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Paper title: **On the locality-scope model for improving the performance of transportation management systems**

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Abstract (200 words):
Events occur randomly within transportation networks. This statement is by no means revelation in the slightest, however, coming to accept such as statement within the context of the management and modelling of transportation networks and the way it affects the modelling and management of traffic is at the very least mind expanding. There are many examples of transportation models that use randomness and probability as their basis; however such stochastic methods are more interested in the aggregation and analysis of data rather than its management. The Locality-Scope Model administers the framework within which data and knowledge are created, stored, analysed, retrieved and actioned. Its purpose is to provide the mechanism by which current and future knowledge requirements can be identified and realised within both traffic management systems and transport micro-simulation tools. It is accepted that the general limitation to the model is that it cannot manage nodes for which there is no electronic management/storage device. Through this framework one can have access to highly optimised, and information rich data at any time of the day or night. Within in the simulated world, it provides the modeller with the ability to purpose manage the information at each point of interest such as intersections or population sinks, and in the real-world, it allows for the improved management of information to and from signalised intersections and their sectional controllers.

Introduction

The Locality-Scope Model grew out of the seminal paper written by Vogiatzis, Ikeda, Woolley and He(2003) which describes a proposed *integrated multi-nodal traffic network system* (named IMAGINATION). In that paper, the authors described a new type of traffic management system whereby all vehicles, network objects, buildings and users are integrated into a singular system. The vehicle objects would function independently, however, the advice that IMAGINATION would give them on the best route-choice for their designated task at hand is based on the knowledge that IMAGINATION manages for the entire system. In such a system, and assuming that each driver took the advice that was proposed, there would a greatly reduced possibility that 'too many' vehicles would act upon advice that would simply move *congestion* from one bottle-neck to another. The purpose of IMAGINATION is that it would know where each vehicle is and tell the appropriate vehicles based on Origin-Destination (OD), driving style, trip purpose, etc, a dynamic route-choice regime(Vogiatzis *et al.*, 2003).

However, Vogiatzis et al identified a significant challenge in such a system, how does one make automated and human-guided decisions in a time-frame that would reduce the number of invalid decisions for the movement of the vehicles because of new events occurring that render any previous information useless. It is conceded that one will probably never be able to make decisions so fast as to eliminate the problem completely (not at least much into the future), and until such time as one can, we need a technique now that will minimise this problem.

It is the authors' aim to develop the foundations of a framework upon which one is able to build techniques that will allow not only increase the speed in decision making, but also a mechanism by which one can develop hierarchies of models without loss of generality.

IMAGINATION is being designed as a ground-up re-think, re-design, and re-interpretation of the currently available traffic signal control systems and micro-simulation tools. Although it looks to the past to a certain extent, its aim is not to be designed with the past in mind. This paper specifically is only interested in the way data is moved within the proposed system, the way data is converted to useful information for traffic signal optimisation and traffic movement optimisation, and how this can be done at speeds that ensure only the most relevant and current information is used in processes performed. In Vogiatzis (2006)(an incomplete PhD thesis), the mathematical framework is being developed that describes the actual traffic movement within the network that is supported by IMAGINATION.

In addition, as a design requirement, IMAGINATION is not designed to be adaptive in the traditional traffic signal management sense; rather, it is designed to use artificial intelligence to manage the traffic network in the same way the human mind manages the human body.

Background

The Locality-Scope Model (LSM) was conceptualised by Ikeda and Vogiatzis (2003) during one night of discussion regarding the challenges posed by IMAGINATION.

During these discussions, it was identified that there needed to be a mechanism that had the following properties: 1) Ability to quickly make decisions at a point of interest; 2) Ability to pass relevant information to other points of interest (where practicable) as required without the need to contact any central system; 3) To distinguish between tactical and strategic decisions (Includes the ability to make such decisions at the macro and micro level simultaneously); 4)To provide the mechanism by which such decisions, once made, become a part of the knowledge-base (KB) for IMAGINATION and is to be used to again improve the decision making process into the future.

The key property is ultimately the ability to only need to create *new knowledge* and hence make decisions based on that new knowledge as few times as possible.

The stated philosophy of IMAGINATION was to use nature as the inspiration to the process of developing an integrated transportation system, and to that end, the concept of the LSM has been taken from the human body itself.

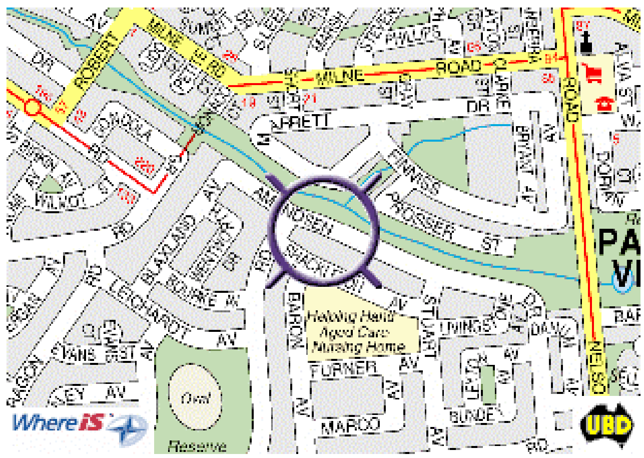

Figure 1 An example traffic network: we will use this throughout the paper(WhereIs.com, 2004)

A. IMAGINATION: an overview

In Vogiatzis et al (2003), a new type of integrated traffic management/traffic micro-simulation system was proposed. It was called IMAGINATION (Integrated Multi-Nodal Traffic Network System) because it required some *imagination* in order to see how all the pieces fit.

Specifically, IMAGINATION began as a decision support system which has now grown in concept to become an intelligent, self-sustaining traffic/transport network management system. It does so by conceptually integrating the three main elements of traffic networks; 1) the users of the network (drivers, pedestrians, etc); 2) the traffic engineer who physically manages the network; and 3) the traffic management system.

It does so by developing the idea of each vehicle in the network being 'connected' to the system, in which case there is no longer a need for the traffic signalling system to be interested in movement of vehicles between intersections, rather the movement of vehicles between 'Locations'. Vogiatzis, Mojarrabi, Ikeda, Kubik and Mojarrabi (2005) deal with a technique whereby vehicles can be tracked within a certain radius, although in the original paper it was suggested by using GPS trackers on each vehicle it would be possible to manage vehicle movement. Naturally, in any sort of individual vehicular tracking system, the privacy of the vehicle owners must be protected except where with the owner's permission personal details can be collected or as a result of legal infringement by the owner/driver of the vehicle.

This system is currently a concept; it is currently in the design phase, and this paper forms one of the design documents for IMAGINATION.

B. *Analogies*

1) *Analogy: Human Consciousness*

We begin with the base analogy that inspired Ikeda and Vogiatzis.

Imagine for a moment a very simplified model of the human brain where there are two basic elements, a physical information system where synapses join various parts of the brain and pass information in the guise of micro chemical-electrical currents, and also imagine that at a higher level, there was the human consciousness which manipulated the data and turned it into useful information. In such a model, we can see that synapses are interested primarily in the *tactical* aspect of managing brain function, i.e. ensuring that when a call is made to retrieve data from the brain, it was able to do so quickly and efficiently. It isn't necessarily interested in *how* the data is used or *how* it is manipulated, only *what* information is necessary.

The human consciousness, on the other hand, is the *strategic* component of the simplified brain model, where its primary concern is not *how* the data is stored or retrieved; but that once it is required it is *provided* so that the *mind* can process the information.

The detailed mechanism by which this occurs in not of real interest to us, just that we can view the human brain/mind in such a manner and that it is sensible.

2) *Analogy: Traffic Flow*

We consider an analogy with relation to traffic flow and traffic management.

Assuming for a moment we are in a completely utopian world (for the purpose of this analogy) and that every intersection has traffic signals; every vehicle has some form of tracking device (with all the appropriate levels of protection for the privacy of the individual) and these would work in concert with one another.

At specific localities, each intersection would have devices that were sufficiently 'intelligent' enough to be able take the role of master devices when and if necessary.

In such a system, individual intersections can manage the flow of vehicles within their immediate locality, and pass relevant data/information to intersections with which it neighbours. This allows vital information relating to the movement of traffic to be passed to each intersection. The movement of vehicles within localised intersections or groups of localised intersections (Locality) is a tactical operation.

However, as a result of the fact that all the intersections are connected as elements of an electronic synaptic network (we avoid the term "neural network" for now), it is possible using a combination of real-time data and historical information, to build a predicative path for vehicles within a given road network. Naturally, if one can identify a *trend*, then one can act *pre-*

emptively, and *fore-warn* intersections ahead of time of the movement of vehicles and appropriate actions to take. This traffic network *pre-emptive multi-tasking* is what will be defined as Scope. Literally, Scope is the combining of indirectly related intersections or groups of intersections. They are indirectly related because for all intents and purposes, the only thing that ties them together is bitumen and the fact that historically there are mirrored movements of vehicles over time. This is not adaptive traffic signal control; it is intelligent traffic management, with the focus on the movement of vehicles between their origin and destination, rather than the movement of vehicles through intersections.

However, it is not simply the movement of traffic that one need consider, rather, one could also take a holistic approach and consider other elements such as emissions and noise levels.

Ikeda, Vogiatzis et al (Ikeda, Vogiatzis, Wibisono, Mojarrabi and Woolley, 2004b) discuss a physical implementation of such a system with a Three Layered Model of Transport System Integration (3LOM).

In this model, data and knowledge are managed physically at three different layers, an upper knowledge management layer, a data management layer and data collection and collation layer. The LSM provides the glue that keeps all these three layers communicating. The manner in which the 3LOM physically manages data streams that interface into the LSM can be found in Ikeda, Vogiatzis, Wibisono and He(2004a).

Motivation

Currently, the type of information collected by present traffic control systems includes *traffic volumes* and *intersection capacity* just to name a few. Systems such as SCATS (Sydney Coordinate Adaptive Traffic System) and SCOOT (Split Cycle Offset Optimising Technique)(Vogiatzis *et al.*, 2003) dominate the way traffic is managed, and they rely on *Detector Loops* and *CCTV Cameras* to control the way traffic flows within road networks(Vengler and Urbanik, 1995).

Vengler and Urbanik(1995) discuss some of the information that can be collected by using detector loops such as *vehicle count, presence, speed, occupancy, and queue length*. However, detector loops can not collect information such as *emissions levels, land-use policy, link type, etc*.

Moreover, the mechanism by which these systems function is primarily intersection-based, although naturally, one can link intersections together, one still finds that the systems choose one intersection as the controlling intersection, after which all other linked intersections are calibrated accordingly.

Interestingly, in order to optimise the movement of traffic within a 'linear' group of intersections, SCATS for example, chooses a specific intersection which it sets as its 'master' intersection, and then sets the time offset of other *area* intersections based on that one (Austroads, 2003). This then has the effect of not allowing each intersection to be optimised in its own right. The basis of many of these optimisation decisions is traffic volume however there are overrides within SCATS allows a human controller to change phases based on other factors.

Ultimately traffic volume is the prime reason that signals behave the way they do within SCATS' dynamic setting. Naturally, the fixed phase setting takes nothing else into account other than a specific amount of time passing.

In an organism such as traffic, however, there are many times when vehicles, for one reason or another, such as accidents, road works etc, will change their movement behaviour and that will not be necessarily reflected in the way the signalling system links intersections. Here is where there is a need for a new type of traffic control/traffic micro-simulation tool; one that is integrated so that when one is making changes within the traffic micro-simulation, once settings have been found that are optimal, it is possible to send those changes directly to the functioning traffic management system.

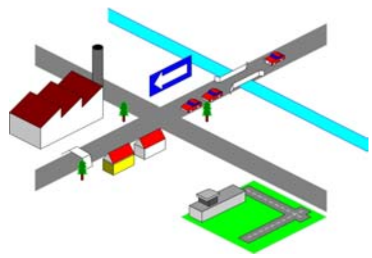

Figure 2 An intersection with numerous points of interest including a bridge, factory, homes, a one way street leading to the intersection and an airport

In figure 2, we identify that points of interest are more than just intersections and how traffic flows within them. In such a case, we have not only points of interest at the intersection itself, but we can treat the entrances to the car-parks of the factory and intersection as being points of interest. In fact should we require additional resolution we can also treat the entrances into houses also as points of interest, and therefore nodes within the network. Also important is that the link between these points of interest also has properties/attributes that can be used to manage traffic movements.

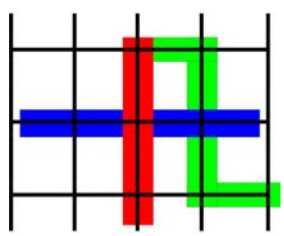

Figure 3 The various shades indicate a possible movement of traffic to be optimised

In figure 3, what we see is that there are times when we don't have just one major movement of traffic that should receive favouritism over the other movements. In such a scenario, we are looking at the intersection of two arterials (the crossed roads) and a path made up of smaller roads and feeder roads. Even though the smaller/feeder roads are able to manage less capacity, they nonetheless may be a major route to a specific location. In fact we assume that all three are leading to the same sink, but for one reason or another, drivers choose to take alternative routes. One may consider that the movement of traffic on the two arterials as being more important as per throughput, but the movement on the non-linear route may cause significant discomfort to residents, there may be schools or homes for the elderly, and it may be an environmental issue. Which priority is the most important one? Unfortunately the answer depends on the circumstances of the situation; however, what is required is the ability to manage traffic in all regions depending on the requirements of that region.

Adaptive Traffic Control Systems

Numerous papers deal with a number of the issues to be raised within this paper. As mentioned earlier, there are many more than capable traffic management systems. In South Australia SCATS is used, a traffic signal control system with more than 30 years of operation within Australia, and a system that is in continuous development. According to Thill (2004) Adaptive Traffic Control Systems can be defined as follows:

> *Intelligent real-time dynamic traffic control systems (adaptive traffic control systems, or ATCS) are designed to effectively respond to rapid variations in dynamic traffic conditions. Real-time traffic control, as opposed to more traditional off-line traffic control systems, utilize real time information from on-line traffic monitors in order to measure the dynamic traffic flow conditions for prediction and control of the traffic condition for the next control period. In order to achieve this, a real-time adaptive signal traffic control system has to include not only traffic monitoring and control equipment but also methods for traffic data acquisition and analysis, traffic pattern prediction, and on-line timing plan selection.*

Conceptually, IMAGINATION slots into this category quite neatly; however the ways in which SCATS, SCOOT, STREAMS, and IMAGINATION work/will work are different.

SCATSSIM (McCabe, 2004) is designed to interface SCATS operation into various available traffic micro-simulation systems including Q and S PARAMICS and AIMSUN. This allows a user of a traffic micro-simulation package to emulate the operation of SCATS within their chosen environment. Conceptually IMAGINATION does the same, so what is the difference?

IMAGINATION is being designed to have **one** view of the network. Any changes within the traffic management geometry are *automatically* updated within the micro-simulation because of the singular world view. The only difference between the *simulated* IMAGINATION and the *physical* IMAGINATION will be the fact that one uses simulated data and vehicle movement routines and the other is managing real-world traffic.

Furthermore, IMAGINATION is being designed as a *purely plug-in* environment so that the system can be quickly and easily upgraded without the need for upgrading the entire system at the one time, and thereby minimising the issues with migration. Naturally plug-in architectures are not new; many of the world's applications use this and the latest version of AIMSUN NG is designed using the same concept (Barcelo, 2004).

Objects within the Transport Networks

Many researchers refer to the object nature of traffic networks for traffic management, route planning, traffic micro-simulation, and much more; examples include Dickmanns (2002), Kecskemethy and Hiller (1995), Dia (2001) McCormack and Roberts (1996) and Yang and Koutsopoulos (1996), just to name a few. However the object nature of traffic/transport is only a small aspect of IMAGINATION itself.

Although this is the case, for the sake of completeness we briefly discuss the object nature of traffic networks.

The object nature of traffic networks allows the network developer to view the relationship between each object in the same way as one would view objects within nature. We can establish that there is an object, called a living creature which has some basic attributes. All living creatures would have those attributes, such as transpiring gases which aid in the chemical reactions necessary for life, and then we can define human drivers within such a context, and therefore within the model with ease.

Examples of such objects include *generic car park* objects and *traffic signal* objects. Depending on what one wants to achieve, this may very well be a collection of atomic data 'bins', however, one can easily observe that each object can actually be described as a compound object derived of a number of smaller ancillary objects.

What we find is that it is not necessarily wrong to treat a car park as a collection of atoms; it simply depends on the level of resolution one wants and the relationships between objects that one wants to build.

For example, we want to build two types of objects, a car park object and a traffic signal object.

We begin by identifying the important attributes of a car park (this is will not be an exhaustive list): Geographical location; Capacity of car park; Number of levels; and Public or Private.

We also develop a non-exhaustive list of attributes for the traffic signal object: Geographical location; Number of lanes; and Number of signals.

Notice that both the generic car park and the traffic signal objects have geographical location as a common fundamental class.

We build on these two by defining both classes of objects within the example network (naturally the definitions will be by no means complete) and we will use UML (Unified Modelling Language) constructs to display the class definitions.

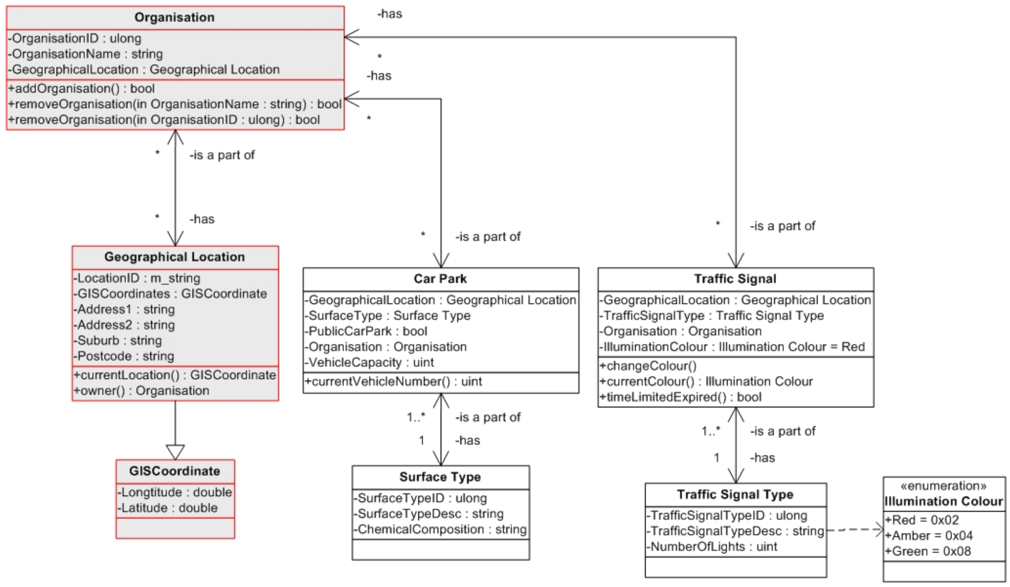

Figure 4 A sample class-object diagram for the car park/traffic signal objects

Here we can see that both ‘car park’ and ‘traffic signal’ can be defined by including the object definitions of ‘organisation’, ‘geographical location’ and ‘GIS coordinate’.

Events within a transport network

When looking at any transportation network, the notion of an *event* permeates the discussion. We talk about moving freight, or signal phases, etc, where each of these is fundamentally an action; intangible in its own right, but we can detect its effect by the fact that lights change colour, or boom gates rise/fall etc.

Each object within a transportation network has an *event* object embedded within it. Network objects are not derived from any such *event* object, but are manipulated by it. One might consider an event as just one more element within the tuple that defines a network object, however event objects are specifically descriptions of either physical entities or their electronic imitators, whereas the event object is not a description of any physical entity, but a reaction to some occurrence that affects the physical entity rather than generate or reduce some informational component of the object. There are other mappings within network objects that manage the ‘information’ manipulation; however event object mappings are a separate entity.

Specifically in Vogiatzis *et al* (2003) the issue of events is described as being a part of the data acquisition process. Data acquisition within the *IMAGINATION* system (and current technologies) is non-linear in nature, insofar as one is unsure when data will arrive. This suggests that all transport systems are non-linear and event-driven systems. All actions within a transportation system are symptomatic; they occur because individuals wish to conduct business, purchase groceries or for any other several million reasons. Without *events*, there is no need for there to be a transportation system.

An example of this is each time a vehicle passes over a loop in the road, this triggers an event. In such a case, the events are used to count how many vehicles pass through an intersection from a particular direction during a particular timeframe. Other cases include people in one city wanting produce from another; this put into motion a number of *events* that ultimately result in the movement of produce/goods etc to the requisitioning city; or even the lapse of concentration by one driver within the transport network affecting the movements (including automated human response incident evasion) of others.

Each event is intimately tied to a mapping describing the action that is to be performed by the owner object once the event is triggered.

Modelling the Transportation System

On can not discuss a traffic network in isolation; rather, the traffic network functions with a greater transportation system which combines a number of regional universal networks (naturally creating the truly universal transport network) into a unified system of movement centres.

We can define a transportation system in the following way:

> *A transportation system can be described as an 8-tuple* $\langle A, L, N, P, F, f, O, p, C\rangle$ *such that:*
> (a) *A is the set of all attributes, including geometry and capacity of the system*
> (b) *P is a graph on* $L \times N$ *; called the set of paths*
> (c) *F is the set of facilities*
> (d) *f is a function* $P \cup O \rightarrow$ *the set of all subsets in A*
> (e) *O is the set of all running objects*
> (f) *P is a function* $L \cup N \cup (O \times T) \rightarrow R^3$ *(geometry: 3-dimensional Euclidean Space* $\{(x, y, z) \mid x, y, z \in R\}$*) where T is the set of non-negative real numbers*
> (g) *C is the set of constraints of the values of P*

From points (a), (b), and (d) we can extract network information and by utilising particular calculations, one can identify a maximal flow. The maximal value of each edge or node is called the *structural capacity* for that specific object. If at any time *t* the flow at a node or along an edge exceeds the maximal value, then we can refer to that point/line as a *hot spot*.

It is possible to create a *hyper-graph*, which is a graph having nodes that originate from a connected sub-graph. If the capacity of each edge of a hyper-graph equals to the sum of capacity of the original edges, then we say that two sub-graphs are connected(Ikeda and Vogiatzis, 2004).

This forms the basis for transport systems integration as described in Ikeda et al's(2004b) work in proposing the framework for transport systems integration. Specifically, the modelling of the transport network falls within the second layer, being the 'database systems' layer. Here we begin to view the network from an integration implementation perspective and we note that such a system, in order to function efficiently, must be distributed in nature. The management system needs to be distributed for a number of reasons; primarily because it is not possible to efficiently manage large quantities of data/information within a singular DBMS (Database Management System). Furthermore, by 'spreading' the locations for the database, it is possible to enhance the security and flexibility of the system. The security aspect is enhanced as the local management DBMS is designed to manage its information directly. Additional, higher-level information can be passed to local DBMS/signal controllers 'one-way' with high-level systems providing disassociated services that do not allow local controllers with direct access to secure information. Flexibility is enhanced by means of appropriately chosen system components that allow for a flexible design. Operating systems such as *Mungi* (University of New South Wales, 2004) and operating systems extensions such as *openMosix* (openMosix Group, 2004), provide the ability to create 'super computer' processing with desktop computer technology. In fact, the purpose of *openMosix* can be seen by its slogan:

> *"openMosix is a Linux Kernel extension for single-system image clustering which turns a network of ordinary computers into a supercomputer."(openMosix Group, 2004)*

Vogiatzis is in the process of installing *openMosix* on a number of Ultra-SPARC 1 computers running Gentoo Linux (Gentoo Linux Group, 2004) as a way to leverage existing technologies and take advantage of the performance gains of a single-address space operating system coupled with aggregated CPUs within his personal research.

This suggests that there are now technologies available that not only distribute computational loads but that it also allow an entire traffic network system to combine every controller into a greater computing platform; creating in a city setting, a metropolitan wide virtual super-computer concentrating on the singular task of managing traffic.

Cetin et al (2002) discusses the computational issues for any such system from the microsimulation prospective, although it is directly applicable to the development of Transportation Management Systems. They support the concept of the distributed nature of traffic requiring a distributed solution, such as that found in the work of Ikeda and Vogiatzis in general. Although of interest is that Cetin is still effectively using computers within a cluster that use overlays to perform interconnectivity between machines for the micro-simulation tasks. They demonstrate that the purely *brute-force* approach will not work and that there are an optimum number of distributed machines that will perform the calculations quickly and efficiently. Naturally, investigation needs to be performed that takes into account a specifically designed distributed architecture such as Mungi and openMosix, and what additional performance gains can be identified over and above an overlaid distributed environment.

This leads us to the conclusion that there is a need to develop a management system that takes into account that traffic needs to be managed at the highest level, and at the individual intersection level simultaneously. However, which of the two is more important?

Definition of Locality and Scope (Implementation)

The question above has a *"chicken or the egg"* ring about them; however the reality is that they both co-exist equally.

There are many ways to define locality-scope; these include characteristic-based definitions, role-based definitions and implementation-based definitions.

In this paper, we concern ourselves with an implementation level definition of locality-scope and we leave a characteristic definition for a later forum.

We begin with two basic and direct definitions:

Definition 1 Locality

Locality is implemented as a transactional system using historical and statistical data as the basis for deciding the optimal phases for a signalised intersection. Furthermore, locality can be either a singular signalised intersection or a grouping of related signalised intersections.

Definition 2 Scope

Scope is implemented as a knowledge generation, management and application system that identifies intentions and objectives as being the basis for decision making.

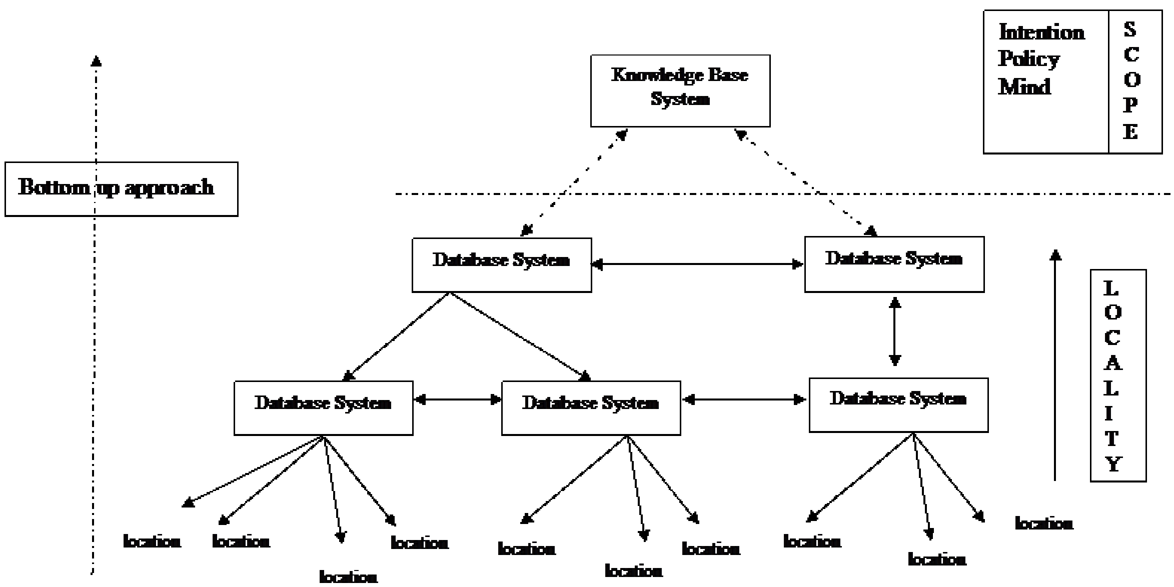

Figure 5 A graphical representation of Locality-Scope

In the figure above, we can see that locality is concerned with the management of low and medium-level information between intersections and groups of intersections, whereas scope is concerned about passing such information to local systems as is required to assist in the on-going management of traffic.

Here we have a system whereby data is collected, transformed into information and then disseminated internally to locations within the designated locality or else passed on to other localities for consumption. In this way, *lessons learnt* can be passed to all localities within the network thus reducing the need for every locality to learn the same lessons individually. This improves the efficiency of the network by creating an *education* rich environment for each locality. Scope, naturally, manages the knowledge (lessons learnt). It provides the conduit by which all knowledge is created and shared within the network. Thus if one locality identifies a trend towards a congested state, one that matches the same trend criteria as another intersection, then the knowledge base is able to convert that into applicable knowledge which can be used by all other localities as required and on-demand.

Information, what information?

So far, we have discussed much about computer systems, managing traffic and so forth, without really talking about what information is used.

According to Guehnemann et al (2001), traffic system authorities need to find the balance between 1) improving the movement of people and goods as well as reducing urban congestion; 2) achieving environmental objectives; and 3) social and economical goals. They suggest the best way to do this is by integrating dynamic traffic microsimulation with impact assessment. However there are many different ways and levels to integration. One way, naturally, is the Guehnemann approach which calls for modelling as the prime catalyst in the ultimate management of traffic as a separate function to the daily traffic management problem, however, locality-scope views modelling as something that occurs within the traffic management system.

The basic data that is collected with current traffic management systems such as SCATS, SCOOT and BLISS is effectively traffic volumes coupled with visual analysis systems. However with the flexibility that locality-scope brings to the implementation of traffic management systems, we can now enhance the type of information collected by the traffic management system to include emissions data and land-use data that can directly affect the way traffic is managed.

From an Emergency Services (EMS) perspective, the additional data collected, the knowledge base, and the localised intelligence ensures that the optimal path (less the temporal environment) can be calculated and thus improve the service provided.

How it fits together

Figure 6 Locality-Scope(WhereIs.com, 2004)

Above we see two images, the one on the left centres on two intersections, and the one on the right shows us the context of these two intersections. These two intersections are within 10's of metres of each other and they do not necessarily allow traffic to flow cleanly during peak times. Specifically, local knowledge tells drivers that if you are on Hampsted Road heading South during peak, it is wiser to be in the left lane, rather than the right as traffic attempting to turn right into Regency Road will block your path. This occurs because there exists a protected right hand turn into Regency that stops traffic turning whilst the North-South movement is active. It is not only traffic attempting to turn right from Hampsted that is problematic. There are times when traffic wanting to travel from Muller Road to Regency Road will actually block the movement of traffic on Hampsted by attempting to 'beat' the lights and move in the current phase rather than needing to wait for another cycle. In short this suggests that these two intersections should be treated as if they are a singular intersection. Although the authors are not privy to the configuration of these two intersections, one would expect that is how they are being treated now; however, what is the impact on intersections away from these two?

Naturally, this is not a critique of the configuration of these intersections; the configuration *raison d'être* is arbitrary, however what we are interested in, is, assuming that the geometry of the intersection is *sacrosanct*, how does locality-scope help with the management of this intersection?

Once each intersection and vehicle (microsimulation now, all vehicles in the future) within the network has been converted into a '*network object'*, then the movement of each vehicle can be tracked, and each traffic signal can be informed of the number and speed of each object heading towards it. Naturally, even without each vehicle being tracked, one can identify the movement of vehicles by counting them at each signalised intersection. By knowing this information, movement histories can be established and areas of 'interest', historical 'hot spots' and other phenomena can be identified, analysed and optimised.

This allows the scope sub-system to form the strategic optimisations of a network, and intersections such as the one described above can have tactical optimisation applied that ensures that the two major thoroughfares, being Hampsted North-South and Muller/Regency are as free flowing as is possible. This can only occur because that particular group intersection will know and 'understand' the loads that are to be placed on it, the time frame it will occur in, and on which particular day(s). This is significantly different to what happens now, where such optimisation is only linear in nature, and the loads of all neighbouring (signalised in this case) intersections can not be taken directly into account. Furthermore, many of the users of SCATS at the moment either discard the historical data collected, or use parts of it for off-line analysis. This means that the system itself is unable (as a general rule) to use this data for long term analysis within its operation. Here the difference with relation to locality-scope is that locality-scope views historical data is an important thing to collect and manage within the traffic management system directly. Although there are millions of raw data records collected (approximately 49 million VS, and 65 million SM records in 1 region of the Adelaide City Council SCATS implementation, collected over a 2 year period(Vogiatzis, 2004)) and the time to processes that number of records would be significant, the decisions performed on the system would be done so using *refined* information; not *raw* data. This ensures that the minimum number of records is used in the decision making process and therefore improving the performance of the network.

Locality-scope identifies a number of things within a transport network such as 1) Movement patterns of vehicles; 2) Time-flows; and 3) Traffic 'hot spots' such as congestion points, accidents, and other incidents that directly affect the flow of traffic; within a distributed computer network environment. It does this by building a 'profile' of each intersection, and group of intersections within the network; this profile then allows a well-formed *bias* to be applied to the decision making process associated with the locality in question.

Conclusions

By constructing a network of database systems at each local intersection or group of intersections, it is possible to combine local decision making processes with global decision making processes.

Local controllers would form *localities* whose prime interest is the direct management of the movement of vehicles between intersections and regions, and *scope* is an over-arching architecture that manages knowledge within the network.

Improvements with the unit movement of vehicles between intersections and within the network as a whole are made by utilising live/on-line historical data turned into value added information and knowledge through the knowledge generation process. Knowledge is then available to all localities for us within localised intersection optimisation.

It is possible to build intersection/location profiles through the use of historical/statistical data and knowledge that allow localities to identify the most important criteria in congestion management for their locality. Furthermore, data on emissions and noise pollution along with *political* inputs such as land-use policies and regional resources are all **important** data sources to assist with traffic management and they are directly usable within locality-scope implementation.

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