age and client architecture there is an increased tendency to share and exchange data across such domains. The need of interoperability of systems and hence the data contained has thus gained increased significance [1]. Interoperability of Geographic information has been a topic of research for some years now, starting from its initial phases of Spatial Data Transfer Standards (SDTS) and culminating into geospatial ontologies and ontology based semantic translations and semantic reference systems. This paper attempts to highlight the significance of semantic interoperability achieved by geospatial ontologies. Agarwal [2] has shown that there are many approaches to specification of ontologies in the geospatial domain. We look at two particular types of ontologies, the algebraic specification approach and the Bayesian network approach to highlight the use of functions geospatial entities in such ontologies. The rest of the paper is organized as follows. This section introduces some of the concepts of geospatial ontologies and their role in semantic interoperability. Section 2 surveys the present techniques of ontology specifications based on hierarchies of entities and the problems associated. Section 3 describes algebraic specifications based on the notion of type classes while section 4 discusses the use of Bayesian network based ontology and its utility in matching most similar entities based on their functional properties. Finally in section 5 we provide a discussion and an outlook for future work.

Semantic interoperability of Geographic information

As in the case of interoperability in general, semantic interoperability [3] is best understood as the state where semantic problems do not exist. Probst and Lutz [4] have identified the following semantic interoperability problems:

· Naming Heterogeneity

· Datatype Heterogeneity

· Conceptual Heterogeneity

Semantics as a subject has been long studied by linguists and philosophers. The connection between real world entities, their concepts and symbols used to represent them is captured by the meanings triangle of Ogden [5] shown in the figure below. The notions of semantic spaces in which conceptual models are defined are employed for such interoperability. Semantic spaces can be imagined to be the abstract space in which concepts are represented. Conceptual models are models of the data entities that are constructed within such semantic spaces. Based on the proposal of Semantic reference systems [6] this can be achieved through

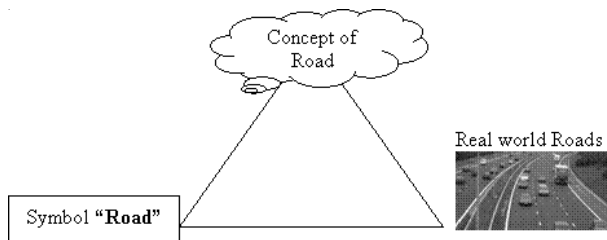· referencing symbols to concept specifications

Fig. 1 Meaning triangle based on Ogden & Richards [1946]

·   grounding concept specifications in physical reality

·   projections among the semantic spaces

·   *transformations* among different semantic reference systems.

Conceptualizations are often specified in the form of formal ontologies. A Formal ontology [7] is a set of logical axioms that convey the meaning of terms for a particular community. Such ontologies have been employed for knowledge based information retrieval and provide important tools to tackle semantic interoperability.

Geospatial knowledge sharing with ontologies

Ontologies of the geospatial domain define geographic objects, fields, spatial relations, processes and their categories. The view advocated by Câmara *et al* [8] *geographical space* as *a system of entities and a system of actions.*

Geospatial knowledge sharing with ontologies aims to provide methodologies and algorithms to translate and map between the models of geospatial data and applications. They aim to provide the semantic knowledge for machine based integration of geospatial information. Attempts to employ geospatial ontologies have been attempted from by many researchers and many approaches to extraction, use and representation of geospatial ontologies have evolved [2]. However, with the increased use of web based services of geospatial data [9] and the emergence of tools in the semantic web[1], there has been increased focus on specification of geospatial ontologies and to study the shortcomings of present day approaches.

Approaches to Geo-ontology specifications

Agarwal [2] has discussed the use of ontologies in the geospatial domain. She points out that there are several approaches to the specifications of such geo-ontologies. It is also discussed that there are

several semantic ambiguities in the geographical concepts used in GI Science.
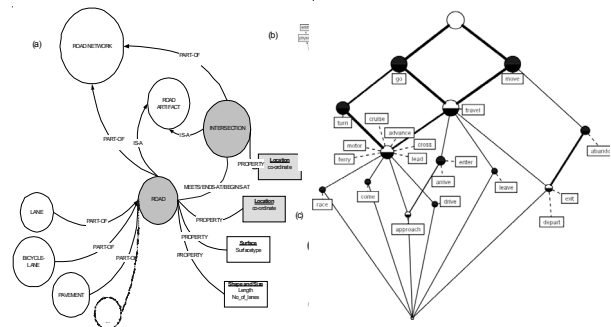

Fig.. 2 two approaches of geospatial ontology specification (a) shows taxonomic hierarchies of geospatial entities in a road transport ontology (b) shows taxonomy of geospatial actions/functions in the same domain

Among the different approaches that are evident in the geospatial ontologies literature we can see two distinct approaches that are relevant to this paper. These are based on the assumption that geospatial space consists of both geospatial entities and geospatial actions. Concepts of such geospatial functions[2] (or the actions) are reported to exist independent of their corresponding entity classes which can posses them. Thus the two approaches which differ upon the centrality offered to geospatial functions are

● Conventional taxonomies of geospatial entities: In this approach categories of spatial entities are structured as hierarchies with the most general class assumed as the parent class of all other classes. See figure 2 a

● Taxonomies which structure taxonomies of geospatial functions as hierarchies. This approach as seen in figure 2b assumes that the functions are important to characterize the geospatial category. Such function based or action based ontologies are significant in the case of manmade entities such as roads, road intersections.

Taxonomies of geospatial entities

Taxonomies of geospatial entities have been traditional tools for geospatial ontologies. Class diagrams in the geospatial domains have represented the notion of taxonomic relations between geospatial entities as seen in the UNETRANS model of transportation (see figure 3). Primary principle of classification in this approach is parallel to the