

THE CSIR NYENDAWEB

Embedded measuring instrument of the CSIR ITS Lab® Collaboratory

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ABSTRACT

The improved access to transport and traffic data by researchers will greatly benefit general Research & Development (R&D) in the fields of road traffic and safety engineering, and traffic management. Obtaining historic data for transport and traffic related research work is generally found to be cumbersome and frustrating. Commensurate validity and verification concerns as well as incoherencies and uncertainties vested in available transport/traffic data, inevitably add to the complexity of analyses and the level of innovative contextualisation required to apply said towards inferences intended to guide transport/traffic management policy- and decision-making.

Amidst government's imperative of accessible information, in this era where many transport and traffic related transactions are digitised in some way, and arguably where digitised data do indeed exist in large quantities, it remains fait accompli that it is very difficult and time-consuming if not impossible to source validated, verified data for not only purposes of R&D but also for the intelligence required for transport or generally built environment policy-making, operation and management.

Against this backdrop, CSIR Built Environment has launched a flagship project, NyendaWeb (see <http://www.nyendaweb.co.za>), based on the "sensor network" concept. NyendaWeb's underpinning theme is the promotion of Intelligent Transport Systems (ITS) in transport. Fundamental to ITS is the intelligent application of data and NyendaWeb is envisaged to enhance efforts to integrate conventional transport/traffic and other relevant data sources, to unlock data sources that are currently not accessible, and create new sources of data by developing new "sensors" that will appreciably add to improved characterisation of the built environment (including transport/traffic). NyendaWeb's key objectives are: a) to dramatically enhance open access to an enriched built environment data paradigm, b) to develop the technology that will contribute to the expansion of the NyendaWeb infrastructure, and c) to contribute towards the development of the science (e.g. data fusion, emergent behaviour, artificial intelligence, etc. including measurement methodologies) to transform masses of data from a plethora of sensors and databases into intelligence in support of policy-making, operations and management in the built environment and specifically the transport/traffic realms.

The paper describes the NyendaWeb technical development concept, the role of NyendaWeb within the ITS Lab Collaboratory® as an international ITS R&D platform, and how the inherent, unobtrusive and 24/7 measurement functionality of NyendaWeb is envisaged to contribute to raising the awareness and interest in the importance of measuring and evaluation in order to continuously improve infrastructure and services delivery with optimal application of resources and to informing transport-greening and energy sufficiency programmes.

1 INTRODUCTION

In April 2007 CSIR Built Environment launched an ambitious research platform development programme, the ITS Lab Collaboratory (ITS Lab), aimed at boosting research and development (R&D), inclusive of human capital development elements, in the field of intelligent transport systems (ITS). The programme is spearheaded by a project named "NyendaWeb: Developing Intelligent Systems for a High Performance Transport Network". NyendaWeb is developed as the main instrument of the ITS Lab to create a virtual ubiquitously-sensed built environment, with an initial focus on transport. NyendaWeb is envisaged as an open, universally accessible data collation and integration resource to facilitate more intensive R&D on ITS, traffic/transport engineering and traffic management, which includes road safety and other environmental aspects.

The need for a NyendaWeb development initiative stems from a number of needs:

- the need for improved access to transport- and traffic-related data, particularly for research and development purposes, but also for transport planning, and traffic operations and management;
- the need for greater integration of data with specific reference to data across-cutting functional lines, e.g. housing, health, education, etc.;
- the need to better utilise the vast amounts of data that is becoming available as a result of the ICT driven economies and processes;
- the need to unlock in-process generated data that could become useful information if appropriately processed and integrated, e.g. fleet management, cellphone data, etc.;

- the need to design work flow processes for the specific purpose of automating data capturing for monitoring and evaluation.

The envisaged NyendaWeb project impacts include:

- a platform for advanced transport, traffic and safety engineering, and traffic management research and development;
- greater awareness, insight and collaboration of transport users of the economic, social and environmental drivers in mobility provision;
- cost and time savings through more efficient road traffic operations;
- promotion of seamless connections among all transport modes;
- lower freight logistics costs;
- the management of mobility demand and supply through appropriate technical and policy measures that complement optimal capacity utilisation of the road network and transport ;
- the availability of real-time traffic and road data in an integrated information infrastructure to assist traffic management and improve transport network management, with due consideration to economic, social and environmental impacts;
- intrinsic performance measurement to evaluate the impact of policy and intervention implementation as well as holistic transport efficiency benchmarking, analysis and evaluation;
- greater transparency of traffic management functions and transport systems performance impacts;
- virtual transport/traffic policy and intervention evaluation and accreditation;
- bandwidth efficient technologies to collect and collate transport data for optimal intelligence dedicated to inform policy-making, managing and operating transport facilities, etc.

2 NYENDAWEB RATIONALE AND OBJECTIVES

“Nyenda” is a Venda (an indigenous Southern African language) word that can be associated with the mobility concept. NyendaWeb is a derivative of the Sensor Web. A sensor network is a computer accessible network of many, spatially distributed devices using sensors to monitor conditions at different locations, such as temperature, sound, vibration, pressure, motion or pollutants. A Sensor Web refers to web accessible sensor networks and archived sensor data that can be discovered and accessed using standard protocols and interfaces (or application program interfaces).

In an Open Geospatial Consortium Inc. (OGC) initiative called Sensor Web Enablement (SWE), members of the OGC are building frameworks of open standards for exploiting Web-connected sensors and sensor systems of all types: flood gauges, air pollution monitors, stress gauges on bridges, mobile heart monitors, webcams, satellite-borne earth imaging devices and countless others (see <http://www.opengeospatial.org/legal>).

SWE presents many opportunities for adding a real-time sensor dimension to the Internet and the Web. This has extraordinary significance for science, environmental monitoring, transportation management, public safety, facility security, disaster management, utilities' SCADA operations, industrial controls, facilities management and many other domains of activity. The OGC voluntary consensus standards setting process, coupled with strong international industry and government support in domains that depend on sensors, will result in SWE specifications that will quickly become established in all application areas where such standards are of use.

Within the SWE initiative, the enabling of such sensor webs and networks is being pursued through the establishment of several encodings for describing sensors and sensor observations, and through several standard interface definitions for web services. The SWE development path is almost evolutionary of nature with vaguely defined objectives and timeframes. As such the progressive development is largely dependent on global consensus achievements through the efforts of the OGC and other collaborators. The NyendaWeb Project is intended to harness the SWE processes but such that it could aid in pushing technological development forward by delivering Sensor Web-type applications in a much shorter timeframe. NyendaWeb embraces transport technology foresight with the establishment of a technologically advanced research platform that will achieve optimal relevancy in transport and traffic engineering and management in 3 to 5 years' time. The current CSIR research agenda is thus driven by an interim deliverables range that will serve as building blocks for various technological platforms or applications with the potential to deliver short term impacts.

In this regard the Science, Engineering and Technology (SET) development focus of the respective Research Area (RA) of the CSIR Built Environment and some of the pertinent issues or needs that emerged from previous research were:

- improved intelligence for impact assessment and operational efficiency,

- informed decision-making based on the above improve intelligence,
- human capital development, and
- the development of science to deal with Information and Communications Technology (ICT) driven transport systems and associated economies.

These issues/needs culminated in the mission of the RA, i.e. to affirm the importance and relevance of scientific traffic engineering and traffic management research, engineering and technology through the creation of relevant research platforms and the development and/or application of advanced ICT-based technologies for more sophisticated transport management. Three thematic components have been identified to describe the approach to scientific research, namely:

1. Developing and/or unlocking of multi-disciplinary transport relevant detectors/ sensors/databases – i.e. sensing transport infrastructure;
2. Development of an ICT-based open source platform for collaborative, coherent, consistent and consolidated data collection, collation, fusion and distribution systems – i.e. systems' intelligence, and
3. The application of the platform for the multi-mode, multidisciplinary characterisation of transport and peripheral systems' performance for purposes of mobility (including social aspects) optimisation, impact assessment, traffic engineering science, analysis and informed decision making – i.e. context sensitive mobility.

3 RATIONALE FOR THE 'SET' FOCUS

The road transport environment is synonymous with many pertinent problems that relate to lawlessness, crime (specifically associated with vehicles as object and instrument of crime), facility operations, operations management to service current demands for transport, and to plan and implement upgraded and new facilities, including concomitant budgets and finance schemes to provide for the future. In this context the importance of having the relevant accurate, appropriately formatted and timely data and information to effectively and efficiently manage the road transport environment is obvious.

The collection of transport and traffic data, however, requires a significant and dedicated effort from all tiers of transport infrastructure managers to deliver the value proportionate to the cost of the monitoring and data collation exercises. For various reasons, this is currently not done coherently, if at all, or not at intensity, accuracy and coverage levels to produce consistent, persistent, reliable and relevant information to be of value for operational, tactical or strategic transport applications, purposes, and policy and decision-making. Other limitations of current efforts to collect transport and traffic data is that the focus is on covering the main road networks and obviously the lower order roads and other public accessible areas and amenities are seldom monitored if not only for specific project purposes.

Arguably, great potential benefit could be derived by improved integration and accessibility to transport-relevant data. The proposition for NyendaWeb lies in, apart from data collected in traditional ways, capturing and integrating systemically generated transport data, specifically including data which are not reliant on the specific efforts or budgets of transport infrastructure managers, through a neutral and integrative platform with appropriate public access and exposure to value-addition. There are numerous conventional sources of systemic transport data and also some emerging ones associated with technological advancements. Conventional sources are the traffic data loggers and a variety of other routine and non-routine traffic counts, including those that are typically done manually, by local and provincial authorities, toll transactions, weigh bridge transactions and logs, vehicle tracking information, goods tracking, train/bus ticketing transactions, the current accident databases, etc. Emerging sources are camera surveillance, electronic vehicle identification or automated number plate recognition, cell phones, transport transactions, GPS-based loggers, etc. By integrating all these sources with the suitable data collation, merging, verification and validation mechanisms and technologies, virtually ubiquitous sensing of transport users and vehicles in near real time over the transport networks can be created and which will generate information for operations and planning on both ends of the demand and supply chain. The premise is that this can be achieved with minimal capital commitment.

4 TECHNOLOGY

To achieve the objectives of the NyendaWeb appropriate software and hardware technologies have to be integrated. This integration will make it possible for the NyendaWeb to provide necessary and relevant data needed for:

- Enhanced traffic management through monitoring and providing information on the state of the road network traffic flow and other performance measures. With the information extracted from the road network, traffic delay and congestion can be reduced if not totally avoided.
- Improved road safety
- Optimisation of available road capacity.

Three functions of the technology aspect of the system model of the NyendaWeb are to ensure reliable data acquisition, efficient data transportation and accurate data presentation. Figure 1 shows a diagram of how these functions are achieved with available technology.

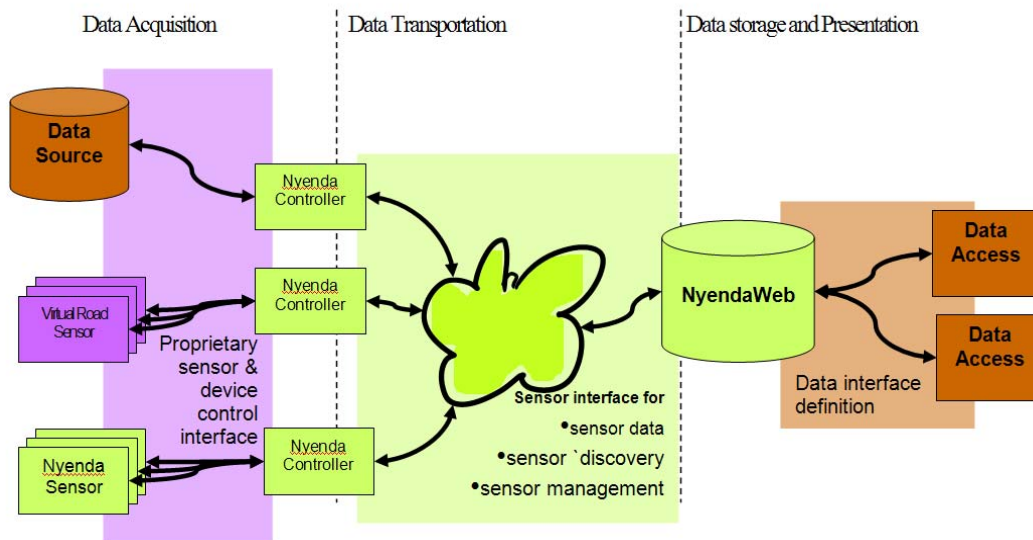


Figure 1: The NyendaWeb Architecture

4.1 Data acquisition

Data acquisition involves obtaining the data of interest, which includes environmental gas emission levels, real time video of traffic, and other conventional road traffic information. Data from other sensors are also acquired.

Sensors are devices that can enable the acquiring of these types of data from the road transport networks. A sensor is able to produce an output, which is a measure of the quality or quantity of the physical measurement it has been designed to detect. NyendaWeb aims to provide a view of the real-world as seen by a set of fixed and roaming sensors. The sensors report their data in both real time and in a store-and-forward manner.

In the design and implementation of the NyendaWeb, some of the applicable sensors are:

Smart sensor

The Smart Sensor observes the attributes of traffic flowing longitudinal to its observation axes. It can thus track vehicles over the short distance in its observation field. Although its purpose is to improve the micro-control potential of traffic signal control at intersections, yet if combined with video, it is a powerful tool which can observe road user behaviour such as lane discipline.

The Smart Sensor will provide the opportunity to explore the wireless communication challenge and to combine the data from one device with complimentary data from another, in this instance, video data.

Wavetronix radar sensor

The Wavetronix sensor observes the attributes of traffic flowing perpendicular to its observation axes. The device is a new age traffic sensor that is not currently a general technology of choice. The Wavetronix radar sensor communicates wirelessly with sensors so that traffic data can be transmitted to the Nyenda SOS server in the ITS Lab.

Two problems that will be solved in this research project are the development of generic protocols for the various field devices and populating the NyendaWeb SOS database.

GPS referenced imagery

This consists of a Digital Video Recorder (DVR), which can connect to a variety of different vehicle-based sensors such as the GPS, accelerometer, cameras etc. A DVR has been procured for an ongoing project (the Moloto project) to serve as a tool that will assist in the road safety assessment exercise and also explore the potential to automate the RSA-procedure using the NyendaWeb technology. However, a challenge that was faced was the initiation of the development of such technology and the first step that has been taken was to determine what intelligence can be extracted from the DVR and attached sensor.

The DVR was installed in a private vehicle which was driven around for some period and about two weeks' data was collected. The DVR was connected to a GPS and three cameras. Two of the cameras observed the front view of the

¹driver and the third camera was a covert type camera focussed on the driver. Now, the challenge is to develop the technology to automate the analysis of the generated data. The technology should be able to identify roadside features such as road traffic signs, etc., incidents and other events, and associate these with a driver's reaction to it.

The DPSS is currently analysing a first block of data to determine its usefulness for driver behaviour studies. Another outcome of their analysis will be whether the quality of the imagery is suitable for advanced image processing and whether the necessary quality could be achieved with different cameras and/or different photo-optical parameter settings.

The intent is now to install this equipment to an accelerometer added in vehicles, buses and taxis, operating on the Moloto Road and to then evaluate public transport driver behaviour.

Digital doorway

A Digital Doorway unit has been ordered from Meraka Institute as part of the NyendaWeb project. This device will be installed in a township in Johannesburg, probably Orange Farm, which will provide the opportunity to wirelessly link with it through NyendaWeb and develop applications that can serve the purpose of a "community road safety sensor". The challenge will be to get the community in the township to communicate with the Council through the Councillor, so that a process of getting feedback information about the status of their road safety concerns and complaints and possible progress with implementation to them can be established.

Road safety human sensor

Also, part of the Johannesburg Community Ward Road Safety Project is to start connecting people with GPS-enabled cell phones to add to the NyendaWeb SOS road safety data component. This should go hand-in-hand with efforts to participate more actively in programmes to improve road safety in the various communities. It is intended to initiate this application with the appointment of a temporary road safety steward in each Johannesburg ward and to equip this person with a suitable device, e.g. GPS-enabled cell phone that can upload photographs and other pre-selectable text to describe road safety problems to the NyendaWeb SOS.

Weather Sensors

These are sensors that can provide information about current and future weather conditions. Some of these types of sensors are already in use by operating weather stations. Since current weather information is linked to the road safety parameters, one of the contributions of the NyendaWeb technology is make real time information from these sensors available. The information (data) can be used to determine the impact of weather on road conditions. The data will also be input into the RoadUseViewer to determine maximum road capacity.

Gas sensors

Gas sensors are used to monitor the environment to detect real time changes in air quality. A number of gas sensors have been procured for Project AQUILA. These sensors are now to be deployed in the field and "connected" with the NyendaWeb SOS.

Other Sensors

Other sensors include, electromagnetic sensors for detecting vehicle and freight movements, Infra-red and heating sensors for detecting pedestrian and vehicle movement, wireless thermocouple sensors for early detection of tyre and break failure on heavy vehicles⁽¹⁾. In addition information may also be collected from the CCTV cameras, Automatic vehicle location sensors, and License-plate readers.

4.2 Data transportation

Data transportation is the movement of all the relevant data from available sensors to the NyendaWeb. The sensors available to the NyendaWeb are connected to a set of distributed databases that are networked together. Through this connection, an easy extraction of all sensors' data is made possible.

In the development of the NyendaWeb, available communication infrastructure would be utilized for data transportation. These communication infrastructures, which may be wired or wireless include fibre optic backbone, existing data networks, Copper wire-line, cellular networks, WiMax, bluetooth and sensor networks.

As shown in Figure 1, the communication infrastructure serves as the interface between the Nyenda Controller and the NyendaWeb. The Nyenda Controller is a sensor controller which is also the entry point for all data gathered by the sensors. It is capable of controlling the sensors and collating all the data from available sensors and other connected databases. All the relevant data which are collated are transported to the NyendaWeb through an available and most feasible communication infrastructure.

The recent advances in communication technologies most especially wireless and sensor technologies have rapidly promoted the seamless integration and transportation of information of various types. Since the NyendaWeb aims to

⁽¹⁾Kobus Labuschagne, CSIR Built Environment Flagship project, NyendaWeb:ITS for improved traffic management,, March 2007.

provide some real-time data such as video, efficient means of transporting and ensuring the quality of these data in a seamless manner will be utilized.

Also, in order to optimize the communication network resources that will be made available through the NyendaWeb project, it is envisioned that inter-vehicle and infrastructure-to-vehicle communications may become technically practical in the near future. The result of this would be an operational, ubiquitous and pervasive “internet on the road” for road-users while they travel through the road network. This concept is termed the NyendaCybernet.

4.3 Data presentation and storage

Data presentation is the displaying of the data that has been acquired from the sensors and other connected databases in a useful format that can be accessed easily. All data are recorded in a format that ensures accuracy. In addition, the type of data with the position or location where the data was received is recorded. This information (data) is made available in a filtered manner for researchers and consultants. In order to ensure accurate presentation and storage of the data, appropriate data fusion, data mining and data ware-housing techniques would be used.

In Figure 1, the data access block can be broken down into what is shown in Figure 2 below. The building blocks of the Data Access section are the NyendaView, the NyendaRoad and the NyendaBEe.

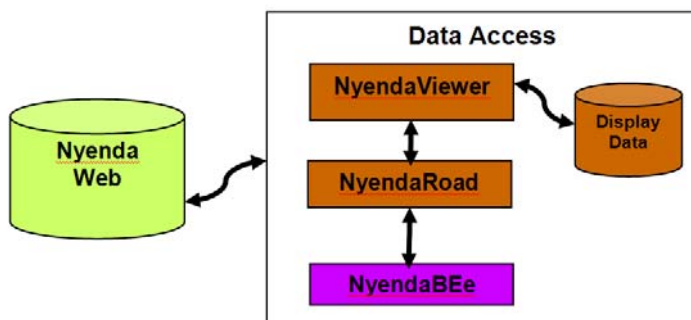


Figure 2: Data access building blocks

NyendaView:

The data collected is viewed using the NyendaView. The NyendaView has the capability of mapping and visualizing the NyendaWeb data. It is a collection of data mining and viewing engines (viewers) which are linked together by the NyendaRoad.

NyendaRoad:

The NyendaRoad is a virtual road map that is made up of road links. The NyendaRoad framework will be defined with a selected real-world road structure inserted in the framework to allow the rest of the Nyenda services to operate.

NyendaBEe:

NyendaBEe is a “road-use” emulator based on swarm theory. It is a generic framework that creates a virtual built environment and runs on multiple servers with several agents doing the real work on independent networked computers known as a computer farm. These agents can be more or less intelligent and they represent various types of transportation objects such as student driver, commuter, policeman, signboard, dirt roads.

The NyendaBEe is used to introduce emulated data into this set for scenario evaluation for sensor and system testing. In this way, it serves as a tool which provides the opportunity for new applied research by assisting in the measurement of impact that technology can have on current road environment and its effect on road traffic. It provides a huge platform for educational projects and research

From Figure 2, the viewers fuse the information received from the NyendaWeb on the virtual road created by the NyendaRoad and then display it in real time. Also, the RoadUse Viewer and NyendaBEe Viewer may have data which are to overlay on the NyendaWeb data. The NyendaView will link to a Geographical Information System (GIS) that will allow the NyendaWeb to have some geographical environmental interactions.

5 NYENDAWEB OUTCOMES AND IMPLEMENTATION

5.1 Research and development focus

The NyendaWeb project is a cutting-edge development that will take 2 to 3 years to achieve demonstrable functionality with current levels of expertise and capacity. But NyendaWeb is also part of the ITS Lab intended to serve as an

international platform for collaborative research and development as well as capacity building in ITS and Traffic Management – of which such skills are in dire shortage. The platform is intended to ultimately provide the means to give exposure to aspiring students (starting at the Grade 10 level) to science, engineering and technology in the fields of transport/traffic engineering, traffic management, electronic engineering and ITS. Undergraduates and graduates are already being recruited to engage in the research and development work to expand the NyendaWeb sensor network or to develop the science and technology aspects of the ITS Lab. Through this, it is believed, the CSIR can make an important contribution to local skills development and the grooming of high level researchers, scientists, engineers and technologists.

5.2 The CSIR ITS Lab@ Collaboratory

The NyendaWeb infrastructure development commensurate with the delivery of the short term transport and traffic project outcomes will contribute significantly to the achievement of these interim results and to the building of the ITS Lab. NyendaWeb is also a part of a broader Nyenda Programme conceptualised to ultimately deliver a world-class tool to support advanced transport R&D internationally.

The Nyenda Programme of the ITS Lab platform is envisioned to be composed of the following three main areas of development, which are also depicted in Figure1 below:

1. NyendaWeb is the transport data capturing and storage system for real time and post processed data. It discovers transport and other relevant sensors and instructs such sensors on the required data delivery and transport data processing.
2. NyendaView is the demonstrator system with the capability of mapping and visualisation of the NyendaWeb data and could include the linking the NyendaBEe (Nyenda Built Environment Emulator) virtual infrastructure, which is the third pillar below, for demonstration emulations, projections, impacts, emergent behaviours, etc. NyendaView as the visualiser / virtualiser / demonstrator will map transport objects from NyendaBEe and thus providing unique tools to combine near-real time data (e.g. with data fusion techniques) with emulated data for various transport/traffic- and other built environment studies (e.g. intervention and scenario testing). NyendaView will also link to a GIS that will allow for geographic environmental interaction.
3. NyendaBEe is the emulator which is a powerful built environment virtualisation system utilising the mass data of the NyendaWeb and, based on amongst other swarm theory where many independent agents, emulate built environment objects operating on a virtual built environment infrastructure. The essence of NyendaBEe is that it consists of a generic framework creating the virtual built environment and running on multiple servers with a whole complexity of agents doing the real work on independent networked computers, called a computer farm. This computer farm can be highly distributed allowing near real-time collaboration between various collaborating institutes.

5.3 Nyenda developmental methodology

NyendaWeb (www.nyendaweb.co.za) is an open platform that will ultimately allow all owners of transport- and traffic-relevant data, to voluntarily plug-in their sensors and/or databases to create a synergistic environment that will improve the quality of information to all levels of potential users, road authorities, businesses, transport operators, etc. NyendaWeb will also be configured to protect users from unauthorised access to their proprietary information. The following are some of the important aspects of the development approach:

1. Sensor networks with a large number of diverse sensors interconnected via a low data-rate communication network have the potential to make a huge impact on many areas. The area of sensing technologies and sensor networks is now considered by international funding agencies such as the European Commission, DARPA and NSF to be one of the top five emerging technologies that will shape the future of human kind.
2. The NyendaWeb research network will harness the great strengths of its highly qualified multi-disciplinary participants in a national co-operative effort which will:
 - a. Provide an urgently needed national focus and identity for research in the rapidly emerging and highly significant area of sensor networks;
 - b. Provide researchers with strong linkages and exchange opportunities with the major international sensor networks research efforts in the USA and Europe;
 - c. Link industry with world class research programs covering all the critical facets of the highly multi-disciplinary sensor network science and technology base;
 - d. Significantly enhance the relevance and quality of postgraduate training in the broad area of sensor networks;
 - e. Provide a framework for guiding and supporting young researchers in the area of sensor networks;
 - f. Build a national collaborative framework to grow and support the essential industry/research co-operation needed to fully exploit advances in sensor network science and technology to address major national social challenges in the areas of mobility, health, environment and security. The scientific challenges which must be overcome in order to realise the enormous potential of sensor networks are substantial and multidisciplinary in nature. The NyendaWeb research network will provide an exciting environment for effective collaboration amongst a multi-disciplinary team of world class researchers

with outstandingly successful existing research programs covering all the core disciplines required for the successful development and exploitation of sensor networks. These disciplines include bio- and nano-sensor science and manufacture, large scale system optimisation, data and information processing, wireless networks and computer communications, electronics and mechatronics.

- g. NyendaWeb strategies are driven by a vision to create the collaborative research foundations which support a world leading sensor networks industry. The NyendaWeb vision will be realised through six strategic priorities:
- i. National collaboration and identity - to build a fertile and effective national collaborative environment for undertaking innovative multi-disciplinary research in sensor networks and to create a strong sensor networks research identity with a focus on the interrelationships of transport, mobility and urban dynamics and deriving value-adding intelligence from the sensing infrastructure.
 - ii. Industry linkage - to work with international sensor network researchers and relevant industry sectors to explore opportunities for the application of sensor network technology and transport, mobility and urban dynamics intelligence.
 - iii. International linkages - to create opportunities and an environment for linking sensor network researchers with the premier mobility sensor networks research groups around the world.
 - iv. Education and capacity building - to actively pursue the expansion of sensor networks related postgraduate student research opportunities in Universities and raise the public awareness of the emerging sensor networks science and explore undergraduate and secondary school educational opportunities.
 - v. Sustainable research funding - to build co-operative multi-disciplinary research teams and industry linkages that will generate a future stream of collaborative multidisciplinary research activities including new multi-disciplinary proposals for research funding.
 - vi. Early practical applications - to pursue early applications of the NyendaWeb platform serving as demonstrators of the sensor web functionality and the NyendaWeb mobility intelligence.

Through these 6 strategic priorities NyendaWeb intends to lay the foundations for a major national collaborative effort to solve the key underlying scientific problems facing sensor networks and provide industry with significant opportunities to exploit and apply sensor network technology in the socially and commercially important areas of mobility, security, health care, the environment and other technological and social issues.

5.4 Current interest

The ITS Lab concept has already mobilise significant local and international support from Tertiary Education Institutes, the ITS industry, road authorities and international research institutions like the TNO and INRETS. Collaboration with the University of Muenster (Germany) and TU Delft (Netherlands) have already been established and will be broadened over the next year of the NyendaWeb Project. The CSIR already supports two PhD studentships in this field – one in collaboration with the University of Pretoria, and the other with the University of Stellenbosch. Both these respective theses are aligned with the ITS Lab objectives and serve to solidify the collaboration of the CSIR with the respective universities.

6 NYENDAWEB DEVELOPMENT PROGRAMME

The basic components of NyendaWeb, i.e. the Sensor Observation Service database, the Web interface to extract the data form the SOS database and the presentation tool had already been developed to a functional level. The development of the NyendaWeb under the “flagship” banner concentrates on the technological infrastructure to link-up various sensors with the aim to support current real world applications as soon as possible. It is a pragmatic approach to focus development on the NyendaWeb sensor network where its functionality can be of direct benefit to specific communities on a project-by-project basis.

Currently there are already three such projects that will benefit from the NyendaWeb programme. The NyendaWeb infrastructure will be developed as a continuum over a period of 3 to 5 years and various demonstrators will emphasise the progressive technological development milestones. In parallel research projects are to be defined to support the NyendaWeb technological development but also to research transport issues for which the research methodology can already be supported by the NyendaWeb infrastructure. These research activities will produce the results to assist the NyendaWeb technology development, the expansion of the transport science horizons with the aid of NyendaWeb and then also start producing knowledge to inform contemporary transport operational and management issues and processes.

7 CONCLUSIONS

The NyendaWeb, as a key tool of the ITS Lab® Collaboratory, has as objective the development of traffic management systems, including hardware, sensors, software systems and data management systems. The research will focus on

sensor networks that provide significant potential to acquire data, link numerous varying transport and other contextual data sources, and to provide broad-based open access for researchers and transport users to such data. As another important objective, NyendaWeb will be configured to sufficiently perform as an extensive monitoring and sensing system that provides timely, comprehensive and continuous real-time data.

The ITS Lab research approach can be summarised in four tenets:

- developing a NyendaWeb as an Open Source platform for connecting transport and related sensors. There is a specific need for the use of efficient data-streaming technologies, real-time data acquisition systems, wireless and mobile communication technologies, data warehousing and advanced data analysis including statistical analysis;
- developing innovative sensors to support the expansion of the NyendaWeb. This research will build capacity in understanding and developing the interface requirements to provide connectivity to a wide spectrum of sensors;
- utilising the real-time empirical data streams of NyendaWeb for research on the improvement of transport infrastructure management and design and operation practices, as well as to provide credible real-time traffic information to transport users.
- promoting human capital development in the ITS and associated engineering and management fields through well structured and institutionalised mentoring and training programmes in collaboration with internationally acclaimed tutors and mentors.