A multi-agent based system to promote collaboration among Namibian transport stakeholders in order to reduce empty runs

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Declaration

I declare that the dissertation entitled **A Multi-Agent Based System To Promote Collaboration Among Namibian Transport Stakeholders In Order To Reduce Empty Runs** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references. I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.

15 November 2014

Mr Logan Fransman | Date

Acknowledgements

Starting to write this part of the research, made me wonder why it would be the first section that potential readers will cast their eyes on. The thought of the reader being deterred from reading the rest and real output of this research, does not help ease the pressure. Nevertheless, it would have been impossible to complete this masters dissertation without the support of certain individuals.

Before a I mention a few, I cannot forget to give thanks to the all mighty Lord, my saviour that has by his grace found favour in me, to grant me with life, and who I believe in my heart gave me the strength to complete this research.

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Abstract

The main aim of transport stakeholders has always been to transport freight efficiently, as this efficiency contributes to the growth and success of their business. A country like Namibia is no different as the efficiency of transport lies in the effective utilisation of carrier capacity in any direction. Due to the various types of freight, transport operators rarely have the capacity to cover all freight movement requests. This research put the empty runs experienced by most of the Namibian transporters at 33%. Empty runs could however be reduced through collaboration and sharing of capacity among transport stakeholders.

Multi-agent systems (MAS) are various individual computer agents that are configured independently to interact with other agents to achieve one goal. These systems have been explored as an approach to achieve collaboration among transporter stakeholders. Taking into consideration the characteristics and requirements of MAS, this research was able to conduct a feasibility of its implementation within Namibia. Concluding with an evaluation of available Multi-agent based systems that could achieve collaboration and reduce empty runs in the Namibian transport environment.

Key Terms:

Multi-agent systems, agent software, freight movement, transport, transportation planning, transport collaboration, empty-running, collaboration, Integration, transport capacity, information sharing, partnerships, developing countries, Namibia

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1 Introduction & Problem Statement

1.1 Motivation

An "empty run" in transport as explained by McKinnon and Ge (2006) is freight movement that is one-directional and that leaves a carrier to run without any load on one of the legs of a route. Transport stakeholders (TS)[1] are continuously challenged as they should always try to find freight for the "empty run" leg. This is because the utilisation of the transport capacity in all directions determines the efficiency of any stakeholder (McKinnon and Ge 2006). The continuous push for efficiency becomes a strenuous daily task for TS. The search and establishment of freight on any journey contributes to the success of any TS operation. Often when freight is not located on the planned return journey, carriers are re-routed to avoid an empty run with the expense of extra mileage (McKinnon and Ge 2006). Empty running within Namibia has been estimated at around 50%, as indicated by Namibian transporters (Savage, Jenkins and Fransman 2012) even though since 2007 all Namibian transport corridors have shown increases in volumes (World Bank, 2012). This percentage of empty running does not bode well for other factors such as cost, road infrastructure, carbon emissions, fuel consumption and truck maintenance. The exploration for possible solutions beckons, and a multi-agent based approach could be one.

Multi-agent systems (MAS) are basically various single computer systems interacting with each other where they are configured to represent and carry out tasks on behalf of users independently (Wooldridge and Jennings 1995). The aim of these agents is to work autonomously with limited abilities, but be able to react to global behaviours (Buhler and Vidal 2002). The use of MAS has been augmented over the past decade, and improvements to achieve intelligent and useful transport systems have been achieved worldwide (Dullaert et al., 2009, Robu et al., 2011, Serna, Uran and Uribe 2011). These MAS have mechanisms that respond to the environmental activities sensed from transport stakeholders and have consequently achieved success as transport management systems (TMS) (Robu et al., 2011). The words "autonomous, proactive, reactive and social" have been associated with multi-agent software (Kwon, Im and Lee 2001). These give the agents their intelligent nature and

[1]Transport stakeholders are defined as any organization that owns, contracts or manages transport i.e. freight brokers, transporters, logistics service providers, and users.

are ultimately the success to an MAS. The intelligent agents can be configured with policies and strategies beforehand to resolve queries that are the best possible fit for all parties, providing that some consensus dynamics are included in the MAS environment (Kwon, Im and Lee 2001, Robu et al., 2011, Olfati-Saber and Murray 2004). The intelligent responses from these agents have developed to a stage where a system associated with the agents allows specific queries to be managed locally (Robu et al., 2011, Moonen, 2009).

MAS have been seen by some as the key to aiding future collaboration among transport and logistics partners (Robu et al., 2011, Moonen, 2009, Kwon, Im and Lee 2001, Weiss, 1999, Dullaert et al., 2009). Advances in agent mechanisms to model various behaviours still continue as most fully-fledged transport collaboration implementations are still in the prototype or testing phases (Moonen, 2009). Collaboration is defined as the act of working with someone or an organisation to create or produce something (- Oxford Dictionaries, a). Collaboration among transporters is not a new phenomenon especially in European based companies (Klaus, 2003, Beevor, 2013, Cao and Zhang 2011, Graham, 2011). Examples of small transport companies collaborating and operating as one major transport company, show it has been common practice in the last 10 years in Europe (Klaus, 2003, Beevor, 2013). There are various types of carriers on Namibian roads that are either owned or contracted by users, forwarders or other stakeholders that wish to collaborate. However, the lack of or limited information sharing of freight or vehicle movement on particular routes reduces the prospect for collaboration and the so likelihood of an empty run increases. This study has explored Multi-agent systems that could reduce this limitation and promote collaboration to ultimately reduce the number of empty runs.

1.2 Problem Statement

Multi-agent based systems have aided the collaboration among organisations, and they have been tested and found to work among some carrier types. In Namibia collaboration is lacking among transport stakeholders, and although the effects of this has yet to be publicly felt or seen, various stakeholders have indicated that it is a problem (Savage, Jenkins and Fransman 2012). Empty running occurs when individuals do not have a return load. The longer the haul, the more economically critical it becomes to find a return load (McKinnon et al., 2010). The exploration of methods to reduce empty running becomes inevitable, with other countries showing that collaboration among stakeholders is one way of addressing this issue (Akintoye, McIntosh and Fitzgerald 2000, Cao and Zhang 2011, Daugherty et al., 2005). Collaboration among competitors may be a sensitive area but there is proof that collaboration does benefit businesses in general (Daugherty et al., 2005, Malone, 2001, Sigala, 2005). There are factors to take into account such as the issue of profit sharing which should be satisfactory to all collaborative partners (Ding, Guo and Liu 2010). The message which needs to be understood by all parties concerned is that the profit is shared, but the individual company still gains. One of the major factors affecting companies (especially Small to Medium Enterprises (SMEs)) in Namibia is the high cost of utilising the available technology infrastructure i.e. internet connectivity and computing power (April, 2005). Other factors are the lack of awareness, and the training and skills to operate in a collaborative environment (April, 2005, Arendt, 2009). There is a need to identify methods that could promote collaboration and aid in the reduction of the number of empty runs. A multi-agent based system needs to be explored as evidence shows this is one of the ways to address the issue.

1.3 Thesis Statement, Objectives and Research Questions

1.3.1 Research Questions and Objectives

Can a transport multi-agent based system be used to promote collaboration in order to reduce empty runs for Namibian transport stakeholders?

Table 1-1 Research sub-questions objectives and methodologies

	Sub question	Objective	Methodology	Chapter
1	What is the estimated percentage of empty runs experienced by transport stakeholders?	Identify and evaluate empty run percentages for various stakeholders within Namibia.	Literature review + Structured questionnaire	2, 5, 6
2	What is the current level of collaboration among transport stakeholders?	Explore current collaboration levels among Namibian transporters.	Literature review + Structured questionnaire + Observation	2, 5, 6
3	What methods of collaboration exist within the Namibian transport industry?	Investigate and evaluate methods used by Namibian transport stakeholders to promote collaboration.	Literature review + Structured questionnaire	2, 5, 6
4	What transportation information is necessary for collaboration?	Investigate information that is needed to promote collaboration among transporters.	Literature review + Questionnaire (distributed through online survey)	2, 5

5	What other methods promote collaboration among transporters?	Investigate and evaluate methods (including non-computerised) to promote collaboration among transport stakeholders	Literature review + Questionnaire (distributed through online survey)	2, 5
6	Why should multi-agent based systems be explored for a transport environment?	Evaluate various multi-agent based transport systems and its applicability to the transport environment.	Literature review + Questionnaire (distributed through online survey)	3, 7
7	What commercial or tested multi-agent based systems are available for transport stakeholders?	Evaluate various multi-agent systems available to base a framework of adoption to the Namibian transport environment on.	Literature review + Software study + empirical component (observation + evaluation)	3, 7, 8
8	Does the use of a multi-agent based system have the potential to reduce empty runs for transport stakeholders?	Evaluate the potential of reducing empty running through the use of multi-agent systems.	Analysis and discussion	3, 7, 8

1.4 Scope and Study Limitations

1.4.1 Scope of Study

The scope of this study falls within the field of an evaluation of the application of Multi-agent Systems to Enterprise Systems (ES) within the limits as specified in the limitations. The evaluation will deal with transportation information and the capabilities of the MAS within it. This scope requires a better understanding of the methods and systems in place to explore application prospects for MAS. Figure 1-1 shows the scope for the research.

There are three segments to this study: -

Firstly, by aiming to provide an overview of current collaboration practices and methods and the empty runs experienced with them

Secondly, to formulate an evaluation and analysis technique to determine the practices or methods that could allow for better collaboration.

And lastly, to propose multi-agent based software for transportation as a possible collaboration solution.

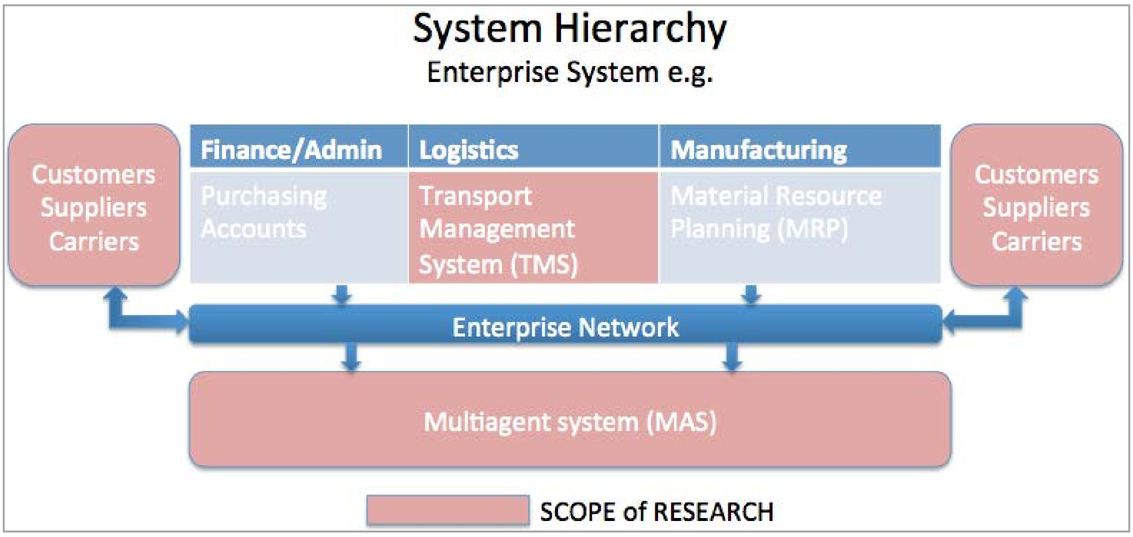


Figure 1-1 Scope of Research

1.4.2 Study Limitations

The focus has only been on the processes, practices, methods and systems pertaining to developing countries comparable to Namibia, with a few examples of developed countries. The evaluations of these have only related to transportation systems, collaboration and empty running. The evaluation of multi-agent based software has been of ones only suited for transportation and based on information received from the Enterprise Systems (ES). The evaluation of the application has dealt with the first level of connectivity to ES. This entails evaluating transport relevant data from the ES with no further adaptation or customisation done of the data.

1.4.3 Research Ethics

Scientific research inquiry where human participants are involved inevitably comes with ethical considerations. Ethics is defined as a system of moral correctness (-Oxford Dictionaries, b) that has to be adhered to when conducting research. Ethics have different facets in various areas of research and should be carefully considered (Sales and Folkman 2000). The ethics in this research pertain specifically to the confidentiality of the organisations involved, as it has gathered information on the systems and methods in use by different transport stakeholders. Having considered these issues this research has taken an advertising approach as suggested by (Miller, 2008) during the recruitment of transport stakeholder participants. The advertising approach involved an email sent to experts and stakeholders on the subject to ask for willingness to participate. It has been on the project overview and has emphasised the anonymity of information, as the research focus is on understanding and evaluating current systems and methods in general, in the Namibian transport environment. Confidentiality agreements have been signed when requested by the participants or organisations. Thus all data and information gathered through this project will be treated as highly confidential, and no identities will be revealed. In addition this research has applied and obtained an ethics clearance through the UNISA ethics committee available for review under appendix.

1.4.4 Environmental Impact

It is becoming increasingly important to consider the environmental impact of research. This is not only to make sure it makes sense financially and socially, but also to reduce the waste of any resources when undertaking research (Pencheon, 2011). This research has the main aim of reducing empty runs, and this should be beneficial to the environment. However there is no research that can be excused from environmental cost (Pencheon, 2011). This research has considered, as suggested by (Tsoulfas and Pappis 2005), Information Communication and Technology (ICT) equipment that are in use with relative longer life spans that would have the least impact on the environment when gathering, evaluating and producing results for the project. Any trial or testing of a system has been done with historical data, to eliminate the actual repetition of processes to gather information thus reducing the impact.

1.4.5 Dissertation Outline

The remainder of the dissertation outline includes the following chapters:

Chapter 2 Literature Review

Chapter 3 Multi-agent systems

Chapter 4 Research Design and Methodology

Chapter 5 Current Transport Collaboration Findings

Chapter 6 Feasibility of MAS in Namibia

Chapter 7 MAS to promote collaboration among transporters

Chapter 8 Conclusions and Recommendations

Chapter 9 References

2 Literature Review

2.1 Introduction

This chapter concentrates on literature pertaining to the transportation stance in the southern African region and Namibia. As the focus for this research is on promoting collaboration it required a look at collaboration stances of the industry and also a stakeholder viewpoint on empty running in the country. In addition to this to understand the pros and cons of collaboration among transporters the literature study also looks at transport operations and how integration and collaboration is anticipated on a daily basis. Collaboration as a key discussion in this section paves the way for the second focus of this research, namely Multi-agent systems (MAS). The chapter ends with a motivation to adopt MAS for transportation planning and collaboration.

2.1.1 Definitions of Key Terms

Empty run and Empty running: - An empty run is defined by McKinnon & Ge (2006) as the movement of freight that leaves a carrier without a load on one of the legs of a route. Another sees it as the deadhead kilometres experienced by a carrier (Mason, Lalwani and Boughton 2007). It is also seen as the economically unsustainable factor of transport operations when it becomes a regular occurrence (Moonen, 2009). Within this research it will be defined as when a carrier or transporter cannot avoid running without a load along a route. Empty running is the accumulation of empty runs experienced by an operator/carrier/stakeholder group usually represented in a numerical format.

Backloading -: Cherret et al. (2011) defines it as the use of delivery vehicles to handle returns with the aim of reducing empty running. Another view describes it as the inclusion of smaller freight carriers to handle an accumulation of loads that would normally cause empty runs (Mason, Lalwani and Boughton 2007). This research defines it as the identification of a transport operator’s route and using or sharing its capacity to load freight on their return journeys.

Siloism -: Is defined by Francis (1998) as the institutionalisation of functions by looking inward and upward at operations instead of outward to customer or partner requirements. This research will see it as the lack of interaction by an entity with others in close proximity, with a focus on internal functions only.

Integration -: It is the act of linking or combining business operations with other related areas to improve the overall output of the whole.

Collaboration -: Collaboration in business is defined as the linking of companies for common purpose or gain (Gomes-Casseres, July-Aug 1994). It is also seen as the implementation of IT to facilitate information sharing with supply chain partners with common areas of interest. This research will refer to it as the fusion of different supply chain entities that sees the benefit of a unified partnership.

Horizontal Collaboration -: It is the sharing of assets and costs between different companies for mutual benefit (Mason, Lalwani and Boughton 2007).

Vertical Collaboration -: It is the act of cooperatively operating with trading partners at different levels of the supply chain, usually supported by 3rd party service providers (Waters, 2007).

2.2 Empty runs experienced by transport stakeholders

In Namibia siloism seems to be the norm (Savage, Jenkins and Fransman 2012) and can be seen as a factor that hinders prospects for collaboration. Other factors include the lack of skills, training and ICT especially among SMEs (April, 2005). It is estimated that there are over 200 freight transport companies active on the Namibian roads, of which approximately 150 are SMEs (Namibian Logistics Association, 2011). An estimated 50 freight brokers (of which about 40 are SMEs) also operate in the country (Namibian Logistics Association, 2011). The number of SMEs in the transport sector estimated to be registered with the Namibian Ministry of Trade and Industry is more than 500. This includes taxis and other passenger transport vehicle, which are not relevant to this research (NEPRU, 2003). Savage, Jenkins and Fransman, (2012) estimated empty running experienced by transporters at about 50%. This estimation is supported and explained further in section 5.1, based on new findings from this research. The sharing of information, integration of systems, awareness among companies and relationships has been seen as limited among transport stakeholders in Namibia (Savage, Jenkins and Fransman 2012). These limitations form part of the reason for the estimated percentage of empty running in the country. An empty run in transport becomes increasingly hard for a business when news reports such as, Namibia recording an increase in inflation partly due to the increase in transport costs affected by the high oil prices, is released (Nyaungwa, 2012). High transport costs are unlikely to fall so transport companies are forced to look at alternative ways to lower costs. Reducing empty running is one method of saving. However, unless the lack of collaboration is addressed in Namibia this method will not be possible.

McKinnon and Ge (2006) and Moonen (2009) use the terms “empty-truck-kilometres” or “empty haulage” when a truck is running without a load. It is difficult not to have an empty run, especially when factors like distance, activity along the route, and economic situation at the destination are not favourable. “There is absolutely no freight from the north of the country”, a transporter said, thus one would assume an empty run is difficult to avoid (Savage, Jenkins and Fransman 2012). Very few companies record 0% empty runs in their operations. The question is therefore: what is a sustainable or what would be an acceptable threshold for empty runs? A percentage that is unacceptable from a sustainable point of view is between 25-50% (Moonen, 2009). The sustainable point is affected when the under-utilisation of carrier capacity often occurs. There are many factors that determine the utilisation of a transport vehicle. McKinnon and Ge (2006) believe that getting this factor right will ensure organisation efficiency. Piecyk and McKinnon (2009) give two factors that determine the utilisation of a vehicle, and that is the loading factor, and empty running. The former is defined as the ratio of the average load-vehicle capacity expressed in vehicle kilometres (McKinnon and Ge 2006), while empty running is the percentage of vehicle-kilometres that are run empty (Piecyk and McKinnon 2009). The key is to improve this utilisation, as it has an overall impact on the business and its environment. Ensuring that the carrying capacity of a vehicle is utilised to the maximum, could mean that with fewer trucks, all or most freight deliveries can be made. Yilmaz and Savasaneril (2012) state that reducing empty runs even slightly, allows shippers to obtain considerable savings.

2.3 Reducing Empty running

Even slightly reducing empty running can take some time and effort to achieve. The key to this would be to obtain an overall view of the transport environment to make better decisions when planning transportation (Mason, Lalwani and Boughton 2007).

However to successfully obtain this view of the country all stakeholders that are involved with transportation have to contribute as it does not rest on the shoulders of transporters alone. McKinnon and Ge (2006) state that the reduction of empty running can only be a joint co-ordinated effort. This is backed with Moonen (2009) confirming that without information-sharing among transporters no progress can be made. Reducing empty or even ‘less-than-truckload’ (LTL) running has received recognition by many governments, who have set targets to ensure that the movement of freight becomes sustainable (McKinnon and Ge 2006). A lot of costs are accumulated when empty running percentages are high. The indirect and longer, more serious costs from carbon emissions and wear to the infrastructure must also be considered. Mason, Lalwani and Boughton (2007) state you have shippers seeing only high transport costs, long cycle times and high inventory costs if the inefficiency of transportation continues. Carriers see it as empty deadhead miles that will have dwindling effects on their operation (McKinnon and Ge 2006). In Namibia an operator claims, “I have to say no to transport jobs, and park my vehicle as it’s not sustainable, I simply will make a loss”. While a transport user says that finding backhauls for transporters is frustrated by operators who wish to avoid the sharing of any savings or profit (Savage, Jenkins and Fransman 2012). This is unfeasible as Mason, Lalwani and Boughton (2007) say that it is critical to the success of carriers to reduce kilometres of empty vehicles. If this is achieved further benefits can be achieved through the optimisation of fleets providing more sustainable distribution systems.

‘Back-loading’ (BLD) can be one way of reducing empty runs for transport operators (Cherret et al., 2011). However this does require the establishment of partnerships with organisations that could ensure transport of items on a return journey (customer returns, re-cyclable goods etc). This could be done as part of a normal delivery run, to ensure the utilisation of its capacity to the maximum (Cherret et al., 2011). A transport user comments on a discussion of a collaboration platform; that if he knew of a particular return load on some of his routes, there would be no hesitation in establishing a partnership (Finkeldey, 2012). BLD is specific and most transporters in developed countries claim that it is more on a “as needed” basis, than a real assurance of business (Cherret et al., 2011). In Namibia some consider finding a back load a daily task, and sometimes going to considerable lengths to do this

(Savage, Jenkins and Fransman 2012). There have been successful establishments of BLD in Namibia, especially in specific markets like charcoal, scrap metal and carrots, though this depends on the time of year and demand (Savage, Jenkins and Fransman 2012). This is usually organised by the forwarders and truckers, with the users claiming that they do not handle this (Savage, Jenkins and Fransman 2012). This is organised by finding a different transporter that usually uses the route where the particular freight is located, and negotiating to load it on their trucks. For example, as one transporter stated “I have had some success moving black carrots from the North of Namibia, using transport returning from Angola” (Savage, Jenkins and Fransman 2012). Cherret et al. (2011) state that within a decentralised environment BLD can be organised with an organisation’s own trucks. However when IT systems bring in a centralised approach, it could mean that the logistics providers having the best view of a supply chain would take over this duty (Savage, Jenkins and Fransman 2012).

Integration among stakeholders is seen as another means to help reduce empty runs. Perego, Perotti and Mangiaracina (2011) see integration as fundamental to providing real-time data across the supply chain which allows for real-time decision-making. Within a transport environment, where the benefits lie in efficiency, the integration with other stakeholders could reduce critical factors such as the lead-time variability (Mason et al., 2003, Mason, Lalwani and Boughton 2007). The integration of supply chains and its benefits is not a new phenomenon, originating with the “beergame” from MIT (Lee and Padmanabhan 1997). The theory of integration is to synergise planning with supply chain partners and eliminate uncertainty (McKinnon, 2004, Mason et al., 2003, Lee and Padmanabhan 1997). In transport where unforeseen events occur during shipments the method of integration would help to provide measures to deal with these. Mason et al. (2003) say that through integration all systems could be managed faster thanks to the real time visibility and information. Marchet, Perego and Perroti (2009) look at the types of ICT systems that are common in logistics and transport environments, classifying some as:

- **Transportation Management Systems** (TMS), managing a organisations fleet, offering tracking and tracing, optimisation and executing, routing and scheduling and freight payment and auditing (Mason et al., 2003).

- **Fleet and Freight Management** (FFM) applications are used as reporting tools for logistics planners on vehicle service times, delivery points and travel times.

The integration of TMS and FFM systems already provides for a different dimension in decision support. The more data available for decision makers, the better the decisions will be which can be taken in the end. Transporters try to reduce their empty runs or LTL overall, to save costs and ensure efficiency. To be successful or at least constant in achieving this, information should be readily available. Crainic, Gendreau and Potvin (2008) say that the demands for empty vehicles are very unpredictable and difficult to forecast, and so require instant decision-making. It does however not end there, because as soon as a vehicle has completed a delivery, to ensure efficiency it has to be assigned as soon as possible to another shipment (Crainic, Gendreau and Potvin 2008). The situation is complicated further when a time factor is considered, i.e. most freight delivery has a time limit. However Crainic, Gendreau and Potvin (2008) further talk of the information already being out there, it is a matter of accessing it, and including it in normal operations. For instance, the installation of GPS systems offer customers and transporters more flexibility and visibility by providing up-to-date information on positions and planned routes of vehicles. Re-routing and changing vehicles depending on the freight request can be done instantly, eliminating some of the uncertainty in planning (Crainic, Gendreau and Potvin 2008). The allocation of certain limited capacity i.e. specialist trailers, empty containers and rail cars, could be done with ease, as soon as requests come in. This however requires the integration of customers and partners to ensure its success. The greater the number of stakeholders connected, the greater the chance of a well-operated transport environment (McKinnon and Ge 2006, Moonen, 2009). **Error! Reference source not found.** shows the integration levels among stakeholders in Namibia (Savage, Jenkins and Fransman 2012). The information obtained from the table is based on a range from 1 to 5, with 1 being an adversarial approach and 5 being an established partnership that has data sharing and integration (Savage, Jenkins and Fransman 2012). Transporters scored the lowest within this study, blaming it on factors such as the lack of IT and an ever-changing environment that leaves no other choice for operators than to operate on a transactional basis.

Table 2-1 Analysis of relationship/integration (Savage, Jenkins and Fransman 2012)

Stakeholder Group	Mean	Approximate split value percentage
LSP/forwarder	4.0	40%
Other	3.4	60%
User	3.0	10%
Transport	2.8	50%

The lack of ICT mentioned by the stakeholders (Savage, Jenkins and Fransman 2012) hinders the prospects of back loading and integration, and should be addressed, as the effects of its implementation in transportation have been significant in promoting collaboration (Mason et al., 2003, McKinnon, 2004, Beevor, 2013). Through this research under section 6.3 there is an attempt at providing a technology stance of Namibia based on stakeholder responses.

2.4 Effects of Information Technology (IT) on transportation

Transport Management Systems (TMS) have long been seen as a separate entity from other business units. Some in the Namibian transport environment state; “We have our ERP, and a separate fleet management system for our transport operations” (Savage, Jenkins and Fransman 2012). There are though, still not many “off-the-shelf” solutions for the transport operators that integrate well with Enterprise Resource Planning (ERP). Logistics and TMS are usually specialised, and as with all ERP system installations, customisation takes time, resources and increases costs (Hong and Kim 2002, Holland, 1999). A Logistics Service Provider (LSP) in Namibia confirms some of this, “Our current system costs were higher than we expected, because a lot of customisations were done to suit our needs”. The costs of systems are high, and the lack of local support hinders its adoption. The installation of any enterprise system has its pitfalls (Hong and Kim 2002), and all organisations have to adhere to and anticipate these. However with all the negativity surrounding the adoption of new IT systems, many authors still consider it inevitable for organisations to adopt Information Communication and Technology (ICT) to ensure an efficient and effective performance in all sectors, especially transportation (Keskinen et al., 2001).

Davies, Mason and Lalwani (2006) say that with the internet already having a major impact by providing new ways of doing business, significant strides have been seen especially in the electronic market places. The need to shift from uni-modal to multi-modal transport operations requires the integration of ICT applications to achieve efficient and effective cargo movement (Harris, Wang and Wang 2012). ICT, referred to as the enabler in a supply chain by McKinnon and Ge (2006) is used to provide real-time and accurate information, to assist in decision-making. It speeds up the data exchange processes and provides for greater flexibility to react to unforeseen changes during transport shipments (Harris, Wang and Wang 2012). The benefit through ICT adoption includes economic and environmental aspects for all if managed correctly (Perego, Perotti and Mangiaracina 2011). When managed within a multi-modal environment, the integration has to be seamless, accurate and efficient to ensure that the maximum benefit is achieved for all parties involved. Harris, Wang and Wang (2012) state that this is not easy to achieve as all or most organisations have different solutions. There are numerous benefits from ICT applications in multi-modal transport environments; from achieving improved utilisation of transport to improved customer satisfaction, and related specifically to this research, a reduction in empty runs (Arcelus, Eiselt and Lin 1998, McKinnon and Ge 2006). Harris, Wang and Wang (2012) produced a summary of current ICT multi-modal transport applications and the potential benefits. A section of this can be seen in

.

Table 2-2 Extracted benefits of ICT applications (Harris, Wang and Wang 2012)

ICT Applications	Potential Benefit
Freight resource management systems:	• Improved operational efficiency • Reduced empty runs through better route planning • Improved utilisation of transport infrastructure • Improved customer satisfaction • Reduced overall costs due to vehicle optimisation
Integrated operational/information exchange Platform/Portal/Marketplace	• Electronic one-stop-shop marketplace for all parties along the multimodal chain, enabling them to provide bespoke services and accelerate data and information exchange within participants • Allow the related authorities to interact with the operators and exchange information and transport related documents

The adoption or the use of ICT applications differs among stakeholders, with all having different operational requirements. Davies, Mason and Lalwani (2006) state that the smaller transport operators in the UK still use the traditional methods of communication and systems, while the bigger logistics companies are supported through advanced applications. This does not differ from the developing countries' perspective, as the bigger and more successful organisations take maximum benefit from advanced ICT. A local transport operator confirms this by saying "systems are expensive and therefore force the use of traditional management practices" (Savage, Jenkins and Fransman 2012). The options to implement ICT based systems have increased, and allow even smaller players to select packages to meet their needs and to enter into the market. Harris, Wang and Wang (2012) name a few sectors that have emerged and changed the multi-modal environment: wireless communication, tracing and tracking, e-commerce internet-based technologies. They further state that with the introduction of cloud computing, software as a service and mobile technologies, an IT infrastructure can be used more efficiently through contextual searching. Transport stakeholders with limited IT capabilities can now take advantage of these technologies, and can benefit through the connectivity to outside networks.

2.5 Technology adoption factors

In any environment, where new systems are proposed, an assessment has to be carried out to discover the current status and to determine the criteria for technology adoption. Adopting new systems or integrating with older ones requires an understanding of previous systems and often needs a complete “overhaul” or replacement (Premkumar and Roberts 1999). In developing countries the technology adoption could have two sides when introducing a new system. Firstly, the introduction of a system where no previous system exists is the most likely scenario, as a transporters’ sample from Savage, Jenkins and Fransman (2012) indicates. Systems are expensive to acquire, and the support is expensive due to limited local expertise (Holland, 1999). Secondly the introduction of new systems on top of existing ones, will render these either obsolete or would require extensive integration through customised solutions. Savage, Jenkins and Fransman (2012) provide some indication of the Namibian ICT situation that varies among stakeholders providing environments like: proprietary business systems, stand-alone PC with excel workbooks, no ICT at all. This research has conducted a more specific study on the status of the ICT stance of transport stakeholders – see Section 6. As it stands in this country, the technology adoption for new ICT initiatives in transport would vary among stakeholders. The factors that some authors consider are the main barriers to ICT adoption are the lack of knowledge, education and skills of both management and staff (Arendt, 2009, Harris, Wang and Wang 2012, Holland, 1999). Bridging this gap requires a look at both ICT accessibility and available knowledge and skills. Manuere, Gwangwava and Gut (2012) specify internal barriers to ICT adoption: the cost and return on investment, and owner manager characteristics. Harris, Wang and Wang (2012) mention the difference in barriers experienced from company to company and even mode-to-mode, whether it is user related, software related or policy related – see Figure 2-1. Consideration of these barriers becomes important when opting to implement or join a new system. The figure shows technological barriers like the integration and compatibility for current systems that need to be verified or even modified to adopt or operate with a new system. The barriers also push organisations to create a profile of their procedures, policies and technology information to allow for easier viewing, assessing and decision making when moving to new systems. Overall with Harris, Wang and Wang (2012) saying that most of the barriers are either user or policy related, this may be different in a developing country where there are sometimes a lack of overall policies and skills in users. In addition to technological barriers that exist, for the developing world there is a different dimension of barriers to consider in the adoption of new systems.

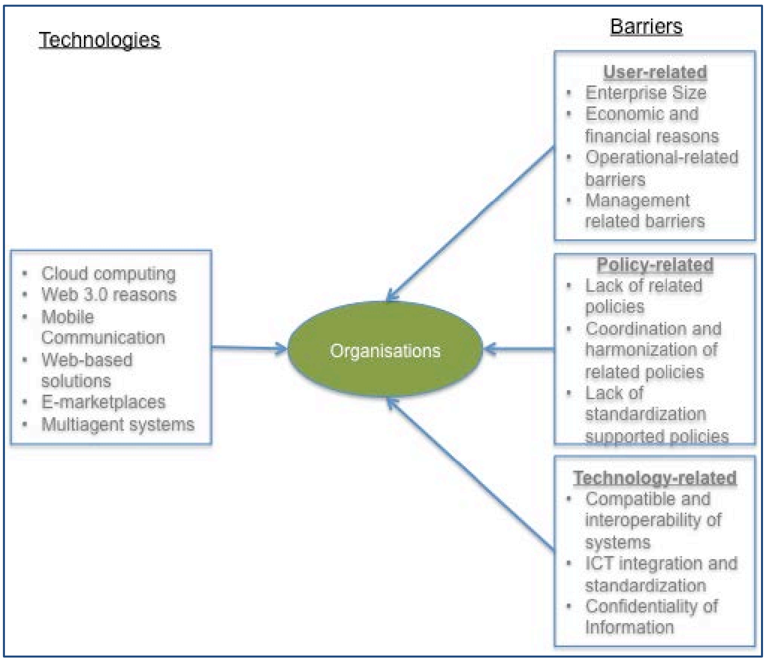


Figure 2-1 Barriers to new technologies in transport, adapted (Harris, Wang and Wang 2012)

2.5.1 Barriers to adoption of ICT

The barriers differ among company sizes; with constraints like financial, human resource capital and ICT expertise and these are the most likely hindrances for smaller organisations (Arendt, 2009). Literature shows that many smaller organisations rely on traditional systems and processes (Arendt, 2009, Harris, Wang and Wang 2012), and this is confirmed by a Namibian transport user indicating that excel worksheets is as far as they will go for now (Savage, Jenkins and Fransman 2012). Larger organisations have the benefit of developing bespoke applications or platforms for business needs (Hong and Kim 2002), but they have other factors to consider, for example: implementation and maintenance costs. There also exists some scepticism when it comes to the return on investments (Evangelista and Sweeney 2006). Human capital is a common barrier among both small and large enterprises, especially when new technologies are introduced. The introduction of new systems in any environment has to consider the ICT specialists to support, the training and education activities concerned and the availability of qualified staff (Harris, Wang and Wang 2012, Arendt, 2009). A LSP responds that “there are a lot of problems associated with finding and retaining qualified staff“ (Savage, Jenkins and Fransman 2012). This is further supported by a transporter stating, “it’s already difficult to find qualified drivers, and its expensive to employ qualified staff” (Savage, Jenkins and Fransman 2012). Larger organisations suffer from other issues like the unwillingness to change to or the adoption of new technologies (Huckridge, Bigot and Naim 2011), This could be attributed to systems and individuals being with the organisation in the same positions for a long time indicating their unwillingness to change, as stakeholders alluded to in the report by (Savage, Jenkins and Fransman 2012). Larger transport organisations are sceptic about returns on initial investments on ICT technologies, and the difficulty in quantifying the benefits they contribute to it (Pokharel, 2005). Having different packages and solutions to choose from, may initially seem like the best solution, but it often ends in an inappropriate use of ICT applications in daily operations (Harris, Wang and Wang 2012). Both large and small businesses suffer from technology related factors like inter-operability, integration and standardisation. The transport environment is a dynamic one with different operational issues and systems found across multiple modes and this hinders the adoption of new ICT solutions. Perego, Perotti and Mangiaracini (2011) state the main reason for technological adoption barriers, is the different ways many stakeholders operate. Harris, Wang and Wang (2012) state that ICT penetration is different in every mode of transport, with different technology providers (e.g. Oracle, Hansaworld, IBM and SAP in Namibia) offering options. Due to the different options, and the lack of compatibility among these, there are further barriers to integration and adoption of new technologies. However there are positive strides from developers and organisations of new ICT technologies who realise the problem of incompatibility and ensure that options to integrate with existing systems are incorporated into new development. Adoption of a system normally considers similar operators and integration with them, but there is also the integration with customers and partners that should be taken in account, as this has a significant impact on the success of a system (Pokharel, 2005). Other barriers include the installation timelines associated with new systems that normally finish later than planned. A transport user in Namibia confirms this, saying within "our company, it's taken 5 years to have the ERP installation where it has 90% of all operational processes covered", and another stating "we have had our system for 10 years, and we still have to fly in an expert regularly to fix bugs and customise old processes" (Savage, Jenkins and Fransman 2012). Organisations that face lengthy system installations can suffer from the rapid obsolescence of technology, especially in the transport environment, where technology is changing quickly (Perego, Perotti and Mangiaracina 2011). New technology adoption must also consider the issue of the lack of knowledge and trust for a product i.e. online transactions and security, information confidentiality and sharing (Arendt, 2009, Marchet, Perego and Perotti 2009). The issue of security that a new system provides normally draws several questions from the organisation, and most are reluctant to exchange information through a new system. All the barriers to ICT adoption have a negative impact on the promotion and improvement of transport collaboration in Namibia.

2.6 Transport Collaboration Status

The transport environment is a dynamic one, that requires the transportation of goods according to customer needs, but the next consignment after the initial delivery has to be organised as well. The decision for each consignment following a previous delivery has an impact on the long-term efficiency of the entire fleet (Crainic, Gendreau and Potvin 2008). Consignment decision-making managed over multiple fleets, with longer periods of time and an unpredictable environment, becomes more and more difficult to handle. Fleet management systems co-ordinated with built-in positioning systems allow for the re-routing of vehicles as new consignments arise (Crainic, Gendreau and Potvin 2008) thus making it easier. These systems are seen as the internal management of fleets and may be better to co-ordinate, but the collaboration with partners gives a different dimension to the availability and re-routing of vehicles. Transport and logistics are highly distributed activities. There is a lot of focus on the individual partner looking to improve their own supply chain, without considering others (Franklin, 2012). This is made worse in a case of a developing country like Namibia, where the level of understanding for collaboration and integration is lacking (Savage, Jenkins and Fransman 2012). Although Aitken et al. (2005) said that it is supply chains that compete and not companies, supply chain collaboration could increase the levels of service of all companies involved. Modern industries are forced to look at other methods to improve service to aid in future growth. The factor of cost saving is important, and collaboration is a method that could aid in this. Collaboration through sharing and integration with partners has been shown to have the potential to optimise transactions and carriers (Ding, Guo and Liu 2010, Ramanathan and Gunasekaran 2012, Yilmaz and Savasaneril 2012). Transport is the integrator of supply chains and so becomes a critical factor and affects all stakeholders (Mason, Lalwani and Boughton 2007). Collaboration has become important and this section shows there has been some success in transportation internationally, regionally and locally.

2.6.1 International transport collaboration

Small shippers, according to (Yilmaz and Savasaneril 2012), have been in alliances with ocean liner companies like Hapag-Lloyd, NYK and OOCL, and United Shipper Alliances. Through some of these alliances many of the small shippers have claimed to reduce their Less-than-truckloads (LTL) and ocean transportation costs by 10-40% for their small ships (United Shippers Alliance, 2014). These alliances allow the small shipper the freedom of carrier communication and management, allowing an existence outside of the framework. Alliances have now evolved into bigger collaboration initiatives with other alliances outside certain trade routes (Grand Alliance, 2014). These alliances have developed into strategic strongholds in this industry and have accumulated decades of experience and knowledge (United Shippers Alliance, 2014, Grand Alliance, 2014). Other transport collaborator groups include System Alliance Europe that specialises in network distribution in Europe, through the harnessing of leading medium-sized logistics service providers (System Alliance Europe, 2014). This group relies on guidelines presented to all member organisations that must be followed to provide guaranteed quality standards and transparent processes (System Alliance Europe, 2014). Beevor (2013) confirms a similar result, where smaller road transporters in the UK have combined capacity to collaborate, have opened up possibilities to apply for bigger tenders as an alliance, and have succeeded in acquiring them. In Namibia an organisation exists that allows for transport stakeholder member registration and which also facilitates relevant information sharing and training amongst them (Namibian Logistics Association, 2011), however it still lack collaboration initiatives. The Canadian furniture industry has identified large cost savings through transportation collaboration and has demonstrated cost allocation strategies in these cases (Audy, D'Amours and Rousseau 2010). Retailers like McKinnon&M, who use transport have now joined and are collaborating with transporters to promote green transport (H&M, 2013) . By ensuring that all goods transported are adhering to the green agenda, they are using tools to evaluate the road freight carrier's performance. According to the National Shippers Strategic Transportation Council (NASSTRAC) Freight Transportation report 2013, 32.4% of shippers collaborate with their suppliers, and around 54% say they collaborate with other shippers (NASSTRAC, 2013). The report recognises companies like the Best Buy Co. who cut their shipment costs by 30% through close collaborations with their providers (NASSTRAC, 2013). Another example is well known producers such as Carrefour, Nestle Waters, Coca-Cola, P&G and CHEP, who share transportation as part of a programme in Italy (Chep, 2014). This initiative was influenced by the significant fuel increases of more than 30% in 2012. Synergistic distribution flows were identified to help eliminate empty running or even reduce it, and ultimately lower transport costs (Chep, 2014).

Waterway systems are plenty and inter-modal and multi-modal collaboration among them is common, especially in European countries where the use of rivers for transportation is the preferred and most suitable method. This method shift is due to heavy traffic congestion, the environmental impact or high economic costs in these countries (EXTR@Web consortium, 2006), and river transportation is seen as a way of alleviating these challenges. These waterways systems make use of a River Information Service (RIS) that is defined as the management of transport and traffic that operate inland, by harmonising information services and interfacing with other modes of transport. It has been built around modern technology and the telecommunication infrastructure. It boasts features that include internet application with notices to shippers, ship reporting systems, vessel tracking, radar systems and route/voyage planning applications. The IT applications make use of various information services, like Fairway Information Services (FIS), Traffic Information Service (TIS) and Information for Transport Logistics. These initiatives are evidence of a successful collaboration in real world situations.

2.6.2 Regional Transportation collaboration

Regional collaboration for this study focuses on the SADC region, as there is a lack of information from other countries in the rest of Africa. Though collaboration is sometimes not fully understood by most transport stakeholders (Savage, Jenkins and Fransman 2012), there are a few examples of collaboration in the region:

Organisations like Northern Haulage offering cross border transport based in South Africa have established strategic alliances in various other SADC countries to ensure a co-ordinated service delivery (Rudd and Bishop 2013). Through these partnerships service delivery has improved by using either local transport or in the case of crossing borders (e.g. Northern Haulage) by making use of its partners' vehicles. Another example is the North Star Alliance which was formed through the unusual partnership of TNT and the non-profit organisation World Food Programme (WFP), to ensure mobile populations have access to high quality health services (North Star Alliance, 2013). The WFP needed transporters to remote areas, while TNT was in need of driver care due to health issues faced driving in certain regions, and so the partnership started. Transnet Freight Rail began a South African multi-modal collaboration initiative by joining with Imperial Logistics to explore opportunities in the logistics and transport sector (Imperial Logistics, 2013). Their aim was to reduce the impact of heavy loads and rail friendly loads on the roads, as well as reduce logistical costs for cargo owners. A collaboration initiative was started by the Transnova transportation network to create opportunities for shippers, carriers and 3PLs to collaborate and reduce costs due to empty running (Transnova, 2014). The organisation provides services to manage the entire transport process and includes options such as the visibility through an online accessible site which provides the available capacities of partners that could be utilised.

These regional initiatives give some indication of the shift towards collaboration within industry. However there are few examples of local transport collaboration initiatives and academic publications documenting the successes.

2.6.3 Local transport collaboration

Local transport collaboration for this research is based on the Namibian Transport industry. Previous literature and the lack of online sources has shown it is difficult to provide a clear picture of the collaboration status within Namibia. This section incorporates various responses from previous research and analysed questionnaires. Various views were received, for example, a local transporter said, 'we normally prefer to work alone, as all are just looking out for themselves' (Savage, Jenkins and Fransman 2012). Other respondents saying that the influence from South African competition is too strong, and complaining that some companies will not do business with Namibian owned ones. The report from Savage, Jenkins and Fransman (2012) indicates that although integration among Logistics Service Providers and Freight Forwarders does exist, the analysis shows very little amongst the actual transporters. Other responses from users indicates that the integration and collaboration with partners was more on a transactional basis rather than through longer-term contracts. Many operators indicate that there is diversity in their integration, with some having a mix of methods for integration. Transporters have indicated they would want longer-term partnerships. Though the report of Savage, Jenkins and Fransman (2012) provides a bleak view for collaboration in the country, there does seem to be some indication of the realisation for the importance of collaboration (Walvis Bay Corridor Group, 2013). The development of the corridors within the country has pushed stakeholders to collaborate. For example the provision of health services to transporters along the corridors was started through the collaboration of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the Ministry of Health and Social Services, the Ministry of Works and Transport and other relevant stakeholders (Walvis Bay Corridor Group, 2013). Another example that stems from the aim of the country to become a regional logistics hub, (Walvis Bay Corridor Group, 2013, Savage, 2013) is the collaboration of the country with some of her neighbouring countries like Botswana, Zambia and the DRC to ensure trade routes are unhindered. The realisation is that to become a regional logistics hub there are many issues that have to be addressed (Savage, 2013), but collaboration with local stakeholders and other countries is an absolute necessity.

2.7 Transportation information sharing

Information sharing involves the divulging of processed meaningful data to a partner or another party that could use it to improve their decision-making or improve their efficiency (Angeles and Nath 2001). Ding, Guo and Liu (2010) give an example in supply chain co-operative environments, where production plans, demand forecasts and supply capacity are shared with upstream and downstream suppliers. The benefits for all can lead to a reduction in inventory and improvement of the order process. Simpler examples show, the manufacturer and a retailer joining to determine the optimum inventory policies for both (Ding, Guo and Liu 2010).

In a transportation environment information sharing can start without any formal contract or agreement just through the advertising of capacity. This provides information to other stakeholders that they have the option to choose to use this capacity or even refer this to another partner. This information usually does not require significant cost and time, but could prove its value in business. A transport user that employed the social media to advertise a load, has claimed success and cost reduction (Finkeldey, 2012). More traditional information sharing through telephones has been claimed by others, saying its their main purpose for the day, and the only way to ensure a reduction in the number of empty runs (Savage, Jenkins and Fransman 2012). A transport expert elaborates that information sharing among transporters these days can use a range of communication forms i.e. telephone/mobile, internet, EDI, location based services (Beevor, 2013). There is however a difference in the synchronisation and availability of this information. The information could thus be: “available when ready”, “real time form” or a combination of both (Long and Baecker 1997). Both information statuses mentioned would have considerable benefits within a transportation environment. In developing countries the aim would be to start with ‘available when ready’ sharing and move towards ‘real time form’ as collaboration is established. The former has some options in the form of online portals, websites and mobile notification services.

‘Available when ready’ information sharing can be achieved through online portals or freight matching sites designed specifically for these purposes. Freight matching sites or “loadboards” are the transport collaboration platforms referred to in the USA and Canada (Internet Truckstop, 2013, 123loadboard.com, 2013, Usacanadaloadup.com,). A transport user in Namibia sees the benefit of these and welcomes the idea of having access to such sites, as it would open up business transportation opportunities (Finkeldey, 2012). These portals bring forwarders and transporters together when they advertise their company profiles. Features from these portals or sites include: finding and hauling loads, dashboard views of carrier movements, load monitoring, fuel prices, maps and weather updates

(123loadboard.com, 2013, Internet Truckstop, 2013). Similar systems are active in Africa with user numbers steadily growing (laaimylorrie.com, 2014, Bid2Load.com, 2013). Registration is required for most of these sites, allowing all subscribers the flexibility of collaboration with others. Connection to these can be made through normal computers/tablets and/or smartphones. Notifications are one of the main features of such portals or sites and require the customisation of company profiles to ensure that correct business notifications/alerts are received and can be responded to. Figure 2-2 shows the typical flow of information between forwarders and truckers, who can now match loads and choose to collaborate (Schmidt, Mbai and Fransman 2011). However it should be noted that all of these systems capture a lot of data from members, but not all of them can automatically analyse the data for further use to provide usable information and thus aid decision-making (Fransman, 2013). A lack of certain automatic algorithms to identify load sharing and back haul opportunities is usually omitted in many of these systems. Such systems are however, a good example of where information is shared on a 'available when ready' status and can take place in vertical and horizontal collaboration (Schmidt, Mbai and Fransman 2011). These systems are referred to as non-intelligent collaboration platforms (Fransman, 2013).

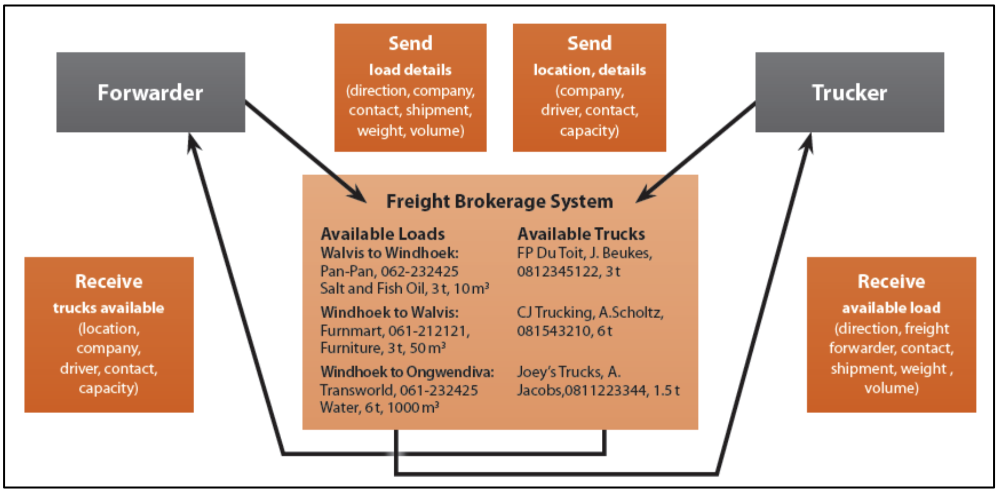


Figure 2-2 Freight Information Exchange (Schmidt, Mbai and Fransman 2011)

The IT cost, security and effectiveness has to be considered when sharing information through portals. The security consideration becomes critical as sensitive information can pass through the portals. Proprietary technology like Electronic Data Interchange (EDI) that caters for the secure exchange of sensitive information has dominated the information sharing systems, but has always been very expensive (Moonen, 2009). However the Internet has revolutionised this with its multiple protocols and tools that exist and that have reduced costs when sharing information. There are several secure information sharing solutions that now exist that make this transition easier for multiple companies (Beevor, 2013). The sharing of information of the movement of carriers or creating an overall view of the status of all transporters is a first step to reducing empty runs (Piecyk and McKinnon 2009, Mason, Lalwani and Boughton 2007, Cao and Zhang 2011).

2.8 Collaboration and its promotion

Any organisation should want to collaborate with their direct partners as up-to-date information has become the key to efficient and effective service delivery, as well as contributing to a business' future success (Cao and Zhang 2011, Ramanathan and Gunasekaran 2012). Moonen (2009) suggests that companies can increase their capacity to process real-time information from supply chain members through collaboration. This is further supported by (Lambert and Cooper 2000) who say that these types of collaborations can reduce uncertainty among supply chain members. Collaboration seems to be the new way of increasing capacity among supply chain members (Cao and Zhang 2011, Dai and Chen 2011, Ramanathan and Gunasekaran 2012, Beevor, 2013), and has been seen to help SME's increase their capacity through utilising that of their direct partners (Crainic, Gendreau and Potvin 2008). Data sharing with partners and the processing of it into meaningful information is the key to successful collaboration. Premkumar and Roberts (1999) explain that information processing in an organisation itself is not enough to eliminate uncertainty. Bretzke (2003) adds to the previous explanation suggesting that through integration with partner organisations, uncertainty is reduced. The process of eliminating uncertainty improves decision-making and improves the "time" factor that is so important in business (Green and Whitten 2007). The availability of real-time information provides another dimension to a business supply chain and increases the performance of an organisation (Green and Whitten 2007, Dullaert and Van Landeghem 2007).

There are various ways in which collaboration might start. Some might try through determining common business practises with others (Davies, Mason and Lalwani 2006), while others are just hoping to find any organisation that is willing to work together or share business. This can be illustrated with the 2 types of collaboration namely: horizontal and vertical (Mason, Lalwani and Boughton 2007, Cruijssen and Dullaert 2007), found in a logistics and transport environment. **Error! Reference source not found.** illustrates the types of collaboration in supply chains.

The forms of collaboration can be achieved through various means: transactional, sharing of capacity, integration or established partnerships. An example of the means and collaboration in practise is organisations having agents or clerks that provide a service to the business by communicating daily with other agents regarding the sharing of services to save costs. This is seen as an adversarial approach when collaborating horizontally. Vertical collaboration works best among supply chain partners where capacity or services are shared (Mason, Lalwani and Boughton 2007). For example the major international corporations Coca Cola, Pepsi, UPS and Walmart are sharing transport to develop a sustainable model for the future (Schuchard, 2014) and this setup as established partnerships.

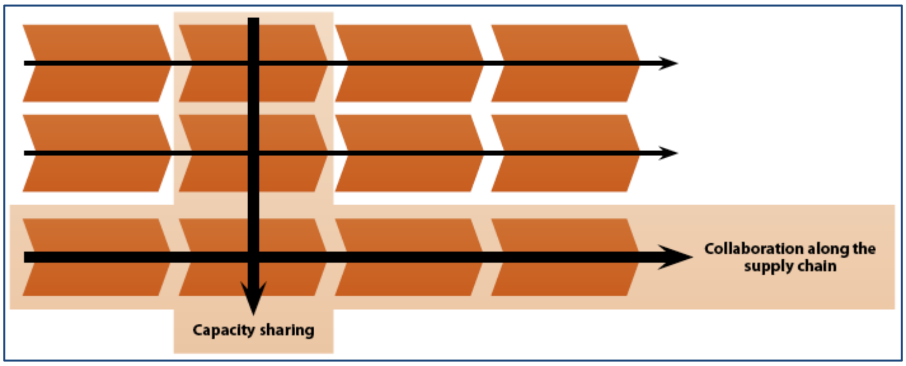


Figure 2-3 Horizontal and Vertical Collaboration (Schmidt, Mbai and Fransman, 2012)

Every company is pushed to compete in a globalised world and would seek any means to improve their business and remain competitive (Anbandandam, Banwet and Shankar 2011, Chep, 2014). Collaboration has thus become inevitable, and this is evident in developed countries where the new “buzzwords” are *clusters*, *hubs* and *corporate villages* (Savage, 2013). More and more corporations are not just looking for solutions to their own supply chains, but are seeking integrated solutions with outside organisations that they are in business with. Some are moving towards collaboration with competitors, for example Coca-cola and Pepsi sharing the same transport to take goods to their customers (Schuchard, 2014), potentially saving both corporations millions. The focus in earlier years was on internal systems and processes to solve a corporation's problems and give it the edge over the competition. This however has changed, as Moonen (2009) discussed; organisations have realised the limitation of their own systems and processes and have to integrate with their supply chain partners to extend their business. Software development companies are developing more solutions that integrate enterprises with one another (Holland, 1999). This is on-going, as most organisations while they are upgrading and revamping current systems have factored in the integration with partners (Malhotra and Temponi 2010). Moonen (2009) suggests inter-organisational systems (IOS) can link an organisation with its customers and suppliers to ease the exchange of products and services. The IOS links are established through networks that span outside the organisations system, which changes the way most enterprise systems work. The 3 types of IOS extracted from Kumar and Vin Dissel (1996) are: pooled, sequential, and reciprocal interdependency. Each of these has their objectives, technologies and co-ordination mechanisms that should be in place to ensure a smooth integration with other supply chain members (Moonen, 2009).

The collaboration and integration of transport organisations can be driven by several factors. The manual exchanging of information has high cost implications, and that through integration it can be reduced (Bakos, 1991). Sharing of capacity in a pooled IOS extends the reach to the market for all its entities (Beevor, 2013). Yilmaz and Savasaneril (2012) suggest collaboration is needed to improve operational efficiency. Other factors that drive the need to co-operate could be the pressure from legislation that requires more controlled environments, especially in transport (Mason, Lalwani and Boughton 2007). In Namibia, for example, there are member organisations that have started to voice the needs of transport operators in addition to helping all to adhere to new legislation and training requirements (Namibian Logistics Association, 2011). Equally, increases in fuel prices have had an effect on operations especially in developing countries, as all are trying to "make ends meet" but this often proves to be difficult. A transport operator says that "remaining profitable is essential and sustainability is the key" (Savage, Jenkins and Fransman 2012). The need to remain profitable is further exasperated with overall high trucking costs in carrier maintenance, parts and specialised equipment (pallet trucks, truck cranes). In the US, for example, cost factors such as rising driver pay scales have jumped from 4% in 2000 to 8% between 2010-2011 and are expected to continue to increase in the coming years (Kilcarr, 2013). The driver pay scales or other cost factors in Namibia are difficult to estimate due to the lack of data, but based on stakeholder views on the subject, it is likely that in the last few years approximately 20% of transport companies have dissolved in Namibia because of these factors. A transport operator said, “organisations cannot afford to run even a light or empty run as it’s not sustainable” (Savage, Jenkins and Fransman 2012).

Many authors have said that transport is an enabler of the supply chain, yet (Mason, Lalwani and Boughton 2007) believe that transport is the forgotten factor. They further explain that the transport acquisition is more transactional rather than as part of a partnership process, as it is not seen as that important. Long-term partnerships with transporters have become vital to ensure the sustainability of businesses in the supply chain (Dinwoodie, 2004). Many transport supply chain members do not realise the potential partnerships in close proximity, as they are often functionally orientated and the success of business is based on Key Performance Indicators (KPIs) (Mason, Lalwani and Boughton 2007). Collaboratively managed supply chains have shown significant reductions in costs and improved service delivery (Moonen, 2009). The 17111 Logistics Service Provider (LSP) in Germany provides a good example of a transportation partnership in a collaborative supply chain, where no trucks are owned by the LSP, but instead they have transporters that carry only their brand and thus have all their transportation contracts (Matzen, 2013). This is also an example of the integration of systems, where the LSP notifies the contracted transporters through it’s IT systems of loads available in certain locations across the country. Systems to integrate horizontal and vertical collaboration techniques are on the list of new ICT developments. Multi-agent systems in transportation are among the systems that promote these techniques, but provide a different dimension to collaboration promotion. There were several methods of collaboration identified among transport stakeholders in Namibia – see Section 5.2.

2.9 Discussion

Empty running is a major concern for the sustainable operations of any transport fleet, and avoiding this state as much as possible is the only way forward for organisations. The lack of certain elements like capacity, ICT and collaboration among transporters are major contributors to empty running. The correct adoption, implementation and use of these elements is detrimental in achieving the reduction of empty runs. There are however many barriers i.e. financial and human capacity, that hinder the adoption of these elements, especially in developing countries like Namibia. In the developed world there are several solutions to the reduction of empty runs, and many have opted to promote collaboration (strategic alliances, waterway systems, freight brokerage or exchange platforms) among its transporters to achieve this. There are many benefits in collaboration such as how capacity extends without extra cost and provides a more sustainable option for transportation by reducing carriers on roads. There are many methods proposed to promote collaboration, with information sharing being the first for many transport stakeholders in developing countries. Multi-agent systems (MAS) environments are among the most recent platforms applied to a transportation management. It provides a different dimension to transportation management with its autonomous and often uninterrupted reactive behaviour. The promotion of collaboration among transporters should become easier with a distributive environment of a MAS, which is further discussed in this research.

3 Multi-agent systems

3.1 Introduction

This chapter is an additional chapter to the literature review. It is focuses on Multi-agent systems (MAS), its origin, platforms, characteristics and transport applications. Further it guides and pushes the understanding of existing views on the technology and solutions available to forming the framework for this research which proposes a system for collaboration. The chapter builds upon the understanding of the structure that makes a software agent and how it operates within a wider multi-agent environment. The chapter concludes with a look at various commercial multi-agent systems available.

3.2 Definitions of Key Terms

Autonomous: - It is a state of operating without the need of intervention from outside parties.

Software agents: - Wooldridge and Jennings (1995) define it as any hardware that is installed with pre-configured software that allows it to operate without human intervention. This definition describes the main property of intelligence that is added to software agents.

Multiagent environment: - The environment is an abstraction for the engineering process of an agent (Weyns and Holvoet 2005, Odell et al., 2002), in fact it is the first aspect in a MAS to consider. Farooq-Ahmad (2002) suggests defining an environment as a set of situations for the software agents to adhere to, therefore influencing agent modelling. The environment is seen as the logical space for agents to operate within, and should be a robust and provide the medium of agent coordination.

Multi-agent systems (MAS): - A MAS consists of individual software agents configured with user preferences and policies that allow them to operate autonomously as well as derive some of its behaviour from its environment (Weiss, 1999).

Protocols: - Seen as a list of rules that guide communication between computers and in this research, between software agents.

Consensus: - It is the state of reaching general agreement where an outcome is needed. This research thus sees a consensus reached between two or more software agents.

Ontology: - Ontology is the description of a business process or data that is readable and is able to be processed by a software agent through a computer.

Distributed: - It is defined as the dispersing of entities over a certain space (-Dictionary.com,). In this research it will be seen as the dispersion of transport stakeholders over an area of operation.

3.3 Software agents

Since the 1990's software agents have been defined different by academics and professionals, however all have the same principle that it is designed to mimic human decision-making in various environments. Its applications are often seen in distributed environments. Wooldridge and Jennings (1995) use the word "symbolic" as a way of defining the method used to design agent reasoning. However in earlier research computational agents were seen as software that possess a location identifier and certain behaviour for it to receive messages thus prompting parallel actions (Hewitt, 1977). Nwana (1996) similar to others provides an overview to software agents as software and/or hardware that performs actions on behalf of the user. However he stresses that this definition is more of an umbrella term, as various agent types exist. These types can be smart/intelligent agents, interface agents, collaborative learning agents and, more specific to this research, collaborative agents (Nwana, 1996). The properties that an agent can possess can be cooperative, learning and/or autonomous, as shown in the figure 3-1.

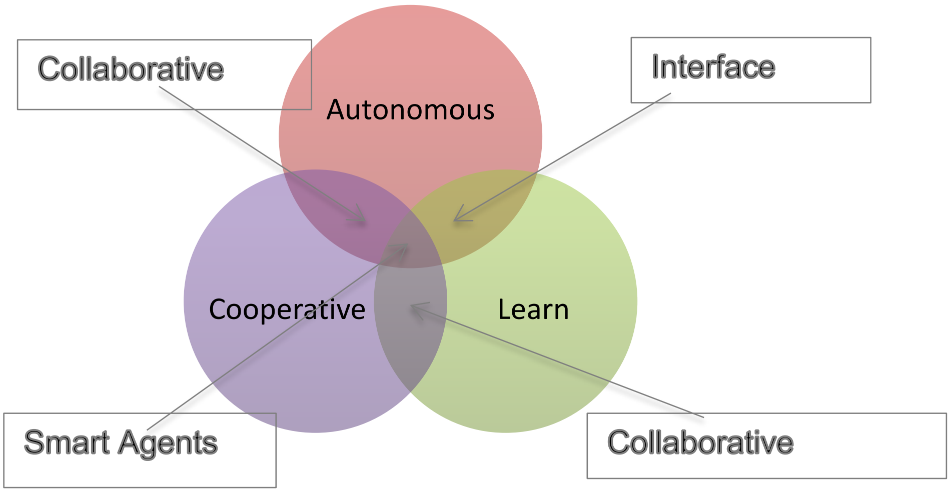


Figure 3-1 Agent Topologies defined by Nwana (1996)

The properties that an agent possesses are important but should be specific to the environment that it operates within. The success of any agent environment relies on the effective handling of information sent from its neighbouring agents. There is the process of interpreting and sharing information with others in the environment, to ensure a well functioning system. Agents are configured with a pre-set behaviour with some allowed to interpret while others are there to learn and share. **Error! Reference source not found.** illustrates the different behaviours of agents. Smart agents possess the feature to cooperate, learn and be autonomous at the same time. Therefore environments exist, to determine what features are needed to co-exist with similar agents.

3.4 Multi-agent foundation

Weiss (1999) defined a multi-agent system (MAS) as being derived from distributed artificial intelligence. Some authors refer to an agent as the lucid expression of human decision-making by a computer program (Schleiffer, 2004, Wooldridge and Jennings 1995). These agents have general knowledge of their environment, limited to the data specified by the user; an important feature as specified (Kwon, Im and Lee 2001, Schleiffer, 2004). They might have different or similar interests within the environment. Each agent on its own may be limited in what it can achieve, but because it operates in a multi-agent environment, through communication with other agents, it can assist in providing a overall service. The key to the success and effectiveness of a multi-agent environment is the algorithm that is used to provide this overview of information (Shoham and Leyton-Brown 2008). However to regard the algorithm as the main contributor to the success of a MAS, may be pre-empting the research. There other aspects to consider such as the characteristics the environment requires, before algorithms are needed. Algorithms are based on processes mapped and output requirements. Thus the success of an MAS is based on good planning and requirements documentation. An agents capabilities follows on from this, as in a MAS environment and specifically in transport, different players representing agents have different capabilities. These capabilities will have an effect on the agent's characteristics.

The settings for each agent must be configured beforehand, to allow it to operate as a functional unit and possess the characteristics mentioned in the previous paragraph. MAS combine individual agents with these features, however with different roles, capabilities and goals (Moonen, 2009). All agents in the environment cannot be successful on their own, and have to rely on other surrounding agents to provide information to make decisions (Wooldridge and Jennings 1995, Moonen, 2009). Achieving this requires agents to possess certain important characteristics with the most important feature being the readiness to send and receive information to other agents (Schleiffer, 2004). This gives the sense of an open system of information sharing that is detrimental to the success of the environment. The information should be centralised with no superior agents, and with a level of modularity within the environment (Wooldridge and Jennings 1995, Moonen, 2009). The modularity defines the structure of the groups within the environment, and gives certain identification to each agent and its role within a group. The environment becomes important to understand, as agents are not the only priority, the environment design and the interaction within it must also be considered (Odell et al., 2002). The interaction and communication considers the language used and the method of information exchanges (Moonen, 2009). The social interaction is achieved through communication using protocols set up by a system e.g. XML, UDDI, WSDL and SOAP (Curbera et al., 2002). The communication and the logic that accompanies the agents within the environment is dominated by language semantics, referred to as meanings expressed in code, and dialogue protocols, that specify a set of rules that regulate the communication (Moonen, 2009). The MAS co-ordinates the communication and the means agents interact to solve a problem in the environment (Wooldridge and Jennings 1995). The problem solving and planning of agents can be described as the achievement of private goals by each agent while assisting to achieve the global goals of the environment (de Weerdt, 2003). The environment becomes ultimately more important than the agents that it is made up of, with the “overall goal” specified to guide the behaviour of agents. Wooldridge (2007) also considers the importance of designing an MAS environment that looks like the business environment. Mimicking the business environment ensures the alignment of the overall goals, and ensures agents operating within are configured to react, based on these goals. The design of multi-agent systems becomes easier to understand for programmers and designers because of the similarity to the business environment (Wooldridge, 2007, Weyns et al., 2005).

Defining the variables that should guide the environment forms the basis for the agent responsibilities, which is not always the same as the overall design. The MAS environment should be independently constructed to provide certain aspects that are not necessary for incorporation within agents. Weyns et al. (2005) describes the construction of a multiagent system as building distributed applications. Modelling of agent environments have been seen in the research of others like (Odell et al., 2002, Serna, Uran and Uribe 2011, Schleiffer, 2004), however their approaches do not focus on agent design. It could also be referred to as the physical layer for the software agents. Using a diagram to represent an agent environment provides a means to model changes or states that the environment will undergo. This should underpin and will influence the agent behaviour and characteristics. In this scenario the set of situations will be analysed with the aim of extracting the most influential ones on the whole environment to allow the modelling of agent behaviour according to that. Each system environment should be guided by requirements of a business case or solution. The guidance to define the environment is seen as the laying of the foundation for the agents that comprise of views, reasoning and acting characteristics. Poole and Mackworth (2010) refer to agents and its environment as a world. Weyns et al. (2005) however allude to the problems when specifying the environment requirements because of confusion between the logical entity and the infrastructure foundation. It is further explained that three layers exist, namely the application layer (MAS residing), the execution layer, and physical layer. This is no different than any 3-tier system, however the requirements at each layer depend on the MAS processing needs. Some complicated processing may be required at the application layer that needs sophisticated execution platforms and equally powerful underlying infrastructure. The MAS business case as mentioned earlier should guide the requirements, for example pertaining to this research in a transportation environment. There should be agents that represent the transporter, forwarder, client and maybe 3rd party logistics (3PL) providers. The environment within which these operate could be a location and information handler. The transporter and forwarder provide information on carrier locations and capacity, while the rest provide information on freight and destination. The environment should have some logical framework in place, however processing the information takes on a different view. Weyns et al. (2005) mention the environment as handling the exchange of information, but when there is numerous inputs from different agents, the logic arrangement is tested. This is where the execution platform acting as the middleware comes in. Processing requires the invocation of methods, threading and load handling (Weyns et al., 2005). The environment middle layer acts as the intermediary between the top layer and the physical layer. MAS would require the middle layer to handle database sessions, security and monitoring of the whole. Referring back to the transportation environment, it would certainly need storage handling to store 'transport' agent information for future use. The negotiation feature referred to in Section 3.2 that some agents would possess in such an environment needs 'customer' agent requirements to be stored and invoked when running. Freight information provided by customer and 3PL agents needs security and monitoring to ensure confidentiality within the system. The middle layer handling the information should then manage resources from the physical layer, like the memory, execution and storage, just as an operating system. Another feature that Weyns et al. (2005) mention is the ability to handle the networking aspect which is important in MAS environment. The physical or underlying hardware is the next level. This is the platform that all layers are built on, and could consist of computer hardware in a network of hosts, or it could be the virtual environments where no physical world exists (Weyns et al., 2005). In a transportation environment, the physical hardware would be computer hardware or palm devices that could act as agents, and where the central hardware infrastructure could be the environment to which all connects.

3.5 Multi-agent characteristics

What makes these MAS intelligent platforms unique or different from other collaboration solutions is the capability to handle unforeseen events. Bernaer et al. (2006) who carried out research on MAS transport system gives the example of a feature of such a system. It should be able to handle unexpected events based on agents around as well as load matching and freight tracebility and an intelligent platform. Agents can have the characteristics of autonomy, reactivity, pro-activity and social ability (Wooldridge and Jennings 1995). Autonomy is defined as each agent operating without outside involvement, and controlling its actions and in-house states. The reactivity is the actions taken when the environment changes. Pro-activity is the ability to send own behaviour changes to the surrounding agents. Social ability represents the interaction that exists either between agents or agent and human (Serna, Uran and Uribe 2011). The mentioned features fit in well with the aim of optimising transport fleets and achieving sustainable distribution levels. Mckinnen and Ge (2006) mention that the reduction of empty runs relies on good networks and sharing of information. The features that the agents possess can reduce the human factor that often hinders networks and drive towards a more co-ordinated effort. There are other features namely: the ability to influence, self-learning capabilities, problem solving and co-operation as some examples (Moonen, 2009), that add to an agent's characteristics. Referring back to autonomy, there are four levels of it as described by Serna, Uran and Uribe (2011); strong regulation, operational autonomy, tactic autonomy, and strategic autonomy, with the main feature of the agents being able to react to their environment. The levels described form the basis for collaboration with other agents. These levels of collaboration and special features would depend on the goal of the agent within its environment. For instance, in an operational autonomy environment agents represent specialised services and react when needed, while a strategic agent would consider only operations that reach the goal of the organisation or person its representing. Figure 3-2 shows a model of the intelligent agent representing the different states of collaboration based on an autonomous messaging system (Lo, 2012). These states tie in with the levels of collaboration. MAS assist with real-time issues because of their pre-configured, reactive and pro-active nature. Systems that operate autonomously allow for potentially uninterrupted service delivery, which could be favourable and could deal with some of the challenges that transporters have i.e. lack of information and visibility of freight.

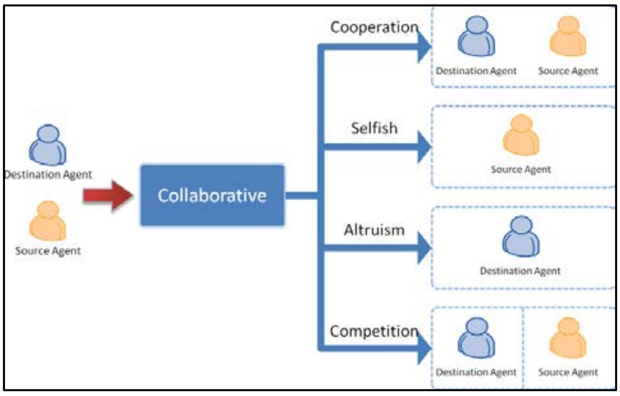


Figure 3-2 Diagram of MAS communication and collaboration extracted from (Lo, 2012)

3.6 Agent and MAS paradigm

The fast moving pace of computers and telecommunications has put pressure on the processing times of information between various applications from anywhere in the world. The Multi-agent paradigm is driven by this distributed nature of information processing with a need for high quality of service. It becomes a very promising technological paradigm to solve the issue of quality in distributed information handling. Because of its distributed nature various communication services exist for the agent technology, but it depends on what type of agent is operating within the environment. The understanding of the whole concept is essentially interacting agents placed in an environment, ready to perform actions with an intended outcome. Achieving the outcome the system relies on others to provide information and perform functions. Due to its dependency on other agents, it pushes for standardization of all agents operating in an environment to ensure there is inter-operability (Odell et al., 2002). The dependencies of these agents towards others can be either subjective or objective. The former gives an example of a negotiating technique between agents, while the latter is pre-configured to operate with an overall aim to achieve the environment objective. However as an agent is an entity on its own, technically it can perform basic functions without information from others. Although this may limit its capabilities. To explain the agent paradigm further some of the capabilities referred to in the previous section, for example, to view, act and negotiate, exists for agents but it relies on information from others to process and operate. The capabilities are set and designed within an agent framework, which is a set of programming tools (Farooq Ahmad, 2002). Constructing the agents depends further on the infrastructure framework it will operate within. The infrastructure then facilitates the agent operations with regulation, and ensures a communication analyses are performed for all agent entities, that is essentially are feeding of each other's output and inputs. Although it may seem the agents are constrained within the environment parameters, it can also be seen as agents take advantage of the services and facilities the environment offers. This is good in a system where players with limited infrastructure capabilities can enter into a MAS environment. This relates back to the paradigm describing the various states an agent can possess. Farooq Ahmad (2002) and Lo (2012) mentions a few states an agent can possess namely: - Facilitators, Mediators, Brokers, Blackboards, Yellow Pages, Collaborative or Cooperative. Each of these possesses its own characteristics that are specific to its system environment. The MAS paradigm because of these states and interactive nature shows potential for several implementations in dynamic environments that operate in networks. To achieve multiagent interaction there has to be a common language, format for communication and ontology. Popular languages Agent Communication Languages (ACL) and Knowledge Query and Manipulation Language (KQML) are discussed by many authors (Odell et al., 2002, Schleiffer, 2004, Weiss, 1999), and basically refer to human linguistics communication analysis on statements that require actions (Farooq Ahmad, 2002). It is also known as declarative languages for agents. In the past that used programming languages like Java were used to give agents procedural communication capabilities. ACL and KQML use different formats and parameters to communicate through its input fields, they are however essentially similar in message handling and action provocation. The field required in each of the communication formats is closely tied to the particular system it operates within. In this research transportation multi-agent systems and its format requirements are discussed.

3.7 Multi-agent systems transport characteristics

Transportation operates in a distributed environment, where a successful transporter has a moving fleet of vehicles that are geographically distributed and where dynamic events are handled as they arise (Wooldridge, 2007, Moonen, 2009). In transportation, freight is hard to predict and anticipate, with real-time decision-making being the key to the success of a fleet. Controlling a fleet successfully requires information to be centrally available and in real-time, however limiting the information to one central place might inhibit centrally based decision-making (Moonen, 2009). Singh, Lai and Cheng (2007) say that an operational level of decision-making is not favourable in a centralised system. A dynamic environment like transportation makes it difficult to have central control of all information and use this for clear decision-making (Serna, Uran and Uribe 2011). Transporters are autonomous when distributed or on the move and so are seen as entities that could redirect and change course if and when needed (Moonen, 2009). Changing or redirecting transporters needs a clear, concrete and overall view of the transport environment. Achieving this requires network connectivity to other entities that can send up-to-date information to others and allows decisions to be autonomous (Serna, Uran and Uribe 2011). This would improve the autonomous nature of the transporter who now could then have better information for decision-making. MAS systems are decentralised in nature, and favour the transportation environment (Moonen, 2009). Further, with negotiations and co-operation being normal activities in transport it matches some of the characteristics that make up an agent. An MAS has the capabilities and the algorithms to promote co-operative and negotiating features (Moonen, 2009, Lo, 2012). The platforms provide more than just access to view, post or retrieve transporter information, they process information independent from users. The agents represent transporters, and though customised with user requirements, they independently carry out requests and events on behalf of the users. To carry out these requests and events it requires good communication between agents, and this needs good languages to use. The previous section alludes to the formats that certain communication languages require and their importance to the particular environment it will be used. ACL is a common language designed by the Foundation of Intelligent Physical Agents (FIPA) and is often the preferred language in MAS. Farooq Ahmad (2002) describes the fields in the message format of the ACL: - Sender, Received, Reply-With, Content, Language and Ontology. Applying this to the transportation environment where a load has been made available through auction and the transporters who are agents, are the bidders. The identification of the message from one agent is indicated at the start. In this instance it is an “information” message. The fields could be mapped as in the figure 3-3.

inform {
Sender: Transporter (01)
Receiver: 3rd Party Provider (04)
Reply-with: Bid for load (#)
Content: Price (Bid Load (#)) $100)
Language: FIPA-ACL
Ontology: auction
}

Figure 3-3 Message format for ACL from transporter

The response in the same format populates the fields based on information required. However to reply the receiver agent has to analyse information from all other agents in the auction. The analysis could be of several factors like the price or as in some systems, agents who have ratings they consider. However the populated message will look as in Figure 3-4.

- inform {
- Sender: 3rd Party Provider (04)
- Receiver: Transporter (01)
- Reply-with: Bid for load (#)
- Content: Approved (Bid Load (#)) $100)
- Language: FIPA-SL
- Ontology: auction
- }

Figure 3-4 Format of message from 3PL

The message formats bring about the complexity of the transport MAS, where the communication and the coming to a common understanding of agents needs understanding. The key to a properly functioning and successful MAS environment is the careful consideration of the consensus among agents, which is important to ensure collaboration is achieved.

3.8 Consensus Dynamics

One of the main features of a multi-agent environment is the interaction of agents with partners and competitors to achieve one goal or task (Weiss, 1999). Although there is competition, the reality of the situation is that a multi-agent environment achieves much more than that which a single agent can achieve. Within an environment where collaboration and co-operation takes place there are bound to be conflicts. These conflicts bring in the subject of consensus within a MAS environment that has to be explored, as it is a major obstacle to achieving collaboration. Consensus is the state achieved where there is an agreement in shared interest (Wu, Xue and Yao 2010). The importance of achieving the consensus within a collaborative environment is essential to it's overall success. Olfati-Saber and Murray (2004) have shed more light on consensus problems for MAS that will need to be considered for this study. Many approaches for consensus in MAS have been proposed. These include the finite time model (Xiao et al., 2009), agents within a stochastic information network (Porfiri and Stilwell 2007), frequency-domain analysis (Tian and Liu 2008), double integrator dynamics (Zhu, Tian and Kuang 2009, Ren and Beard 2005), decentralised consensus control strategy (Wu, Xue and Yao 2010), and co-operative game theory (Semsar-Kazerooni and Khorasani 2009). Kwon, Im and Lee (2001) propose central operating agents that have higher priorities which can be put in place to allow for conflict resolution. Consensus theory investigation forms part of this research, to ensure that proposed solutions or systems allow for conflict resolution and consensus, as this will affect its performance.

3.8.1 Finite time model

Xiao et al. 2009 propose the finite time model against the impractical assumption that agents in a network should obtain information about position from global co-ordinates. The argument is that if there are a lot of agents in the network, the amount of information to be exchanged will be large, and the uncertainties and disturbances could affect transmission (Xiao et al., 2009). The finite time model proposed makes sense in large MAS environments with smaller operational areas that could function without regular inputs from other agents. The model uses the formation of global and local agents, where the former concentrates on accumulating the global information, and the latter only focuses on the local environment. The global agents are referred to as the "leader agents" who decide on the geometric pattern of desired information. Having a few leader agents that obtain the global information to direct the local environments ensures more consistent and easier data exchange. These can be seen as facilitators within the environment that avail and regulate the services within the environment. The local agents adjust their behaviour and positions according to the leader agents. The foundation of this consensus is referred to as the formation control framework. Xiao et al. (2009) believe that this type of formation of agents improves the robustness of a proposed protocol against the data transmissions and also ensures consensus is reached in a finite time. There is some logic in this method that could deal with critical situations or at least in an environment where an outcome is required fairly soon. Transportation in some instances becomes critical, especially when there might be perishable goods that need to reach the destination and they are time bound.

3.8.2 Stochastic information network

Porfiri and Stilwell (2007) discuss the stochastic information network for agents, where each agent is modelled as a vertex on a graph that determines its successes. A stochastic network is based on the receipt of random values over time. The communication of all agents takes place when the vertex edge interconnects with other vertices on the graph. The method uses stochastic graphs with arbitrary weight agents for communication, where the consensus among agents is treated probabilistically[2] (Porfiri and Stilwell 2007). Successful consensus is indicated where vertices are strongly connected and balanced over time. Vertices are undirected and the interconnection with others is not straightforward. In positively weighted graphs, it is believed that over time all agents will interact with each other. Practical applications are assumed in using this form of consensus e.g. a negative weighted graph may indicated declining communication among multi-vehicle teams. The method assumes consensus will be achieved asymptotically (Porfiri and Stilwell 2007), which means that a value or curve is approached arbitrarily closely (Weisstein, 2014). The consensus status and success within the environment is easily identified, with negative tendencies clearly spotted. The method, because of its stochastic nature, allows all agents an equal chance to achieve consensus over

[2] The word probabilistically used in computational complexity theories tests a proof through algorithms generated randomly and plots this on graphs (Pofiri and Stillwell , 2007).

time. This method is proposed for dynamic environments where scoring systems for agents are important to the future success of collaboration with others.

3.8.3 Frequency domain analysis

Tian and Liu (2008) consider the input and communication delays within a MAS using the Frequency-domain analysis. It is important to consider the delay, in an MAS environment, which is the time taken between agents when communicating. This is called the communication delay while the processing times when information or packets arrive are called input delays (Tian and Liu 2008). Consensus is achieved when agents share the same delay state value as their neighbours. This consensus requires that the agent learns and compares its own delay to that of its neighbours. Tian and Liu (2008) consider two decentralised conditions for consensus. One is a MAS based on undirected graphs similar to but with diverse input delays only, and the other one looks at diverse communication delays and input delays within undirected graphs (Porfiri and Stilwell 2007). Tian and Liu (2008) suggest that the consensus achieved is independent of the communication delay as long as an agent can be reached, while the input delays play a more significant role. A transport agent failing to process packets from other agents will ultimately fail in any future consensus. Tian and Liu (2008) refer to the topologies that need to be considered in a MAS environment to ensure being interconnected is achieved. In a transport environment one would consider this method to distinguish agents that have common input delays to collaborate to achieve consensus as opposed to all agents having an equal chance to link with other agents despite having delays. Agents adjust the communication and input delays so they match others and therefore should be able to find matching neighbouring agents more quickly. This method has a sense of the collaborative approach among lets say transport agents where they are forced to ensure they match their parameters to partnering agents to warrant future consensus. There is an element of adjustment and consideration required for collaboration to be achieved among agents. Its success is related solely to agents understanding and adjusting to the requirements to interact.

3.8.4 Co-operative game theory

Another method is the co-operative game theory to achieve consensus which is proposed by (Semsar-Kazerooni and Khorasani 2009). Game theory as suggested by Shoham and Leyton-Brown (2008) is used in interactive decision-making, and these days is commonly used in economics, political science and more recently in transportation planning. A simpler term is the study of mathematical models that involve clashes that use the outcome to achieve consensus among logical decision makers. Semsar-Kazerooni and Khorisani (2009) try to achieve consensus among a team of agents based on common values using the co-operative game theory approach. The theory is used within a team of agents where each one wants to optimise its own cost. Optimising the cost within a team shows neighbouring team agents that co-operation is preferred. If an agent chooses not to co-operate but manages to reduce its cost it increases costs for other agents in the team, thus affecting the whole team. If agents choose to co-operate they have to show other agents in the team their willingness and therefore minimize costs, and so ultimately providing a clear consensus strategy. Once a team of agents has a good consensus strategy it ensures lower costs than a team with a non-co-operative solution. Semsar-Kazerooni and Khorisani (2009) suggests that if agents achieve lower costs for most members using a certain set of consensus strategies, all remaining members will switch to this set. Within transportation a co-operative game theory approach would be sensible in urban transport planning or transport alliances where the consensus success is based on the compliance of all the team agents. The transport agents would try to minimize their own costs to ensure an overall increase in the performance of the whole team. This method would be most suited for transporters in fairly close proximity with various transportation routes or opportunities, and the clear benefit of collaboration is known.

3.8.5 Central operating agents

Central operating agents are suggested by (Kwon, Im and Lee 2001) in their approach to achieve consensus in an agent-based web service environment. Having centrally operating agents that control conflicts in a MAS environment could promote collaboration among agents (Kwon, Im and Lee 2001). Kwon, Im and Lee (2001) refer to the central co-ordinating agent as the Multi-Agent Co-ordination Enhancer for

Supply Chain Management (MACE-SCM) that is introduced as a separate engine that handles the strategic collaboration and consensus among agents. There is some similarity with the finite time model that has leader agents who facilitate communication among agents. The MACE-SCM is separate from all other agent identifiers and provides the framework for other agents. This framework is also known as the environment within which the agents operate. This framework is referred to as “the collaboration ontology” and it is a requirement for collaboration with other agents in this method as it provides information to agents (Kwon, Im and Lee 2001). The MACE-SCM is making use of a case base that acts as the regulator for agents within the environment (Kwon, Im and Lee 2001, Kwon, Im and Lee 2007). This information includes environmental data such as market demand, total cost and the total revenue in the supply chain. The MACE-SCM allows the other agents to access the case base information in order to decide whether to collaborate or not (Kwon, Im and Lee 2001). There are two situations where the MACE-SCM improves collaboration and consensus among agents. The first is a web service directory that agents can subscribe to by uploading profiles and parameter requirements. The MACE-SCM could then use the directory to find similarities among agents and when particular collaboration traits are identified, all other agents are discarded and only the remaining agents are used. The second is without a central directory where agents are sequentially searched by the MACE-SCM to find similarities. The latter could prove to be more time consuming and resource intensive in huge MAS environments. Applying this method in a transportation environment with a central operating agent could have some benefits especially in new collaboration initiatives. New collaboration initiatives would require the set-up of regulation and rules and the use of central agents would ensure that it is adhered to. A central operating agent is, suggested to be feasible among small shippers or organisations due to the relative inexperience in collaboration often demonstrated by them. Kwon, Im and Lee (2001) note that the MACE-SCM may not perform well in demand and supply uncertainties. However a further study on MACE-SCM, which specifically focussed on uncertainties, has introduced a prototype that makes the method feasible in a supply chain environment. Due to transport being the enabler of the supply chain, the method could be considered to achieve consensus among transport agents. Centrally controlling the outcome of a particular freight movement by assessing the waiting “transport” agents performance could be a method to ensure quality.

3.9 Transport based multiagent systems

Agent based software has been tested in a multi-modal transport scenario, as an intelligent communication support platform (Dullaert et al., 2009). Such a system can therefore act as an integrator that exchanges correct, reliable and relevant data. One of the most important characteristics though, is the real-time aspect that is very important in a transport and logistics environment (Dullaert and Van Landeghem 2007). Combining these systems with web-based services allows for platform independence and allows all stakeholders to have access with their in-house systems (Kwon, Im and Lee 2001). The intelligent integrating capabilities have another benefit to a transport environment when the autonomous handling of queries by agents can have a twenty-four hours a day collaboration directive. This chapter looks at various MAS systems available for transport environments.

3.9.1 MamMoeT

MamMoet is an intelligent communication platform for transporters that was developed by a Dutch organisation with the developers Dullaert and Van Landeghem (2007). This Dutch acronym, which stands for multi-modal transport was proposed as it is the most common form of transport in Europe (Dullaert et al., 2009, Dullaert and Van Landeghem 2007). MamMoeT provides a platform that allows companies to be represented by agents. It is seen as a virtual community where agents negotiate to achieve a certain goal on behalf of companies. These agent-based platforms have been seen to be a good fit to multi-modal transport, because of its distributed nature. The idea of the MamMoeT architecture as described by (Bernaer et al., 2006), is a one to one mapping of transport representatives to personal agents. These reside on central servers, and are usually manipulated and configured by users from computers. Bernaer et al. (2006) further states that because the agents are online constantly, questions, requests and views can be responded to quickly and without dependence on user availability. MamMoeT is classified as an intelligent communication platform, as it can match supply and demand for the transport sector, enable traceability of transportation and handle events, whether expected or not.

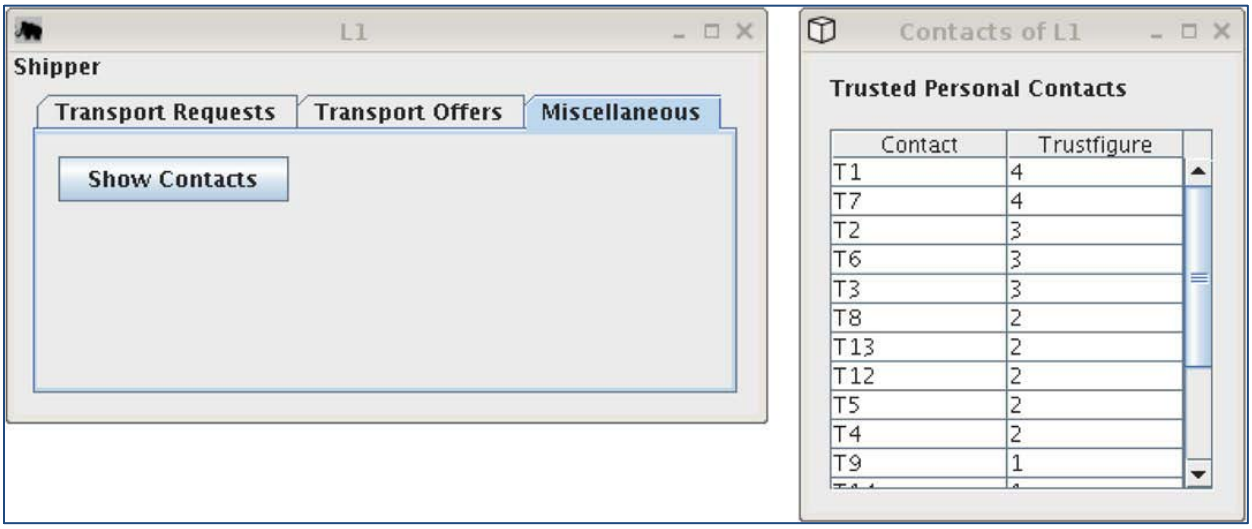


Figure 3-5 MamMoeT trust figures for Transporters (Dullaert, Van Landeghem 2007)

Agent-based platforms are a fairly new phenomenon in the road transport industry, however Dullaert et al. (2009), suggest the use of the MamMoeT platform for shippers and barge operators. These are represented as shipper agents and transporter agents in the system (Bernaer et al., 2006, Dullaert et al., 2009). Shipper agents place a transport request, view transport offers and manage trust figures. Trust figures are values numbered in the range of -3 to 4, assigned to transporter based on their reliability on delivering the service (Dullaert and Van Landeghem 2007). The higher the trust figure for transporters, the more chance they have of being used by shippers – see Figure 3-5. The system notifies a shipper if the request received a response, and can then decide if the response is suitable or not, and so adjust accordingly (Dullaert and Van Landeghem 2007). This process is an example of agents that interact with each other to achieve the best possible solution. The requests and responses are received by the opposite agents and are then handled based on figures and settings associated with them, without user involvement. This shows success of collaboration among shippers and transporters, and thus the potential for adoption within other environments.

3.9.2 Post-Kogeko

Post-Kogeko is an LSP company based in the Netherlands, and they have a specific interest in the movement of containers. Though Post-Kogeka performs transportation, distribution and forwarding as its core business, it offers other services such as financial and administrative support to clients. Moonen (2009) worked on a prototype of multi-agents to help improve container movements for Post Kogeko. The prototype considered the information that needs to be available to allow agents to decide on the best course of action when assigning containers to trucks. Moonen (2009) suggested that first monitoring agents (called TruckAgents) should be available to gather information on all truck and container movements as well as to check for traffic jams. This was followed by an OrderAgent who could respond to customer preferences as well as monitor the availability of containers within the network (Moonen, 2009). The OrderAgent when assigning containers to trucks considered timelines of delivery, the general movements of fleets, reduction of empty runs, and the potential delays in traffic. The system described by Moonen (2009) is easily comprehended, as it was modelled initially on human behaviour. The TruckAgent mimics the job of a LSP operator, who monitors trucks and as soon as one becomes available it starts to look for the next freight that could be assigned to the truck. The agents choose between orders received by selecting the highest ranked according to a score that each receives. This is based on a formula that considers various criteria like customer time windows, customer importance, empty mileage and traffic jam avoidance. The TruckAgent claims an order only when no other truck provides a better solution, then the trucker is instructed to execute the job. There are however other agents that were proposed in the prototype, the characteristics were as follows (Moonen, 2009):

a. TruckAgent:
    i. Finds the best order
    ii. Monitor order availability
    iii. Utilise truck locations
b. OrderAgent
    i. Find the best truck
    ii. Respect customer preferences
    iii. Monitor truck patterns
c. CustomerAgent
    i. Negotiate delivery time
    ii. Provide time preferences
    iii. Monitor deliveries
d. TerminalAgent

i. Coordinate truck arrivals
ii. Sort containers
iii. Monitor order arrival

Moonen (2009) performed the multi-agent system in Eclipse with a Qfreight database, which is an open-source java development environment. The agent toolkit used was the Java Agent Development Environment (JADE) that exists as a framework in Java. The agent toolkit employs a middleware that uses a graphical interface to debug agent logic and support the deployment phases. Moonen (2009) reiterated the efficiency of JADE and the light overhead that it had over the system. Figure 3-6 shows the dashboard of the Post-Kogeko prototype.

Figure 3-6 Post Kogeko UI (Moonen 2009)

3.9.3 Magenta Technology

Magenta Technology is a software development company known for providing scheduling solutions in transport and logistics. Solutions range from real-time scheduling of transporters to haulier management systems. Magenta advertises field-tested Multi-agent solutions in ocean and road fleet management (Rzevski, Himoff and Skobelev 2006, Himoff, Skobelev and Wooldridge 2005). Magenta Technology also provides dispatch and tracking solutions for car rental companies called Wizmap (Himoff, Skobelev and Wooldridge 2005). Through this technology companies can make use of real-time dynamic scheduling and thus optimise deliveries and collections. The technology comprises of PDA handheld devices that provide position of drivers and communicate requests quickly and with minimal disruption. Multi-agent solutions become easier in these environments with a technology set-up and communication up to a particular standard with the handheld devices (Rzevski, Himoff and Skobelev 2006). A solution by Magenta that builds on this technology is the Multi agent software called iOcean to help identify and specify the best cargo combinations within a fleet – see Figure 3-7. It uses the dynamic fleet scheduler that identifies cargo, matches it to the fleets and then calculates the profits of this particular combination. It bases its decision making on the most advantageous schedule at that moment. As with all multi-agent setups, the system allocates an agent to each stakeholder within the network. These agents find the best possible combination within the entire fleet. Individual requests and submissions are handled in such a way that it is strategically beneficial to all players (Himoff, Skobelev and Wooldridge 2005, Rzevski, Himoff and Skobelev 2006). Agents through parameter set-ups consider several factors: freight rates, costs, ports, transporters, distance and positions and speed (Rzevski, Himoff and Skobelev 2006). The system also makes use of a knowledge base that agents use to store decisions and become parameters to consider in the future.

Magenta platform

Magenta is programmed on the Sun Microsystems platform, using the Enterprise Java solution for easier integration to Java services (Himoff, Skobelev and Wooldridge 2005). Magenta uses this platform to design their solutions using the Ontology Management Toolkit. The aim of the toolkit is to provide designers with the means to map business processes into objects and classes in Java. The capturing of the business knowledge and processes is done through ontology (Himoff, Skobelev and Wooldridge 2005). The main aim though within a Multi-agent system is to get these ontologies from different elements/players to agree or abide by similar rules. The ontology concept is thus designed to provide the overview of a Multi-agent environment, then players can provide their attributes and features based on this (Himoff, Skobelev and Wooldridge 2005).

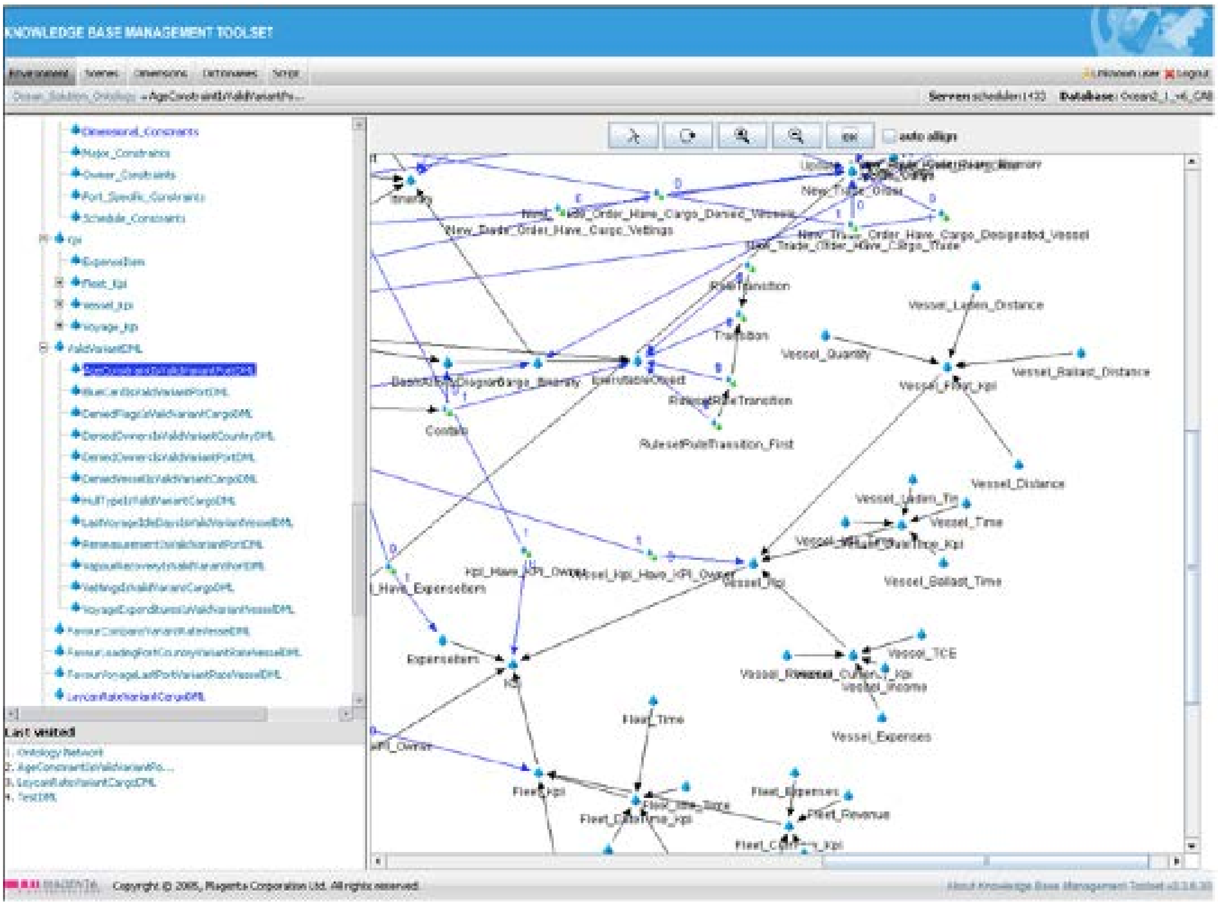


Figure 3-7 iOcean Scheduler Screenshot (Rzevski, Himoff and Skobelev 2006)

3.9.4 NuTech Solutions

Nutech solutions (recently acquired by IBM Netezza Corporation, previously known as the BIOS Group) is a software development company that specialises in artificial intelligence (AI) (Belecheanu et al., 2006). Organisations could approach Nutech seeking automated solutions to their problems. Nutech has made use of artificial intelligence solutions that are biologically driven. Biological theories have become useful in complex adaptive applications especially in logistics (Leitao, 2009). Nutech took advantage of this and demonstrated these technologies to solve complex transportation and other problems in the two following cases.

Case one: Air Liquide experienced difficulties in delivering industrial and medical gas to the industrial customers, as their demands changed frequently, and the routing process of delivery to the plants was time consuming and inefficient (Leitao, 2009, Belecheanu et al., 2006). Nutech developed a computer model based on certain algorithms that behave like Argentine ants. The ants use pheromones to release the toxins as they moves, and thus trails become reinforced for others to use (Leitão and Vrba 2011). Similarly Nutech sends numerous agents out to find the most frequently used routes and assigns trucks to these (Belecheanu et al., 2006). The system factors in the production schedules and adapts this to projected energy prices. It also takes into account weather and client demands. Based on this Air Liquide combined the ant technology with other AI techniques, to get the best possible solution for truck routing on a daily basis (Leitao, 2009).

Case two: a solution from Nutech that incorporates ant technology and swarm intelligence/behaviour principles (i.e. collective behaviour of decentralised or self organised systems), which were used to get planes faster to and from available gates at Sky Harbour International Airport (Leitao, 2009, Belecheanu et al., 2006). Swarm intelligence mimics the traits of bees that work together for the overall benefit of the hive. The idea in MAS is to have the agents behave like bees by interacting locally with others, but end with a complex system that provides overall global behaviour (Leitao, 2009). Pilots at the airport use their knowledge to find the best solution for their arrivals and departures, and these solutions will be the same for the whole airport (Leitão and Vrba 2011). Pilots try to go the gates that allow them to arrive or depart as quickly as possible through the use of alerts from the airport that notifies them of gates that will open in due course (Belecheanu et al., 2006, Leitao, 2009).

These technologies provide a different solution to others mentioned as they use biologically derived behaviour to create complex solutions. Figure 3-8 shows the engineering of a complex distributive and adaptive system, used in Nutech solutions.

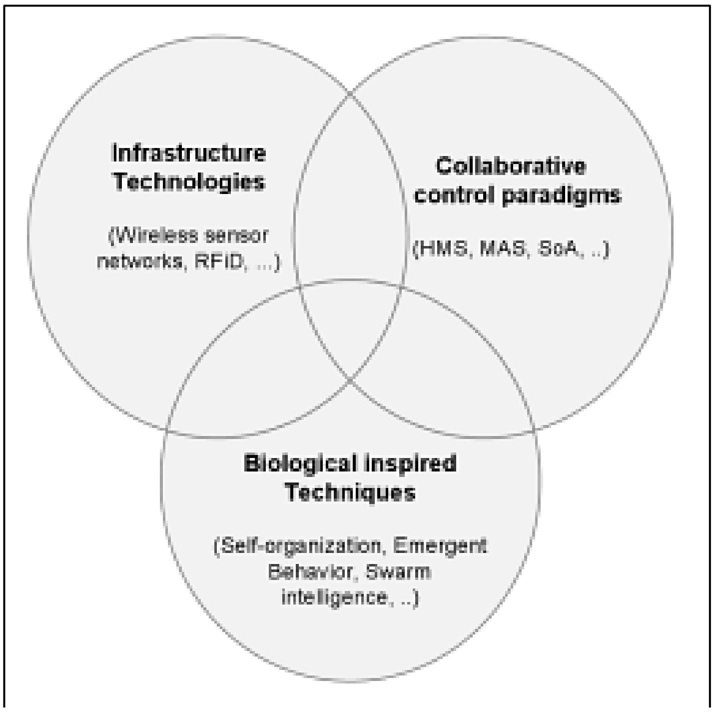


Figure 3-8 Complex distributive and adaptive system engineered (Leitao, 2009)

3.9.5 Whitestein Technologies

Whitestein Technologies from Switzerland is an innovative software development organisation that bases all its designs on the detailed understanding of their customers business operations. Whitestein has developed agent-based solutions to automate the optimisations of large-transport companies (Luck, 2005, Belecheanu et al., 2006). The system operates by taking into account the size of fleets, cargo and its drivers to find optimised solutions (Luck, 2005). Planning in transport when performed manually has some difficulty if unexpected events occur. Manually changing routes or vehicle can be time consuming especially in a hectic transportation network. Whitestein agent technology tries to curb this, by relying on the driver and freight updates to plan future trips through automatic agent negotiations. According to Belecheanu et al. (2006), the Whitestein agent infrastructure only makes up 20% of their entire solution, as all other information is processed by other interfacing systems. Figure 3-9 shows a Whitestein agent infrastructure and module within real world IT applications. Brantschen (2002) following trials and discussions with agent challenges in the real world emphasises that agents systems require a well-defined platform and infrastructure.

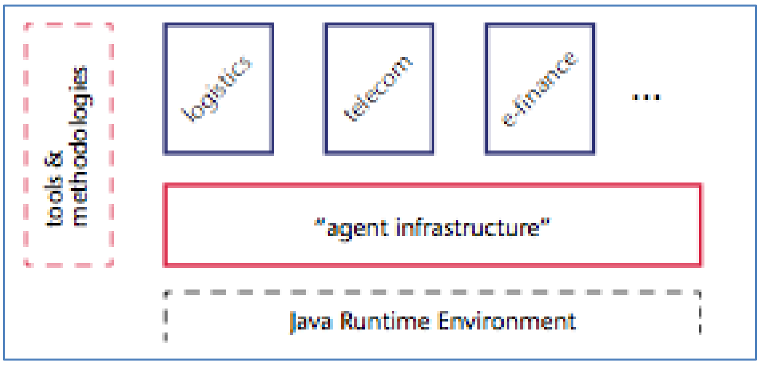


Figure 3-9 Whitestein Technologies by Brantschen (2002)

The Whitestein application server or middle tier is where all business logic is configured for agents. The server receives information through various protocols from the frontend and backend systems. The former using IIOP[3], SOAP[4], UDDI[5], WSDL[6] or ebXML[7] while the latter uses standard sql, or are open to proprietary protocols (Brantschen, 2002). However there is very little information on the initial communication languages used like FIPA ACL and KQML that laid the foundation for the initial agent architecture (Farooq Ahmad, 2002). Belecheanu et al. (2009), explain that the Whitestein setup assigns individual agents to each transporter. These agents then negotiate on behalf of transporters to determine if loads are available or could be assigned to other transport agents. However because of competition among agents, it uses an auction based system, where the agent with lowest delivery cost wins the auction (Belecheanu et al., 2006). All the information used by the agents is based on communication from its transporters. The information starts from its current location and its route, plus its capacity and availability.

[3]Internet Inter-ORB Protocol (IIOP)
[4] Simple Object Access Protocol (SOAP)
[5]Universal Description, Discovery and Integration (UDDI)
[6]Web Services Description Language (WSDL)
[7]Electronic Business Extensive Markup Language (EbXML)

3.10 Discussion

Agent software defined as independent operating entities that could operate within an environment, are at the forefront of distributed systems. The spawn of Multi-agent environments that through computational capabilities mimic human or organisation processes is suggested for transportation systems. Well-managed transport environments possess the features of autonomy and uncertainty that match a MAS requirement. Distinctive MAS with the feature to handle unforeseen events are favoured by many researchers i.e. (Moonen, 2009, Dullaert et al., 2009, Lo, 2012) in transport environments. Environments are seen as the platform upon which agents operate with various methods for modelling their behaviour. Typical 3 tier systems (application, middleware, infrastructure) describe these differing environments with requirements at each level according to the particular system goal. The main purpose of most transport MAS is to handle unforeseen events without human intervention. MAS that can equip agents with autonomy characteristics should achieve this. However communication is particularly important to achieve this. Agents need clear language guidelines to ensure formats are adhered to and operating environments are matched. Together with this to achieve common agreement among agents there are several consensus dynamics to assist. MAS systems rely on achieving consensus as this guides collaboration among agents. Agents possessing these collaborative features can represent transportation stakeholders to achieve collaboration. However systems like MAS have not been applied within a developing country such as Namibia, and this research has set out to investigate its potential implementation to promote collaboration among transporters and so reduce the number of empty runs.

4 Research Design and Methodology

4.1 Research Method

The study had an interpretive component where the acquisition of knowledge regarding the current practices and methods of collaboration as well as the level of integration of systems and processes among the transport stakeholders in Namibia is evaluated. The inclusion of the percentage of empty runs experienced by stakeholders has set a measurable value based on the practices and methods associated with it.

The study included an observation, literature and a software study into variations of transport MAS designed, implemented or tested. The investigation of these has a focus on the suitability for transport stakeholders in Namibia. The suitability focus has entailed checking if the system can run in a Namibian Information Technology (IT) environment and if it is compatible to read information from many of the existing stakeholder IT systems. The selection of various MAS has been the basis for the comparative element of the study, where the selection of a suitable system for further exploration was proposed.

The study had an empirical component with an evaluation of selected systems. The evaluation entailed running the selected systems with relevant historical or real world information received from ES or transport stakeholders. The MAS feedback was evaluated to see if information derived assisted with decision-making on carrier movement to benefit the related stakeholders and ultimately verify if the number of empty runs could be reduced.

Though the research was mostly positivist through its empirical observation, system evaluation and theory verification, it also included an interpretive component that gave a constructivist view to the research. This view was derived from the collection of knowledge to understand systems, processes and methods.

4.2 Data Collection

Data has been collected through four main methods

Semi-structured interviews: This was the preferred method for the interpretive component where there can be questions that are measurable i.e. empty running percentages, but can also include questions that could allow for more detail and explanations pertaining to the systems and methods in use.

Literature and software study: The study started with an extensive literature review on existing MAS for transport. This necessitated journal and books reviews, online searches, demonstration download, installation, testing and evaluation and finally email or telephone correspondence with designers, modellers, consultants and users. The analysed results from the correspondence have been referenced as personal communication/interviews/site visits/telephone and email.

This study included information from previous data collections in which the author was involved, where semi-structured interviews were conducted to obtain stakeholder information. Although this study included a broader stakeholder list (i.e. user, logistics companies, freight forwarders, state, logistics service providers and transport firms) (Savage, Jenkins and Fransman 2012), the author extracted information suited to this study. The background of the study showed that the stakeholders were chosen from directory services and telephone directories, with the organisations purposefully selected to reflect the stakeholder types (Savage, Jenkins and Fransman 2012). The interviews were face to face, and lasted between 45-60 minutes. The transcripts were analysed using the Nadin and Cassell (2004) data matrices strategy, to analyse similarities and differences from responses received. These matrices were reviewed and combined with information received from questionnaires stemming from this research.

Questionnaire: The questionnaire in this study was created for the local transport stakeholders to obtain a better understanding of their perceptions on collaboration methods and empty running in the country and to support and build upon the findings from (Savage, Jenkins and Fransman 2012). The questionnaire also included a section to obtain the technological stance of stakeholders in order to help determine the feasibility of MAS in Namibia.

Observation: Firstly as part of the information acquisition on stakeholder processes there was an observation study that added to the semi-structured interviews. Secondly there was an observation of software in practice that was conducted through the viewing of demonstrations and videos of tested solutions at companies conducted by previous researchers. Identified software was derived from the literature and software study as well as from responses received from previous researchers on MAS.

4.3 Data Analysis

Following the semi-structured interviews the information was segmented into stakeholder groups for comparisons. The information obtained from the groups was inserted into a data matrix to provide a better overview and cross-site comparisons to identify similarities and differences in the methods, processes and systems. The analysis included a mapping process to allow for the identification of the shortcomings of collaboration. Since the study had a qualitative component and the sources were multiple varieties, data matrices were recommended (Nadin and Cassell 2004).

The information obtained from the literature and software study was divided into the features and capabilities that the systems provided. These were analysed and rated according to the suitability for the Namibian transport environment. The planned questionnaires were added to further develop an understanding of and the suitability of the collaboration systems through giving an experienced rating of the systems. These two analyses made use of Nvivo 9 to allow for the selection of a system for further exploration. Nvivo has allowed for the analysis on new perspectives to gain a better understanding and has central management capabilities.

The information obtained through the first observation segment of the study has been documented and analysed with the semi-structured interviews, to provide an outsider’s view of the methods, processes, and systems. The results were mapped into flowcharts to show areas of collaboration. The second observation on MAS was analysed and compared to produce real world examples to compare or match with the output from the literature, software and questionnaire study. This observation gave the basis for the selection of MAS that would be feasible for implementation.

5 Current Transport Collaboration Findings

5.1 Introduction

Understanding the management of fleet operations of companies in Namibia is important for two reasons. Firstly, it gives a general picture of the state of operations in country, and secondly it provides a springboard for further planning and improvements for all processes in the sector. This section provides a view based on responses from stakeholders on a survey and partly from a structured questionnaire conducted through interviews.

5.1.1 Empty Runs, Less-Then-Truckloads (LTL), Full-Truckloads

Empty running as stated by (McKinnon and Ge 2006) is the running of an empty truck on one leg of a journey. The higher the percentage of empty runs experienced by a transporter, the higher the cost. Savage, Jenkins et al. (2012) findings, based on stakeholder views, has put empty running at 50%. However to get a broader view of the stance of transport runs in the country, one has to look at the other indicators such as ‘less-than-truckloads’ (LTL) and full truckloads (FTL) of transport. LTL is defined by McKinnon (2010) as a service provided to transport relatively small loads. This is a service that combines the loads of several different companies on their trucks, for a more cost effective solution. LTL is the movement of freight that does not require a large truck and trailer, and is normally handled easily on route to a destination. The use of LTL is a suitable way for an organisation, if transporters are experiencing empty runs. FTL is the movement of a large cargo on a truck with a trailer, where the cargo fills a trailer and is usually assigned to a single customer (Piecyk and McKinnon 2009). FTL is usually destined for delivery without intermediate handling, and a transporter usually specialises in a particular freight in this segment. Understanding these (3) three stances provides a better view of transport operations experienced by stakeholders in Namibia. The survey conducted asked stakeholders to give an estimate of occurrences of these three stances of fleet operations. The results are seen in the figures 5-1 to 5-4, based on a 33% response rate from transport stakeholders.

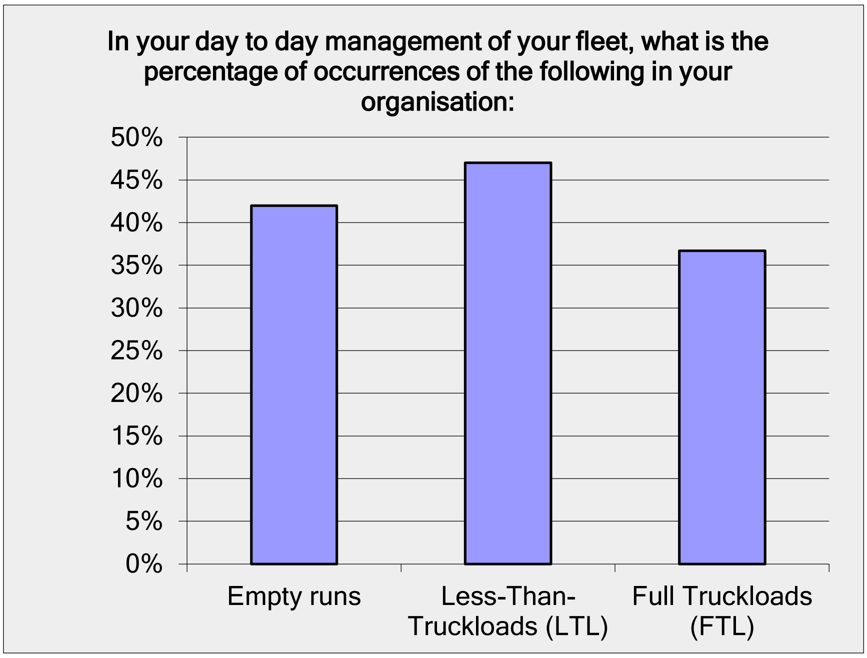


Figure 5-1 Percentages of stakeholders experiencing LTL, FTL and Empty-Runs

Figure 5-1 interpreted shows the percentage of respondents that experience the (3) transport stances. Empty runs pegged at a little over 40% does not deviate too much from the findings by (Savage, Jenkins and Fransman 2012). However what should be noted was that the questionnaire used in this study targeted transport stakeholders that specifically have a better a view on transport and empty running and thus provide a more accurate percentage which could be used. Savage, Jenkins and Fransman (2012) received their estimates from general stakeholders in Namibia. However even if its slightly less than the their estimated 50%, an empty running percentage of over 40% is still high and is not sustainable, as suggested by (Moonen, 2009). It provides a foundation for this research that aims to propose a solution to reduce it. The results, which can be seen in Figure 5-1 may also suggest that empty-running could have been at a higher rate as there is a high percentage of LTL. Since LTL is the combination of several loads from different companies on one transporter this could be seen as organisations recognising the high percentage of empty runs and thus combining with LTL. The findings are further explained in Figure 5-2 that shows the percentage of occurrences of each stance within the respondents' organisations.

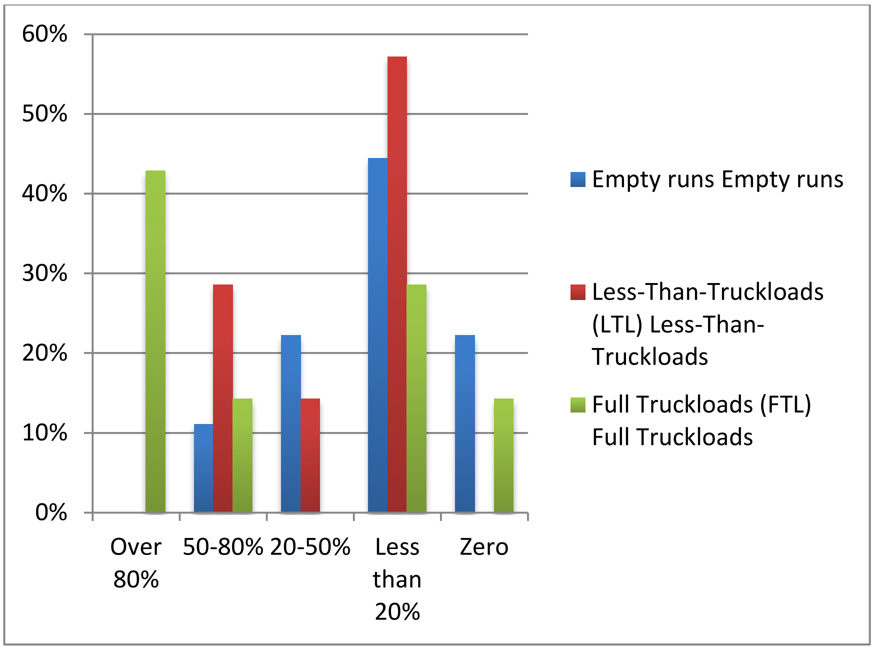


Figure 5-2 Percentage of stakeholders per LTL, FTL and Empty Runs

Initially the results would seem to show that about 42% of respondents have over 80% FTL. This could indicate that there are several transport contracts among stakeholders that require FTL delivery of freight and also shows that there could already be some form of collaboration taking place on a more formal basis. Results show 28% of respondents experience less then 20% FTL in their organisation while 14% notice it happens between 50-80% of the time. The percentage of respondents that experience some form of FTL from the 33% response rate stands at 52%. Results also reveal an anomaly with about 57% of the respondents indicating that LTL occurs less than 20% of the time. However only 28% respondents have put LTL between 50-80% of time, whilst slightly more than 14% have this at 20-50% of the times. The percentage of respondents that experience some form of LTL from the 30% response rate stands at 40%.

LTL figures are a good indicator for transporters opting for this option when empty runs are experienced. Looking at empty running being the most relevant to this research It has been noted that over 40% have indicated that they experience empty running in their organisation. This can be further broken down with the largest percentage of 44% respondents indicating that it occurs less than 20% of the time, while 33% (11%+22%) indicate that it occurs between 20-80%. A positive part of the results is that 22% of respondents indicate that there is a no empty running occurring in their organisation.

Thus though over 40% of respondents experience empty running, only about 33% are within the unsustainable limit of 25-50% as suggested by Moonen (2009). Though not as high as one would expect the research still explores the reasons for empty running. There are several reasons for the empty run result, with Savage, Jenkins and Fransman (2012) finding the lack of collaboration being the main cause of empty running. This research asked respondents to give reasons if they experience more than 20% empty running. Some stated that "there are not enough backloads" which refers once more to the volume levels on certain corridors. Some respondents gave other reasons such as poor planning and linkages in the transport sector. They also referred to the poor balance of trade in the country with freight mostly coming into the country and going to the north, with very little going out or coming down from the North. This reflects the findings of Savage, Jenkins and Fransman (2012) who noted the volume of freight going up to the North to service the less developed regions, with very little being sent back. Analysed results from previous data collections include a customer saying that "trucks are nowhere to be found, we just see them on the road but don't know their origin or destination". A freight forwarder also states "I am willing to work with anyone on transport, but I need details which are difficult to find". Although there are other reasons these results show it is primarily the lack of integration, information and collaboration among transport stakeholders that are the main causes for the number of empty runs.

5.2 Collaboration among stakeholders

The research set out to determine if the lack of collaboration contributes to the empty running experienced by transport stakeholders. This section looks at the collaboration methods that exist for transport stakeholders, and also indicates which are the common ones used among Namibian transport stakeholders.

5.2.1 Collaboration methods for transport stakeholders

Collaboration can take many forms and with different types of partners. An organisation can collaborate with local, regional or international partners if they choose to, as long as they can come to some sort of agreement. Deciding with whom and with what ease to achieve this agreement are the decisions that organisations face. The agreements can take many forms, and this research has considered a few that are possible and the ones most likely to be experienced by Namibian transport stakeholders. These are:

a. Arms-length, Transactional, One-off

These are agreements that do not need to be formally set-up and operate on a transactional basis where organisations identify quick collaboration opportunities. The agreements are usually seen as low return and often as a “one-off”. A Logistics Service Provider (LSP) explains an example of this by saying **“**Identifying potential backloads is a key daily task” (Savage, Jenkins and Fransman 2012). This type of collaboration although often the preferred way in developing countries, holds some sort of risk as often the partners chosen are not contractually bound and may change their mind from what was agreed originally. A transactional or arms length agreement does not often repeat itself, however it could pave the way for more formal agreements.

b. Formal Long and short term agreements

These are established signed contracts that are valid over a certain period of time. The agreements can be either long-term; spanning from a few months to several years or short-term contracts that could be from a few days to several months. The agreements are legislatively bound and require specifications of terms for all parties to adhere to. The contracts when agreed upon require the parties to have a responsibility towards the agreement, and often have steps included for when and how contracts can be terminated that are satisfactory to all parties. These types of agreements although often identified as beneficial to all parties often lead to more strategic partnerships when success is achieved.

c. Strategic Partnerships

A strategic partnership is a formal agreement set up for organisations that have identified that they need assets or capacity from each other but that are too difficult to acquire by themselves. This type of collaboration can be explained with an example of specialised abnormal loading vehicles which are sent from a partner in South Africa when they are needed. The partners often wish to extend their business but can not do this on their own and thus identify potential organisations that have the necessary assets to achieve this. These partnerships can often be very complex and may require negotiations to iron out areas such as profit and expenses sharing, but ultimately are set up to help both organisations grow.

d. Integrated IT systems

Integrated IT systems are the linking of organisation systems of different partners to promote information sharing and allow for better co-ordination. The integration allows the visibility of processes and data of all entities linked, and is used to automate certain processes. Automating processes saves time for both parties. An example, provided by a retail customer, shows that they have a system connected to a distribution centre that receives automatic notifications of stock levels and sends replenishments when certain levels are reached. These systems are used when formal agreements or partnerships have been created and are often included in the requirements of the agreements.

e. Internet Portal Communities

These are referred to as on-line or virtual communities that can take a social network service, blog or discussion forum form to allow members to interact. Internet portals are often in the form of posted communications that do not require an instant response. However, there are other ways members could interact immediately, such as, chat rooms or instant messaging services. The online portal systems usually require some form of registration or a profile to identify the person or organisation. This can either be free or require a nominal fee to take part. Within transportation, freight brokerage systems are an example, where transport operators register their profiles and could post information about their next delivery destination or date. The success of internet portal communities depends on the accuracy of information posted and the regular update and participation of all members. There are disadvantages with some of these portals where no screening is done and this often leads to unwanted and inaccurate profile registrations that contribute to a lot of false information. However if information is accurate it could be a useful tool to allow for collaboration.

f. Joint Tendering

This is where a group of individuals or organisations join to bid for a specific tender. The joint tendering includes various forms where sub-contraction is allowed, but where all groups assume or share the liability towards the tendering authority. The agreements include the assigning of full authority to a member from the groups who then handles administrative duties when the tender is assigned. The groups are usually within the same line of business but could be tendering by different lines as well. A joint tendering example is small transport firms that join to apply for a forthcoming tender thereby increasing their chances of the tender being awarded (Beevor, 2013). This often allows smaller firms to gain valuable experience. In the complex world of tendering that requires a set of deliverables that are difficult to cover by one particular company it pushes the idea of joint tendering as a means to curb the requirements Joint tendering requires established partnerships through legal agreements that cater to the requirements of all parties and also protects all organisations. Another example is from Jacobs, (2010) who has seen a joint tendering process that was legally set up but then completed with one of the partners not adhering to some deliverables. This meant that the other partners had to satisfy the outstanding deliverable but in the end received a bigger profit share. Joint tendering can achieve success for many partners if all adhere to the deliverables required.

g. Alliance Agreements

These agreements are started between businesses and refer to members that are trying to reduce costs or improve their customer service. This is an agreement set up between members to share risks and costs to achieve a similar goal. The agreements can stem from new projects that specify the scope and the period of the alliance and are managed centrally until the completion and sign off of the project. The agreements are often suggested when risks are not easily identified before projects start and the alliance can be set up to cater for any unforeseen risks or requirements. Alliance agreements can include several businesses and could form part of other global alliances (Grand Alliance, 2014). Alliances have guidelines that all members should adhere to but are set up in agreement with all parties. Alliances can be long term and could provide extra benefits to the members associated, for example in a transport alliance where buying transport fuel in bulk or applying for joint maintenance contracts on all vehicles can be done at reduced prices.

h. Common planning and information sharing

This is similar to the transactional or one-off collaboration however it involves a lot more planning beforehand with identified partners rather than a crisis or backup approach, as is often the case in a transactional-agreement. The planning involves the sharing of information on certain projects and identifying partners that would be willing to collaborate by sharing their own activities. The information sharing among supply chain partners has seen its success demonstrated with the “beer game” by MIT (Lee and Padmanabhan 1997). Common planning helps to mitigate the uncertainties up and down the supply chain. In transportation there can be a sharing of planned or current movements which helps other potential partners identify ways to collaborate by considering how their plans could be integrated. An organisation’s yearly projects or job planning could include potential partners deciding if they are willing to join or not. A common understanding in planning, if successful, could pave the way forward for the synchronisation of company activities with others.

i. Synchronisation of activities

Synchronisation agreements are when partners identify similarities of activities with other partners and then decide to join to reduce costs in delivery of the same service. Synchronisation of activities requires information sharing and identifying potential areas where it would be sustainable for all parties. Achieving synchronisation can be useful but is usually only seen among players in the same line of business. Another example is the synchronisation of warehousing and logistics functions such as the scheduling of staffing and machinery to load and unload shipments at certain times (Cruijssen and Dullaert 2007). This should be beneficial in reducing idle times, reducing waste and repetitions. In transportation synchronisation between companies can have numerous benefits: - environmental benefits in reducing carbon emission through fewer carriers on the road, reduction of uncertainties and freeing up of resources to allocate to other existing or new projects. Achieving a synchronisation of activities can become demanding and requires a lot of collaboration.

5.3 Collaboration and Integration in Namibia

The question posed to transport stakeholders in Namibia was "*Does your organisation collaborate with its supply chain members?*" This question was aimed at finding an overall view of the collaboration status within industry. Though the sample of 33% is small it can be used to give a general view, over 90% of respondents said "*yes"* to this question. Following on from previous research done by (Savage, Jenkins and Fransman 2012) where collaboration and integration were analysed and were found to happen purely by chance among supply chain players, this answer received from a specific stakeholder group with common interest gives a more positive picture. The next question was to find out the methods of collaboration among the transport stakeholders, and so determine if the collaboration mentioned by 90% of respondents is sustainable or not. The levels of integration or collaboration methods – section 5.2.1 – have been put on a Likert scale (to a large extent…not at all). This was to determine the commonly used or preferred mechanisms by the Namibian transport stakeholders. Figure 5-3 shows each collaboration method and put a percentage of stakeholders that use it and to what extent. The figure shows the arms length or transactional method being used to a large extent in their organisation by about 55% of respondents. This percentage agrees with (Savage, Jenkins and Fransman 2012), who put their respondents on a scale from 1 to 5; where 1 was an adversarial approach to collaboration and 5 representing full long-term strategic partnerships. The respondents scored an average of 3 in their research. Savage, Jenkins and Fransman (2012) separated the stakeholder groups and noticed that transport operators lean more towards an arms-length transactional methods while the Logistics Service Providers (LSP) lean more towards stronger partnerships. There is however an interesting indicator where over 20% of respondents do not use arms-length methods at all. This shows some maturity of collaboration where other more secure methods are preferred. The figure shows this with over 60% using formal short or long term contracts when doing business. This is a good sign for the industry and demonstrates a potential shift by many to more strategic methods of collaboration.

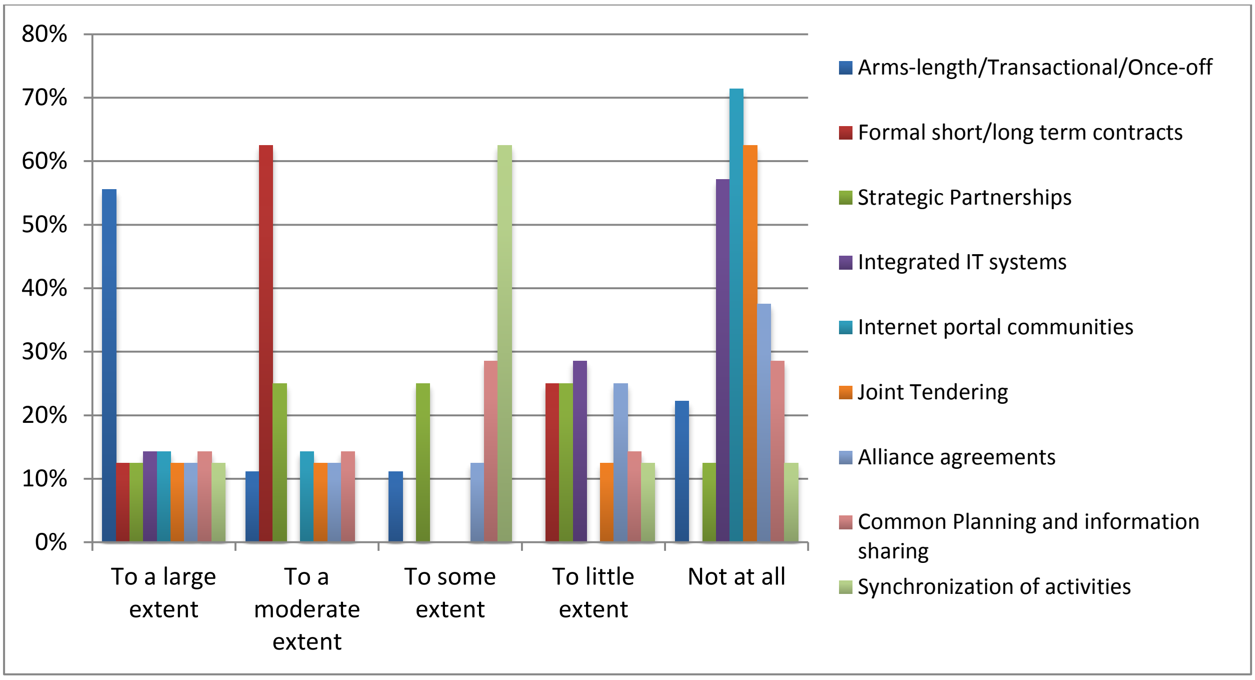


Figure 5-3 Collaboration methods used by Namibian stakeholders

Another indicator of diversified methods is practised by a small percentage of respondents –see Figure 5-3 '*to a large extent*' – indicating that an average of over 10% use all the methods offered to them. There is still a lot of room for improvement in this area and pertaining particularly to this research it would be encouraging to see more Integrated IT systems and internet portal communities being used. Though there could be other factors like poor technological capabilities seen among transport stakeholders that could be a hindrance to these. This is elaborated on later – see Section 6.3. Integrated IT systems reach over 55% with many stating they do not do this at all while Internet portal communities stand at over 70%. Savage, Jenkins and Fransman (2012) discovered from some that they did not use IT at all in their business while others stated that it was difficult to integrate different and sometimes obsolete systems. This could be the reason for the response rates for these two particular methods. However there could be other hindrances like the lack of expertise and the cost of integration in the country. A respondent from the interviews sheds more light on this matter by stating that "it's taken 5 years for IT consultants to finish the customisations of our systems". This normally has huge cost implications for organisations and can usually only be afforded by big enterprises. The integration of IT systems is not completely discarded, with over 27% doing this to a little extent. *Figure 5-3* further illustrates that other important methods stand out like synchronisation of activities which is practised to some extent by over 60% of respondents. This could be a sign of the transparency of activities among stakeholders where synchronisation is seen to be beneficial. It is not possible to state which group (e.g. freight forwarder, transporter, logistics service providers) of the transport stakeholders uses this method as many skipped this part of the questionnaire. The synchronisation of activities shows the willingness of stakeholders to collaborate and also to share information. These are both good indicators which are needed for a possible successful future for collaboration in the country. The literature review touched on joint tendering achieving great success in European countries, but from the findings this does not feature highly among Namibian transport stakeholders. This is a worrying factor, as a developing country such as Namibia issues over 30 tenders to transporters annually (aztenders.com, 2014). There is huge potential in joint tendering for the growth promotion of small organisations and the further extension of players into regional and international markets. Due to the difficulties when building a business in a modern era the industry might have to look from a financial point at improving this method of collaboration to help organisations who on their own could not win a tender. This method also helps smaller organisations that normally lack the means to collaborate gain access to systems owned by larger organisations to do this.

The collaboration and integration among transport stakeholders does exist, but further promotion of this is needed. *Figure 5-4* shows the rate of collaboration in Namibia from stakeholder responses. A mature, prospering and well performing transport industry collaboration and integration should be common among the majority of players.

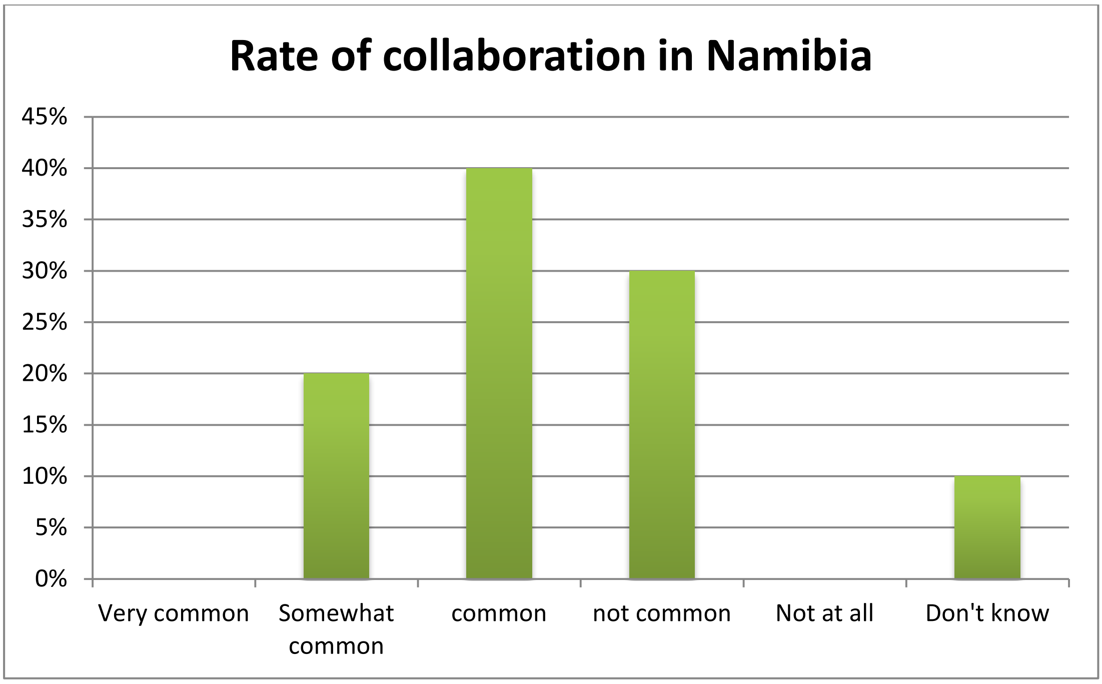


Figure 5-4 Rate of collaboration in Namibia

Organisations sharing information further then their own company walls and broadening their collaboration initiatives achieve greater success than the closed up solo operator (Ding, Guo and Liu 2010, Pokharel, 2005). In promoting and achieving collaboration the transport industry has the potential to reduce the empty running percentages discussed in earlier. To justify the need for collaboration systems targeted stakeholders were asked a few statements on collaboration to check the level of agreement. The results show some variance amongst the respondents – see **Error! Reference source not found.**. A small percentage states that systems already exist, however the majority show some kind of uncertainty by being neutral. It is clear that 60% of respondents agree that collaboration is lacking in Namibia, and notably 66% agree that collaboration among transporters can reduce empty running. If the promotion of collaboration achieves success and the transport industry becomes a knowledgeable collaboration segment it should be easy for stakeholders to accept systems like Multi-agent systems (MAS) that could take collaboration to a new level.

Table 5-1 Stakeholders view on collaboration and empty running

To what level do you agree with the following:					
Answer Options	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Collaboration among transporters is lacking in Namibia	10%	50%	30%	10%	0%
Collaboration among transporters is easy to achieve in Namibia	0%	44%	22%	22%	11%
Collaboration among transporters can reduce empty runs	44%	22%	22%	11%	0%
Collaboration platforms are available to the Namibian industry	22%	0%	56%	22%	0%

6 Feasibility of MAS in Namibia

A feasibility study as described by Pergl (2010), sheds more light on the viability of the implementation of a recommended system, by identifying crucial aspects based on requirements. It should be noted that Pergl (2010) suggests this analysis for software development projects. This research extracts a small part of the steps required that are applicable for the adoption and installation of new systems. The requirements analysis follows two paths; one side looks at the technical requirements of systems (in this case MAS) while the other looks at the requirements or demand for such a system by industry (Pergl, 2010). This study focuses on these requirements that will be supported with the following selected aspects, advised by (Hofstrand and Holz-Clause 2009):

- Market feasibility
- Industry Technical feasibility
- Economic feasibility

6.1 Feasibility study explained

Pergl (2010) defines ‘requirement analysis’ as the identification and quantification of demand function of the system. This will allow the identification of infrastructure needs and sheds light on the complexity of fulfilling these needs. This research, with a focus on Multi-agent systems (MAS), can however not expect a clear demand picture for such systems due to the lack of knowledge of MAS environments. Therefore the demand is based on the need for collaboration systems and the reduction of empty running. A requirement, derived from Savage, Jenkins and Fransman (2012) through the report’s sample, for example, is where there is clearly a need for collaboration among transport stakeholders. The demand for a system to aid in the promotion of collaboration is further supported – see Section 5.2 – by that extracted collaboration stances from respondents that indicated that there is a lack of collaboration or that there is room for improvement. An example of this lack of collaboration was evident again from the high percentage of empty runs experienced by many. Another requirement for collaboration platforms is the need to obtain up-to-date corridor movements in Namibia, with the aim to help others to probe collaboration options. Pergl (2010) lists a few steps to determine the feasibility of a project. These steps reduced and extracted for this research are:

1. Determine requirements
    a. What are the requirements, i.e. infrastructure
    b. Licensing and its costs
    c. Maturity of the technology
2. Requirement analysis
    a. Inputs, Outputs, Inner elements and relations
3. Difference functions
4. Substitutions identification
5. Resulting differences
6. Evaluation and interpretation

Pergl (2010) explains the steps by using various analogies to assess each segment of a project most commonly used between systems theory and software projects. These analogies, which are common in general systems design, are inputs, outputs, relations and inner elements. The analogies are put against software development steps or in the case of this research software selections and implementations represented by symbols.

Pergl (2010) uses other combinations of these symbols that are not needed for this research. **Error! Reference source not found.** has data that could be relevant to this research and shows how the analogies and symbols are mapped and used for this feasibility study. It should be noted that Pergl (2010) has chosen to focus on the inner elements and relations for a demonstration of the model. This research chooses to include the inputs and outputs for the demonstration.

Table 6-1 Analogy between systems adapted from Pergl (2010)

Systems Modelling	Software project factors	Set Symbol
Inputs that are crucial for the implementation of system	Clear requirement for such a system Feasibility report System selection	I_s
Inputs that can affect the implementation of system	Lack of understanding Unwillingness to adopt and change	I_e
Inputs combined	All inputs affecting impacting software implementation	$I_s \cup I_e$
Outputs of project	Installed system and its objectives Technology infrastructure suggestions for running system Documentation Training programmmes	O
Inner elements	Implementation team tools	R_1
Relations	Clear project process Project management	R_{10}

The suggested model is based on the use of objects, classes and set notation. For the purpose of this research the software project factors are represented in a class by different objects e.g. clear requirements, feasibility report, system selection. To explain further the use of this model all software project factors form part of a set denoted as 'C' with a single factor represented as '*s*', while a single input is represented as '*a*'. The set notation as an example will read as follows $a \in \mathrm{I}\ and\ s \in \mathrm{C}$. Pergl (2010) defines this as the demand for a system, and notates it as $dem\ (a, s)$. The mapping between the two would be represented as $\mathrm{I}\ \mathrm{x}\ \mathrm{C}$ where it is put on an ordinal scale {0,10}. In this scale the zero would mean the input 'a' is satisfied with factor 's' and there is no adaptation needed. In the example given in **Error! Reference source not found.**, the software factor "clear requirement for such a system" satisfies the request for input that is crucial to implement the system. The higher the value the more adaptations are needed to fulfil the factor requirement i.e. more resources are needed.

Another definition is the substitution of systems, meaning that one factor could cater for the needs of another factor. This focuses on the project factors represented as 'S_1' or 'S_2' with a set looking like $\mathrm{C} = \{S_1, S_2, \ldots\}$ and the substitute notated as the following $\mathrm{sub}\ (S_1, S_2)$. The mapping would look like $\mathrm{C} \times \mathrm{C}$ with the ordinal scale {0,10} saying that substitution is not possible between lets say 'S_1' and 'S_2'. Table 6 illustrates this with the factor "feasibility report" which cannot substitute "system selection" and therefore has to adhere to the full requirement. The higher the value, the more the factors become substitutable.

Another important definition applicable to this research is the difference factor notated as $dif(s_j)$ where the j=1,…,n, assigning a number to every project factor. In doing this Pergl (2010) proposes the following equation to explain this: $dif(s_j) = \sum_{i=1}^{m} dem\ (a_i, s_j)$. The equation shows 'm' as the total number of inputs, and a_i the individual input demand checked against the project factors s_j. This is summed up to provide a total score that would need to be compared with substitutions for project factors to determine which area of the project requires more assistance.

The total substitutions are represented by another definition as $csub(s_j)$ where j is the same as in the difference definition. The total number of substitutions is represented in $csub\left(s_j\right) = \sum_{k=1,k\neq j}^{n} sub\ (a_i, s_j)$. The equation result is ultimately deducted from the difference to get the resulting difference of the project factors.

The resulting difference is represented as $vdif\left(b_j\right)$ in the following equation: $vdif\left(b_j\right) = \max(0, dif(b_j) - csub(b_j)$ and provides the value that will be used to determine if the project factor is crucial or not.

Determining the crucial factors of any project implementation is of the utmost importance in its success or even to see if it can simply work or not. The next step was to accumulate the inputs and factors for the feasibility of MAS in Namibia. To achieve this the focus moves to market feasibility, technical feasibility and economic feasibility Hofstrand and Holz-Clause (2009).

6.2 Market Feasibility

Being able to identify what the market for such a system holds is important. This should show there is potential for the system within the local industry. Factors to consider would be the potential number of players, if other alternative systems exist, and the future market potential. The market feasibility will look at the following as inputs to check feasibility: readiness, accuracy, and positivity.

6.2.1 Number of potential players

The study looks at the size and scope of the industry, the level of competitiveness, and the market potential. The Namibian transport industry or operating members registered by Namibian Logistics Association, (2013), totals 46 and consists of various transport stakeholders. These are divided into transporters, freight expeditors or a combination of the two. This provides some estimate of the size of the industry as the number of stakeholders mentioned was extracted from a member community's site and may not be an accurate representation. The number of transporters operating in Namibia may be a lot more, due to South African (SA) based companies moving freight in the country. The size of the stakeholders group could be doubled when taking into account the number of users of the services within the industry. The users that supply the freight or goods that are moved around need to be included when trying to determine carrier movement. The scope of the industry could be inflated as any stakeholder with transport related information could be a potential collaborator.

6.2.2 Alternative systems

Competitiveness with other stakeholders and similar platforms both regionally and internationally need to be considered. Savage, Jenkins and Fransman (2012) report that several South African (SA) registered companies operate in Namibia of which all could be benefitting from systems not available to the local industry. There are several reasons for this. For example, SA industry which enjoys advanced technology for transporters has not yet been adopted by many in Namibia and this provides an edge over the local competition when it comes to moving freight for customers. There is little concrete published data concerning collaboration among South African transporters, however freight exchange platforms and partnerships exist regionally and with some being accessible in Namibia - see Section 2. The rollout of such systems may have needed more marketing and training to allow the local industry to take full advantage of it, but unfortunately the accessible systems show little input from the industry. The Namibian industry lacks a local collaborative platform for transporters and although the region has alternatives it may be difficult to use as the information shared is only on freight movement of the host country. Another indicator that there are very few alternative options are from the results of the survey on collaboration systems and methods – see Section 5.3– which indicate the lack of usage of ICT systems. Another finding which justifies the lack of systems could be seen in the agreement by 60% of the respondents on the lack of collaboration among transport stakeholders, and over 70% saying they were either not sure or that they disagreed that collaboration platforms are available in Namibia – see Section 5.3, **Error! Reference source not found.**.

6.2.3 Future Market Potential

Market potential considers the future emerging market, with the aim of Namibia becoming a logistics hub through the Port of Walvis Bay. The port currently operates at +/- 250000 TEU per annum, but with the projected expansion the aim is to boost this to approximately 1Mil TEU's (www.namport.com.na). There will be an increase in the movement of freight from neighbouring countries with the nearest destination for export being Namibia, once it is completed. There are several industries in the country that would require a working and reliable transport system. One in particular is the coal that is to be transported from the port to the regions in the near future (Savage, 2013, Walvis Bay Corridor Group, 2013). Another is the movement of manufactured cement on a regular basis within and outside of the country (ohorongo-cement.com, 2014). Certain market segments like fresh produce supply always require reliable transport and with the regions in Namibia developing well this should increase (Tlhage, 2014).

A collaboration system to provide a platform to manage the transportation of potential freight could be well suited for the Namibian industry. The system should also promote collaboration between transport stakeholders.

6.2.4 Buyers for collaboration systems

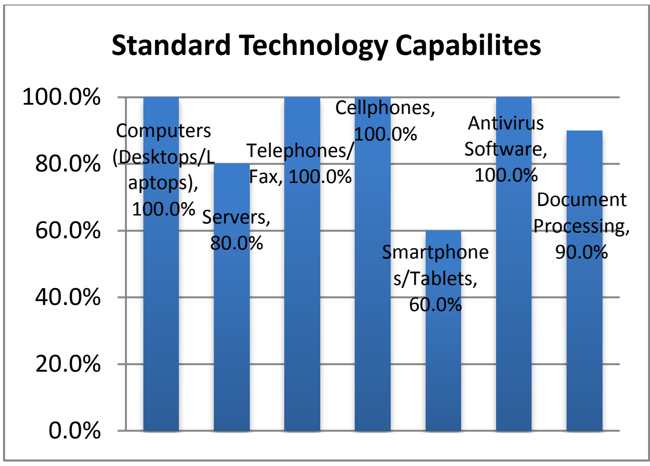
Identifying the potential buyers of a collaboration system is important for the viability of the project, its continuity and projection of sales. The Namibian industry has various players that could be potentially interested in collaboration systems. The literature review considered the number of transporters registered and operating in the country including many of the small companies that may not have the means to access to any system. Collaboration systems whether it is within a MAS environment or just any application platform – see Section 3 – hold many benefits that could attract operators that have few collaboration options. Potential buyers of collaboration systems could be the 65% of respondents agreeing with the benefits of collaboration systems – see Section 3.7. The buyers could be inflated to any transport stakeholder who wishes to collaborate through transportation capacity.

6.3 Technical Feasibility

Multi-agent Systems, as defined earlier, are technically a group of computers configured to communicate and operate amongst each other. To achieve this a reliable infrastructure, Information Communication and Technology (ICT), “know-how” and support and training is required to have a successful operating environment. This chapter looks at the technical feasibility of MAS. The technical feasibility will look at the following as inputs to check this: availability, support, and reliability.

6.3.1 Namibian ICT

Namibian Information Communication and Technology (ICT) support has steadily increased in capacity and has shown stability and increases in the areas of fixed broadband subscriptions and secure Internet servers (Dutta and Bilbao-Osorlo 2012). The country's population also has good mobile-cellular network coverage with international Internet bandwidth growing by 10 times since 2005. Recent upgrades of the bandwidth in the country have received good reviews with more options coupled with price reductions becoming available lately (www.telecom.na). However other networking infrastructures within organisations need to be identified and seen to be good enough to connect to the internet bandwidth that is steadily increasing. The technology of organisations however does vary in the Namibian environment, and needs to be considered when adopting a new system like a Multi-agent system (MAS). As part of the research the respondents were posed a question to ascertain their technological stance. Typical ICT technologies were listed and they were asked to select the ones that are being used by their companies. Figures 6-1, 6-2 & 6-3 shows the likely technological capacity found within a stakeholder company extracted from the questionnaire sent to industry. The response rate at 33% shows that almost all available Standard ICT i.e. computers, servers, cellphones, fax and anti-virus software, is being utilised by the majority of the stakeholders. Communication capabilities varied among stakeholders with a good 90% indicating internet is used in their day-to-day running of the business, while 70% are saying that specialised services like Voice Over Internet protocol (VOIP) and social media have been adopted by their business. Electronic Data interchange (EDI) and Cloud Services is only being used by 30% of the respondents. Specialised transport and logistics software i.e. Global Positioning System (GPS) is used by half of the respondents, while about 40% say they have implemented Freight Forwarding Software (FSS). However only 35% say they have implemented Transport Management Systems (TMS) in their organisations, while none of the respondents indicated they make use of rfid/barcoding in their business.



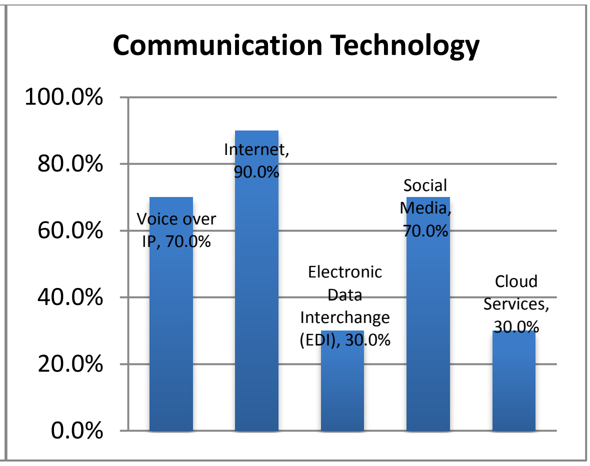


Figure 6-1 The percentage of transport stakeholders using standard computer technology

Figure 6-2 The percentage of transport stakeholders communication technology

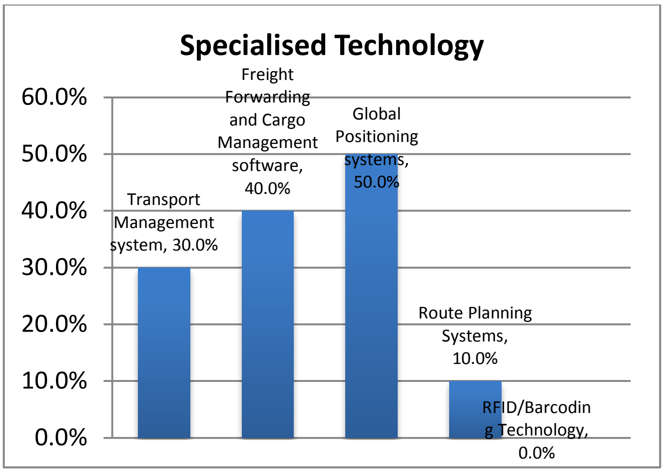


Figure 6-3 The percentage of stakeholders using specialised transport technology

A summary of the ICT capacity for the industry reveals a healthy view, however the research lacks the specifications of the systems (age, operating systems, mobile capabilities and internet bandwidth) and this could still prove to be a burden to MAS. For a MAS to run successfully it needs certain systems to be in place and used by stakeholders. These are basic systems that most organisations would have i.e. servers, databases, communication protocols and connectivity to the internet. Many MAS solutions are robust enough to link with third party software (Rzevski, Himoff and Skobelev 2006) and thus should provide for easier integration. The stance of ICT for the Namibian transport stakeholders should provide a good platform for integration with the proposed MAS, providing the ICT specifications are verified and are found to be capable.

6.3.2 Availability of Facility for a collaboration system

Implementing a MAS environment requires several inputs, and the most important is the technical ability and "know how" to support it. The facilitation and the housing of such a system needs to be identified first. Due to the various stakeholders that would take part in such an environment a regulatory framework need to be identified as a consensus is often difficult to achieve. Before identifying a possible site one needs to understand the system would be centrally hosted and controlled by a neutral organisation to which all stakeholders subscribe for access. The neutral organisation would require a central server where all connections go through and where backups or archival processes would be handled. The site would need all the facilities to ensure a 24-hour a day active system. This would include reliable electricity, water and sanitation for on-site staff and the necessary uninterrupted power supply systems. Coinciding with all these facility requirements are others such as the support, and equipment and parts supply to ensure continuity of the system. An assessment of the cost of supplying equipment needs to be identified. It all forms part of the production inputs that are required. For the requirement to access agents from anywhere in the country a system would need to be web hosted. Namibia has various suitable web hosting services that could be approached to identify best possible and optimal solutions (www.iway.na, www.telecom.na, www.africaonline.com.na, www.namhost.com). These have plans where an organisation can be in control of their own dedicated services under their own domains and with support services.

6.3.3 Inputs on pre start-up and start-up

Managing a Multi-agent system (MAS) environment would require experts to ensure its continuance, and to provide training to ensure capacity is built locally. This would already be a requirement at pre- start-up where the experts should assist with the feasibility and planning. This would continue into the system implementation and ultimately to provide training for the staff that will takeover the running and maintenance of the systems. Due to MAS not being easily obtainable and available in Namibia, the experts would have to be brought in from organisations in other countries where the systems are already available. This would require considerable financial input at the start-up and during the feasibility and implementation phases. Due to developing countries struggling to attract qualified staff from developed countries a further assessment would have to be done on the potential and means to attract the experts for such system. However there might still be potential interest from the international MAS suppliers – see Section 3.9 – that might like to extend into the African market. Despite this issue, the financial cost will be the major consideration throughout the implementation of the system.

6.4 Economic Feasibility

Estimating the total capital requirements for the implementation of a system shows the economic feasibility of it. The capital needed to start such a project would be difficult to determine with all solutions being unique and "off-the-shelf" solutions do not usually cater for a developing country's (for instance Namibia), needs. The inputs to check the economic feasibility would be: accuracy, practicality, and variances

6.4.1 Estimated cost of MAS

Due to the fact that there are no solutions or collaboration platforms available in Namibia to make a comparison with, this research selected two from five suppliers of the Multi-agent systems (MAS) discussed – see Section 3. The cost was estimated based on the location and information obtained from suppliers. The two selected were Magenta and Whitestein as seen in **Error! Reference source not found.**. These are the cost estimates for the implementation by the supplying organisations. The costs of flying in experts or consultants for a period of time would also need to be calculated in and that would inevitably inflate the overall cost of implementation. The cost of support, training and service level agreements are not included. Any project would need to have a detailed budget before commencement as with most project budgets there has yet to be a precise estimate. Nevertheless this gives a starting point for the implementation of MAS.

Table 6-2 Estimated costs based on supplier responses

Cost Factors/Company	Magenta	Whitestein
Location	United Kingdom	Switzerland
Estimated implementation cost but depending on the size	N$300000 – N$ 500000 (Quote Estimate)	N$200000 - N$500000 (Quote Estimate)
Product	Haulier Management System	Transportation planning system

6.4.2 ICT costs for users and revenue returns

Information was obtained to determine the anticipated technological capacity of transport stakeholders – see Figure 6-1. In this section the technological stance is needed to help estimate capital requirements for equipment needed to bring the industry up to a level where it is able to handle Multi-agent Systems (MAS). The information revealed a sound start for the basics of computing power and connectivity that are used by about 80-100% of respondents. Thus it depends on which MAS is selected and which technological platforms it requires. This should give an idea if an organisation’s current technology stance is ready or whether would it need further capital investment before it can begin to implement MAS. The MAS platforms may be compatible with the Namibian organisations, but further investigation into specific computing platforms (Windows, Linux, Apple etc) and its compatibility would be needed to confirm this. The capital investment (though not too much from the users side), would need to be put into the acquiring of the servers, internet connectivity and support for the hosting site. The investment options though available are not part of this research but can be identified from sources like the development banks and foreign investors that might see the potential of such a system.

A proper Return on Investment (ROI) analysis would be needed to justify the MAS adoption and implementation in Namibia, but due to the lack of accurate cost figures of a system implementation it will not form part of this research. However the economic returns for members of the system through the sharing of capacity and work are noted here. In European countries where a collaboration platform exists efficiency and cost gains have been between 6 and 10% (Graham, 2011). The percentages of cost gains can be expected to be higher for the Namibian industry, which has a higher percentage of empty running than most European countries. There could be further economic benefit for members to gain opportunities to grow their businesses with the access to markets and freight previously not known. The expected revenue of MAS would be from the facilitation of a platform for other agents and receiving a fee for undertaking it. Collaboration platforms charge their members fees, which should be able to sustain the operations as well as ensure the continuous development and improvements of the system. Other means of generating revenue are through the provision of other services related to the system for the members, for example: financial options for small operators, news headlines, and weather and road traffic reports – see Section 2.7.

6.5 Evaluation with feasibility model

Once the market, technical, and economic information have been obtained, the feasibility study, as suggested by Pergl (2010) can be mapped and evaluated with these as the inputs. The next step involves quantification of the demand functions or information obtained and matching these against all project factors. For simplicity this research will use the ordinance scale of {0,10} as a demand value to determine adaptations.

The range of the adaptations would be as follows:

- {0,10} no adaptations,
- {4,10} moderate adaptations,
- {8,10} high adaptations.

To help explain this, the number of project factors – Section 6.1, **Error! Reference source not found.** – has now been adapted to the derived input from the market requirement and put next to the factors {number of potential players, other alternatives, future market potential, buyers of collaboration system} – see Section

6.2. Quantification follows when the information in **Error! Reference source not found.** is reviewed. The 'number of potential players' identified by the size and scope of the industry to take part in collaboration platforms shows there is an opportunity to make progress. The factors are put on the ordinance scale quantified by using $dem\ (a, s)$. The ordinance scale would then be {0,10} as the input 'market requirement' is satisfied with the 'number of the market potential'.

Table 6-3 Market feasibility factors

	Input Market Feasibility			
Project Factors	**Readiness**	**Accuracy**	**Positivity**	**dif(s)**
Number of potential players	0	2	0	2
Other alternatives systems	8	2	0	10
Future market potential	2	2	4	8
Buyers for collaboration systems	2	2	2	6

The next step is to quantify if there are any substitutions among inputs and project factors. The substitutions identified will be mapped to find what the resulting difference would be and determine exactly which factor needs more attention in the project. The example to use would be to the 'number of potential players' and 'future market potential' and how they might substitute each other. Weighed against each other, they could be partially substituted as the future market potential expects an increase in freight that should amount to an increase in players in the market. This on the ordinance scale would be {2,10}. The table shows a final table with the resulting difference.

Table 6-4 Market feasibility with resulting difference calculations

	Market Feasibility Resulting Difference		
Project Factors	**Total difference: dif(s)**	**Total substitutions: csub(s)**	**Resulting difference: vdif(s)**
Number of potential players	2	2	0
Other alternatives systems	10	2	8
Future market potential	8	2	6
Buyers for collaboration systems	6	2	4

Assessing the information in **Error! Reference source not found.** with the model suggested by Pergl (2010) shows that certain project factors have slight substitutions and therefore have produced some variations when it reaches the resulting difference. Through this can now be deduced that for market feasibility to be based on the factors in Table 6-4, the areas to concentrate on are the 'other alternative systems' and 'future market potential'. In the case of the "alternative systems factor" it could be that there is not enough published information on systems and the project would require either further research. On the other hand the "future market" factor depends on an outcome that is based on optimistic projections for the future, which means that it is not secure.

The technical feasibility aspects can then be reviewed, using the same mapping process and ordinance scale. The factors and inputs are listed as follows. In particular the high difference under 'inputs on pre start-up and start-up will need further adaptations due to the availability of information on the experts needed and the reliability of the information on consultation needs. Availability of facilities and Namibian ICT show low adaptation figures as information can be easily verified locally if needed.

Table 6-5 Technical Feasibility factors

Technical Feasibility factors				
Project Factors	**Availability**	**Support**	**Reliability**	**dif(s)**
Namibian ICT	0	0	2	2
Availability of facility	2	2	2	6
Inputs on pre start-up and start-up	6	4	8	18

The technical feasibility can also be mapped to find if any substitution exists and thus the final table will look as follows.

Table 6-6 Technical feasibility with resulting difference calculations

Technical Feasibility Resulting Difference			
Project Factors	**Total difference: dif(s)**	**Total substitutions: csub(s)**	**Resulting difference: vdif(s)**
Namibian ICT	2	2	0
Availability of facility	6	0	6
Inputs on pre start-up and start-up	18	2	16

The resulting input shows that Namibian ICT would need very little resourcing when implementing a new system, due to the strong usage of current systems by the stakeholders. However availability of facility and inputs on start-up are seen as the crucial areas. Facility identification and selection could be a challenging task with the location, facility infrastructure and ownership all playing a part. Inputs may require many resources, especially with regard to flying in experts to assist with the system. This is seen as a particularly important area to focus on during planning phases.

Finally the economic feasibility that comes with the implementation of a new system like MAS must be considered. The areas were on the estimated cost of the system, and the expected user investment needs and revenue returns expected. These two were selected, as they remain a crucial decision factor in accepting the start of any project or system implementation.

The table is represented as follows:

Table 6-7 Economic feasibility factors

	Economic Feasibility factors			
Project Factors	**Accuracy**	**Practicality**	**Variances**	**dif(s)**
Estimated cost	8	4	8	20
ICT cost and revenue returns	4	2	4	10

The estimated cost shows adaptation needs under all inputs due to the difficulty in estimating exact costs on implementation. The costs received were for implementation only from suppliers. It would require further research and input from actual suppliers and consultants to receive exact figures. The ICT cost and revenue returns show lower adaptations as there are examples of other collaboration platforms internationally that show requirements for their systems and how they manage subscription fees as part of the revenue return. The substitutions although few, are shown next

Table 6-8 Economic feasibility with resulting difference calculations

	Input Economic Feasibility		
Project Factors	**Total difference: dif(s)**	**Total substitutions: csub(s)**	**Resulting difference: vdif(s)**
Estimated cost	20	2	18
ICT cost and revenue returns	10	6	4

Error! Reference source not found. shows that there can be very little substitution expected under estimated cost, as other inputs cannot contribute to determining the costs of the system, This would require considerable resourcing to ensure its accuracy. ICT cost and revenue returns have some substitutions from the market and technical sections and thus may require fewer resources.

6.6 Discussion

This chapter focussed on the feasibility of MAS in Namibia using the Pergl (2010) requirements model, augmented by the Hoftstrand and Clause (2009) feasibility guidelines. The outcomes show that there are many factors to consider such as the market, technical and economic feasibility. The requirement for introducing any new system is high and demands considerable planning to ensure its success. Certain requirements are easier to adhere to while others may need more attention. The feasibility report showed positivity under areas such as the Namibian ICT, facility requirements and revenue returns for MAS where very few changes would be needed. These areas show some readiness to adopt collaboration platforms and could ease the process. Other factors for example the number of potential users and the future market show the level of possible interest in systems and may not require too many resources when the systems are implemented. However there are areas that would need to be considered and investigated further (the estimated cost and the required inputs during pre start-up and start up) before a decision could be made to implement MAS in Namibia.

7 MAS to promote collaboration among Transporters

One of the purposes of this research is to provide an evaluation of Multi-agent Systems (MAS) capable of promoting collaboration. This chapter will focus on a selected system suitable to the Namibian industry and try to demonstrate how it will promote collaboration. The second focus in this chapter is on the MAS as a potential system to help reduce empty running. **Error! Reference source not found.** shows a comparison of the five MAS found in this research – see Section 3. The comparison criteria selected were taken from the perspective of the type of organisation and the solutions they offer, the technology used and finally, the status of the organisation or the solution. Due to the fact that some MAS solutions are still in the design prototype and testing environment, the information shows three organisations that are providing agent-based solutions. These three are Whitestein, Magenta and Nutech, with the solutions from Post-Kogeko and MamMoet both being products of research that developed prototypes only. Each MAS provides a different solution for their customers with specific problems addressed such as the Container Management Systems by Post-Kogeko. A Haulier Management System and Transport Planning System by Magenta and Whitestein respectively, show specific solutions for their customers. The Multi-modal Management System provided by the MamMoet prototype gives a different solution for barge operators and shippers and is not targeted by other MAS. The organisations that provide commercial solutions are Whitestein, Magenta and Nutech, although the latter is currently dormant with very little news available and the website down.

It is through circumstance therefore that the selection of a specific system can only be between Whitestein and Magenta for the Namibian industry. Both are very similar in providing solutions that could be customised. This research looked at their customer base for comparisons and discovered the more suitable solution for the Namibian industry.

7.1 Multi-agent System Selection

Table 7-1 Multi-agent systems (MAS)

Provider/Solution	Type	Solutions	Software Platforms used	Database platform	Protocols	Status
Whitestein	Software development organisation	Transport Planning Systems	Sun Microsystems (Java Enterprise, J2EE)	Oracle	XML, SOAP	Active
Magenta	Software development organisation	Haulier Management Systems	Sun Microsystems (Java Enterprise, J2EE)	MS SQL and Oracle	XML, SOAP, UDDI & WSDL	Active
Nutech	Software development organisation	Custom solutions for complex transport problems	IBM Netezza	Platform Independent	XML, SOAP	Dormant
Post-Kogeko	Research outcome prototype tested not implement	Container management systems	Java Agent Development Environment (JADE)	Qfreight	FIPA for agents	Not available commercially
MamMoet	Organisational Prototype tested not implemented	Multimodal management system	Not known	Not known	XML, EDIFACT	Not available commercially

Magenta provides various agent based solutions with transportation logistics being one of them (www.magenta-technology.com). A customer that used the Haulier Management System needed a solution that could help with the rating of its sub-contractors when it came to transportation. It was also difficult to manage the communication between the organisation and its transporters in addition to customer requests. Magenta provided a solution that managed the shipments by tracking and monitoring the statuses, plus defined the strategies to be used in operations. This solution, that now provided a ranking system for shippers, could automatically assign shipments to the fitting sub-contractor. The system rated shippers on their pricing, past work and service quality amongst other factors. Lastly pertaining more specifically to this research the system finds return freight for its sub-contractors (Wooldridge, 2007).

Whitestein offers a transportation management system among other intelligent solutions (www.whitestein.com). A customer was faced with the challenge of benchmarking transport utilisation and capacity within its organisation to ensure better quality service delivery. It also needed tools to help their dispatchers manage queries and make the decisions more quickly to make the best of all transportation opportunities. Whitestein provided a solution that took the optimisation and decision making of dispatching in real-time and placed it in a central environment for better overview and benchmarking. It achieved success by helping the dispatching team increase efficiency overall by making the best use of expensive transport, by increasing the load factors and reducing the kilometres driven. The system provides a complete and transparent overall picture of operations, with features for filtering relevant information as needed. Whitestein can integrate with a current infrastructure or legacy system and other transport solutions (Brantschen, 2002).

As a result of the analysis of the information Magenta’s Haulier Management System would seem to be the best choice for the Namibian industry for the following reasons. Firstly it is a stand-alone solution for transporters that will fit well with an industry that still lacks the available solutions. Secondly the solution is aimed at specific problems such as the managing and tracking of shipments that are still lacking in the industry and the allocation of freight on return journeys which specifically targets empty running. It also offers other services to its customers through the management of customer billing and service reports that could be advantageous to its members and provide an extra incentive to join the system. Once this choice had been made it was necessary to see if the system would be able to can reduce empty running in Namibia.

7.2 Magenta Haulier Management System

Using a Multi-agent System (MAS) in an organisation is actually the mimicking of processes by agents. The agents are assigned the duties already existing to learn, handle and respond with on behalf of the users. The Magenta Haulier Management System (HMS) starts with a solution that takes certain aspects of an organisation and eases it's handling with agents (Wooldridge, 2007). The MAS provides for a synchronised processing of operations by a large number of agents in a distributed network. The agents handle operations with knowledge gained through data entries and negotiations completed and thus a key feature of the system is that it operates independently. The HMS is a transport scheduling system with collaboration and decision making support for transport stakeholders. It offers other benefits like online portals for customers to use and for third party transporters or contractors to utilise their own capacity. It also uses the information retrieved to assign backloads to its sub-contractors. The system makes use of maps by assigning identifiers to its locations and transport channels. This makes it easier for fleet operators to be in control of all shipment information and movement. Application agents are used to represent all aspects of the HMS. The agents are assigned to a specific task or entity e.g. pricing or sub-contracting. These form part of a swarm of application agents that feed the Ontology Management kit. The kit is the layer in the Magenta technology that captures the information from agents and builds up a knowledge base for future decision-making (Himoff, Skobelev and Wooldridge 2005, Rzevski, Himoff and Skobelev 2006). Another important aspect of the Magenta system is a virtual market engine that is used to create and run agents to use the knowledge base created. It is also used to show agent behaviour through its debugging mechanisms. The agent technology that forms the basis for the HMS could now be explored by the Namibian industry.

7.3 Transport Process to Software Agents

Understanding the transport process and mapping it to software agents is important for developing a framework for the adoption of a system. Knowing where the requirement for a transport operation starts is important, as well as how information flows through the system. Referring back to section 3 that mentions the foundation for any agent systems is only through understanding the environment of which it will be based on. Processes are guiding the environment, and the more clearly it is defined the better it is for agent design. Odell et al. (2002) give an equation for an environment by defining it as a set of processes. A scaled down set of processes of transportation as guided from observations and stakeholder interviews is shown in.

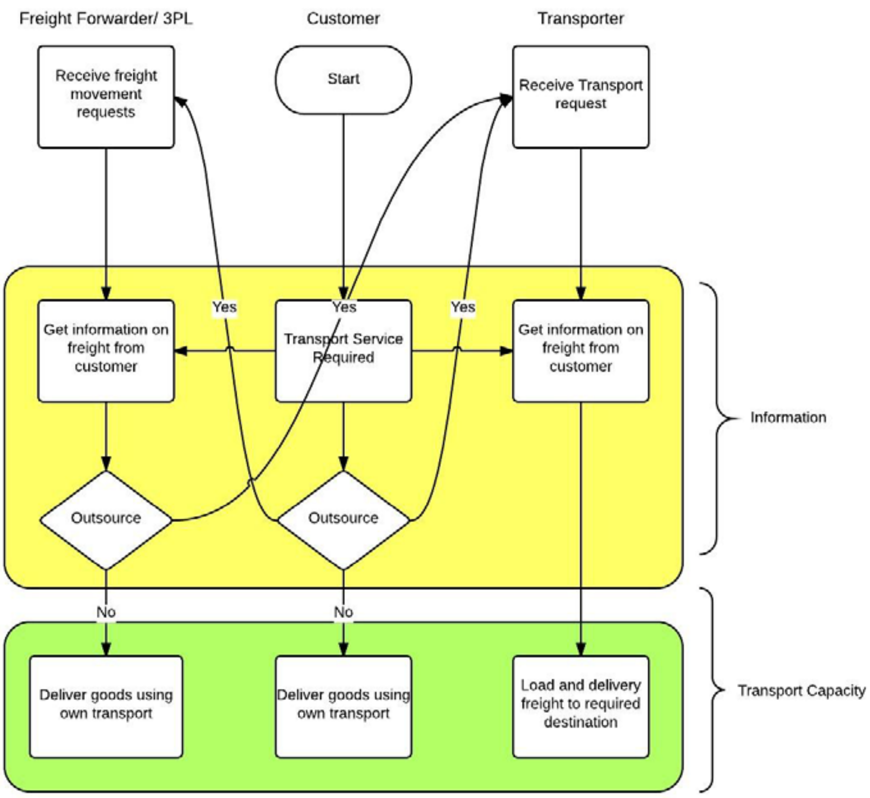


Figure 7-1 Example Process flow between transport stakeholders

The process flow although a basic system shows the general way transport stakeholders can communicate to manage transportation. This flow example starts from a customer that requires a transport service. This could well be started by any other stakeholder that has a similar service request. Nevertheless, this provides the basis for agent environment modelling. It also highlights the areas that should be considered in the modelling, which is the information areas and the capacity. Shoham and Leyton-Brown (2008) mentioned the algorithm that guides the environment for agents, thus the characteristics needed should also be defined. The characteristics can become very complex when presented to stakeholders but to move towards mapping of processes to agents, this research looks at characteristics in **Error! Reference source not found.**, based on the flowchart in Figure 7-1: -

Table 7-2 Characteristics of transport stakeholders to map to agents

Transporter	Freight Forwarder/3PL	Customer
• Request handler • Service interpreter • Fleet assign, deliver and monitor	• Request handler • Service Interpreter/Issuer • Outsource • Fleet assign, deliver and monitor	• Request Issuer • Service Issuer • Outsource • Fleet assign, deliver and monitor

The three stakeholders used in the example, have output and inputs based on their immediate neighbours or to whomsoever they are connected to. The customer requests services, and therefore sends it to either the transporter or freight forwarder if they are outsourcing. However they can also assign their own fleet and deliver their goods. The forwarder and transporter both handle requests, however the former can issue a transport service to a transporter if outsourcing is one of their options. This provides the basis for transport stakeholder communication that could now be further mapped to a Magenta Haulier Management Systems (HMS) framework.

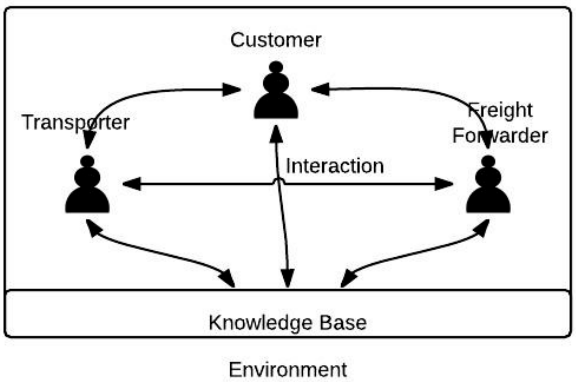


Figure 7-2 Transport agents interacting in HMS environment

One of the features for HMS is the ability to create agents that could be both programmed with parameters or could learn from its environment. Another key feature is the knowledge base that forms part of the Magenta system that is built up over time to aid in future decision making. Figure 7-2 demonstrates the framework for a Magenta HMS with transport stakeholders that interact with other agents and with the knowledge base. The key to the system is to promote collaboration, which is what HMS offers through its solution. Agents sharing information with others and a central environment ontology kit showing the transparency with which the system operates. The transparency that all agents gain through interaction and from the knowledge base, can now allow for the assignment of backloads to transporters, which in the end can reduce empty running overall for all.

7.4 Promoting collaboration and reducing empty running

Namibian Transport Stakeholders (TS) can achieve collaboration through the use of the Haulier Management System (HMS) by Magenta technology. The organisations that previously had no fleet management systems can be provided with one, while others with existing systems can either link into the HMS or only use the applicable services, whichever is most appropriate to their needs. The TS can enjoy overviews of transportation within the country through the mapping tools provided by the HMS. This should allow the identification of the freight on routes and potentially allow TS to combine their capacity. The organisations that choose to set up contracts with third party contractors can provide services for them as well, for instance, by notifying them of potential backloads. As mentioned before, the HMS provides the benefits of accumulating information on partners, customers and third party contractors that could be used to rate future collaboration initiatives. Through the system certain Key Performance Indicators (KPIs) can be identified to ensure that the quality and standards of deliveries are achieved. What will prove beneficial for the TS that can not afford a new HMS is the availability of online portals for third parties to use. The portal gives notifications of accepted and declined shipments and the possibility of a shipment arising. TS can also post their preferred jobs on these portals to receive specific notifications. Due to its automatic allocation of shipments that arise for third party transporters on their routes the system also caters for the reduction of empty running for those that are linked to it.

8 Conclusion and Recommendation

This research set out to investigate Multi-agent systems (MAS) for transportation and the feasibility of implementation in a developing country like Namibia. The overall aim for the investigation on such a system was to find out if it can promote collaboration among transporters to ultimately reduce empty running. This chapter summarises and discusses the findings of this research as well as looking at future recommendations of work.

8.1 Discussion on Findings

The main aim of this research was to gain an understanding of Multi-agent Systems (MAS) available for transport stakeholders, and especially to consider if they are suited to the Namibian industry. In understanding MAS for transporters and if its capabilities, roles and goals could operate within a developing country like the Namibia, contributed to literature that emphasises its applicability in distributed environments (Weiss, 1999, Wooldridge and Jennings, 1995, Schleiffer, 2004, Kwon, Im and Lee, 2001). This research also set out to contribute to the overall understanding of transport operations in Namibia from a stakeholder's point of view. The research has taken the views accumulated from stakeholders and other sources and used an interpretive approach to understand and produce a stance of the operations which were considered. There was also a comparative part to this research after finding a MAS available for this purpose. Finally there was a large contribution from literature to this research that helped to answer the research question and test the thesis statement – see Section 1.

The overarching research question that kept this research focussed was "Can a transport multi-agent based system be used to promote collaboration between or to reduce empty runs for Namibian stakeholders?". The question, supported by sub-questions – see Section 1.3.2 – was used to test the thesis statement "A multi-agent based system could be used as a collaboration platform amongst transport stakeholder to reduce empty running". The questions were answered through the literature, findings and analyses in this research. The research has an explorative stance due to the lack of published information on certain subjects, but also raised more questions. Some were answered but some have been moved, perforce, to future work. Nonetheless the key findings included the collaboration status and empty running of Namibian transport stakeholders, some MAS available, and the feasibility for MAS in Namibia.

There were several questions answered with this research but the main ones are shown in the findings that include the collaboration status and empty running of Namibian transport stakeholders. The research set out to ratify previous findings that put empty running in Namibia at approximately 50% by obtaining a more detailed view from a transport stakeholder’s angle in Namibia. The findings showed that stakeholders have about 40% empty running in their day-to-day operations. However findings clarified that for only 33% of respondents the number of empty runs is proving to be unsustainable – see Section 5.1.1. Empty running being one of the key contributors to unsustainable transport, is referred to by Moonen (2009) and Mason, Lalwani and Boughton (2007) as an instigator for collaboration research initiatives. The empty running, clearly experienced by many, still needs solutions and this research agrees and proposes with authors Lambert and Cooper, (2000), Moonen, (2009), Piecyk and Mckinnon, (2009), the idea that collaboration is one of them.

With reference to the collaboration status of stakeholders, the findings showed that there were several methods used in Namibia. The research set out to understand the different types of method and some of the advantages and disadvantages for organisations, ranging from transactional to full partnerships and alliances. These ideas were offered to the stakeholders to select for use in their organisation – see Section 5.2.1. The results varied across the range of respondents but with the majority leaning toward transactional linkages with their partners only. However it transpired that many have contractual partnerships that showed good signs of existing collaborations. The research also set out to find which integration methods are used (e.g. Integrated systems, internet portals – see Chapter 5.3). The results revealed that the methods of integration used by stakeholders were limited to contractual agreements and to some extent the synchronisation of activities. The lack of integrated ICT was clearly indicated by many and showed that there was a need for solutions for this. The findings built on previous research from Savage, Jenkins and Fransman (2012) are now providing a more specific stance of collaboration among a specific stakeholder group. The research indicated clearly through literature, that the only way to improve collaboration is through the sharing of information with outside partners making integration essential to its success.

Another focus was the feasibility of the MAS in Namibia adapted from a model proposed by Pergl (2010) – see Section 6. This focus was needed to establish if there could be a market for such a system; whether Namibia has the technical ability and whether it makes economic sense. Firstly the market feasibility for a collaboration platform returned good prospects for the number of potential players and future markets mostly motivated by findings under collaboration statuses and methods – see Sections 5.2, 5.3 & 6.2. The research not only looked at the actual size of the transport industry also emphasised the importance of other interested parties that have transport information as potential members for a collaborative platform. The growth expected for the transport industry noticed under future markets feasibility, should contribute information to the suggested collaboration platform. The market feasibility looked at other alternatives for the system, and this led to a few regional solutions to collaboration supported by the available literature – see Section 2.6. The solutions although they exist as alternative options are still only catering for a host country and cannot attract enough involvement from other countries. Secondly the technical ability of the industry was another positive indication for the readiness of accepting MAS – see Chapter 6.3.1. The utilisation of almost all standard ICT options within the Namibian industry was seen among stakeholders to be crucial. However specialised technology seemed to be lacking among stakeholders, with many just relying on basic technological necessities to run their business. The ease of integration of some MAS into existing systems mentioned in this research tied in very well with the ICT stance of Namibian stakeholders and assisted in proving the thesis statement of this research. Lastly the economic feasibility proved difficult to estimate due to lack of budget examples by organisations. It became more challenging to estimate as costs increase when new systems are installed by an outside (foreign) agency. However the estimation provided a foundation for the financial concerns for the implementation of MAS. The feasibility study carried out using the Pergl (2010) scoring system concluded that although it looks favourable for the implementation of MAS in the Namibian environment, there are still issues, for example, financial concerns and pre start-up inputs that have to be addressed.

In addition to the literature another chapter that focused on Multi-agent Systems (MAS) its origin, paradigms and characteristics were documented. This guided the analysis that concentrated on the possible transportation solutions by MAS. Though the agent based systems idea originated in the mid 90's– see Section 3.4 – it has only been seen to make its transition to transportation systems in the last decade. Multi-agent based systems were seen as a “good fit” for the transportation industry due to its distributive nature. Computer agents were seen as the perfect way to handle the unpredictable and real-time decision-making processes. Wooldridge and Jennings (1995) gives agents the characteristics of reactivity, pro-activity, social, and autonomy within an environment limitation. These characteristics can be applied to transport stakeholders and can be represented as agents. Most importantly this research set out to find what changes and developments have been made in these systems and to check their applicability to the Namibian industry. The results found some commercial solutions and a few in prototype status through the outcome from previous research and consultations – see Section 3.9. The solutions that are in prototype status had some good examples of transportation planning, specifically MamMoet. This system is aimed at the management of barge operators and shippers in a multi-modal environment. This system being a stand-alone system that assigns agents to all operators, enjoys all the benefits of fully fledged Multi-agent environment, that includes intelligent independent decision making, around the clock capabilities and operator rating mechanisms. Unfortunately due to its prototype status it could not be seen as a viable option for the Namibian industry. The commercial solutions found showed that there have been some significant steps towards Multi-agent transport platforms and there might be more in the future. The solutions provided by organisations had four case studies that demonstrated their successes in implementation. However the solutions based on the case studies involved customisation. This was a good indicator of the practicality of MAS in the transportation environment and set a basis for the selection of an appropriate solution for the Namibian industry. A comparison of the systems shown earlier aided in the selection process. It should be noted that many of the solutions have cohesion in areas of software and database platforms as well as protocols usage. This could bode well for future development and integration with certain systems. The research was narrowed down to the Magenta organisation as a possible provider for a solution and specifically the Haulier Management System for the Namibian industry as it met the requirements. The selection was made on the key areas it tries to improve within transportation, which are: tracking and monitoring shipment status, operations strategy definition and management, third party ranking and a service delivery system. The solution though designed for a single organisation to buy can also be used as a central operating system for all transport stakeholders to access through its online portals. This was seen to be important in a new environment where collaboration is better controlled through a central point to avoid bias, as discussed in Consensus Dynamics – see Section 3.8. However a notable feature pertaining to this research was its automatic assignment of backloads to transporters to fully utilise capacity and reduce empty running. Thus answering the research question " Could a Multi-agent system be used to promote collaboration and reduce empty running?".

8.2 Recommendation, future work and implications

This research as with all research had its limitations which added to the number of questions of this research and these are worth considering for the future. The first recommendation builds on the 33% response rate that was trying used to reach an accurate view of collaboration and empty running rates. This needs further concretising with follow-up questionnaires or interviews. An accurate view would not only motivate the introduction of collaboration platforms but would also aid in better decision-making about future transport planning for the industry (Mason, Lalwani and Boughton 2007). O'Flaherty (1997) has stated that a successful transport development process is always preceded by a transport planning process that relies on a proper framework which is understood built on policy development. It is for this reason that it is important to continue to accumulate statistics on transport within the Namibian industry.

Secondly justifying the need for this research with the previous findings on empty running and collaboration made it difficult to examine the other benefits of MAS in supply chains. Transport systems built on agent technology are developing quickly and there could be many more organisations becoming suppliers of such solutions in the near future. There are other agent-based logistics solutions that could provide other services for transport stakeholders. It is, therefore, suggested to build upon the current findings and identify the MAS solutions for each supply chain component.

Thirdly the information on the financial estimation for the implementation of MAS was limited. Without this financial detail a clear project proposal for implementation could not be achieved. This will need further clarification and planning by contacting more than the found suppliers – see Sections 3 & 7. The cost estimation can be worked in detail and mapped to a project plan and combined with a feasibility study it should pave the way for the adoption of MAS that should then have a better overview. Look at the actual implementation plan of MAS only could be a future study.

The feasibility study has some limitations in the project factors selected by this research – see Section 6. The focus was on market, technical and economic factors but lacked certain inputs such as the definition of business scenarios or organisational or managerial feasibility that would look at the structure and owners of MAS. This may well form a major part in the final decision-making for implementation and is recommended to be a focus area in the future.

Penultimate in this research is the engineering aspect of agents that would always be missing from a small research output as this one, but could be the focus for the next level in understanding and moving towards the designing of agent based solutions. This should be of interest to many when the considerations of a developing world are incorporated in the agent behaviour. Tying this in with the consensus problems faced in MAS would surely be different among third world users and could have significant contributions in the field.

Lastly research and developments on MAS are moving fast, and new trends and solutions are expected in the near future. The implication of MAS being a solution to reduce empty running within a developing country, needs continuous updating to ensure it remains current, cogent and relevant. The Namibian transport industry is evolving, albeit relatively slowly. A practical implication to this is the potential use of MAS to develop and improve the transport sector's capabilities.

8.3 Closing Remarks

MAS in transportation solutions exist and can be introduced into a country like Namibia and would hold numerous benefits, but the lack of understanding of them may be the biggest obstacle. However the need for solutions has been identified and the means to create knowledge of the technologies are possible. Thus if there is general willingness to achieve the overall aim of reducing empty runs among transporters, all that is needs is careful planning.

9 References

- Dictionary.com - *"distributed" Dictionary.com Unabridged, Random House Inc*.

- Oxford Dictionaries a, - *"collaboration". Oxford Dictionaries. April 2010*.

- Oxford Dictionaries b, - *"ethics". Oxford Dictionaries. 2009*.

123loadboard.com 2013, *, 123loadboard-Post-Find-Haul*. Available: http://www.123loadboard.com/ [2013, 08/01].

Aitken, J., Childerhouse, P., Christopher, M. & Towill, D. 2005, "Designing and managing multiple pipelines", *Journal of business logistics,* vol. 26, no. 2, pp. 73-96.

Akintoye, A., McIntosh, G. & Fitzgerald, E. 2000, "A survey of supply chain collaboration and management in the UK construction industry", *European Journal of Purchasing & Supply Management,* vol. 6, no. 3-4, pp. 159-168.

Anbandandam, R., Banwet, D.K. & Shankar, R. 2011, "Evaluation of supply chain collaboration: a case of apparel retail industry in India", *International Journal of Productivity and Performance Management,* vol. 60, no. 2, pp. 82-98.

Angeles, R. & Nath, R. 2001, "Partner congruence in electronic data interchange (EDI) enabled relationships", *Journal of business logistics,* vol. 22, no. 2, pp. 109-127.

April, W.I. 2005, *Critical factors that influence the success and failures of SMEs in Namibia in the Khomas Region*, Masters edn, Stellenbosch, Cape Town.

Arcelus, F.J., Eiselt, H.A. & Lin, E.Y.H. 1998, "Minimizing empty hauls in multi-day, multi-depot trucking", *International Transactions in Operational Research,* vol. 5, no. 3, pp. 201-210.

Arendt, L. 2009, "Barriers to ICT adoption in SME's: how to bridge the digital divide", *Journal of Systems and Information Technology,* vol. 10, no. 2, pp. 93-108.

Audy, J.F., D'Amours, S. & Rousseau, L.M. 2010, "Cost allocation in the establishment of a collaborative transportation agreement-an application in the furniture industry", *Journal of the Operation Research Society,* vol. 2011, no. 62, pp. 960-970.

aztenders.com 2014, *, Tenders, RFP's, Procurement Notices*. Available: http://www.aztenders.com/site/index.php [2014, 05/30].

Bakos, J.Y. 1991, "Information links and electronic marketplaces: the role of interorganizational information systems in vertical markets", *Journal of*

Management Information Systems-Special sectionL Strategic and competitive information systems, vol. 8, no. 2, pp. 31-52.

Beevor, D. 2013, *Collaboration platforms in transport and the view on multiagent systems*, Roadtech, Radlett, UK.

Belecheanu, R.A., Munroe, S., Luck, M., Payne, T., Miller, T. & Pechoucek, M. 2006, "Commercial Applications of Agents: Lessons, Experiences and Challenges", *AAMAS'06,* .

Bernaer, S., Burke, E., De Causmaecker, P., Berghe, G.V. & Vermeulen, T. 2006, "A multi agent system to control complexity in multi modal transport", *Cybernetics and Intelligent Systems, 2006 IEEE Conference on*, 7-9 June, pp. 1-6.

Bid2Load.com 2013, *, Bid2Load Secure Return Loads*. Available: http://bid2load.co.za/ [2013, 08/01].

Brantschen, S. 2002, *Whitestein Technologies*, Whitestein Technologies AG, Switzerland.

Bretzke, W.R. 2003, "Supply Chain Event Management - Bridging the gab between planning and realisation", *Business Briefing: Global Purchasing & Supply Strategies,* .

Buhler, P.A. & Vidal, J.M. 2002, "Towards the synthesis of web services and agent behaviours", *Proceedings of the Agentcities: Challenges in Open Agent Environments Workshop*Springer-Verlag, , pp. 25-31.

Cao, M. & Zhang, Q. 2011, "Supply chain collaboration: Impact on collaborative advantage and firm performance", *Journal of Operations Management,* vol. 29, no. 3, pp. 163-180.

Chep 2014, *, Collaboration in Transportation: Benefits Environment, Optimises, Efficiency, Reduces cost*. Available: http://www.chep.com/resources/case_studies/collaboration_in_transportation/ [2014, 03/30].

Cherret, T., Allen, J., McLeod, F., Maynard, S., Hickford, A. & Brown, M. 2011, "Understanding urban freight activity - key issues for freight planning", *Journal of Transport Geography,* vol. 24, no. 2012, pp. 22-32.

Crainic, T.G., Gendreau, M. & Potvin, J. 2008, "Intelligent freight-transportation systems: Assessment and the contribution of operations research", *Transportation Research Part C,* vol. 17, no. 2008, pp. 541-557.

Cruijssen, F. & Dullaert, W. 2007, "Horizontal cooperation in transport and logistics: A literature review", *Transport Journal,* vol. 46, no. 3, pp. 22-39.

Curbera, F., Duftler, M., Khalaf, R., Nagy, W., Mukhi, N. & Weerawarana, S. 2002, "Unraveling the web services web-an introduction to SOAP, WSDL, and UDDI", *IEEE Internet Computing,* vol. 6, no. 2, pp. 86-93.

Dai, B. & Chen, H. 2011, "Profit allocation mechanisms for carrier collaboration in pickup and delivery service", *Computers & industrial Engineering,* vol. 62, no. 2012, pp. 633-643.

Daugherty, P.J., Richey, R.G., Roath, A.S., Min, S., Chen, H., Arndt, A.D. & Genchev, S.E. 2005, "Is collaboration paying off for firms?", *Business Horizons,* vol. 2006, no. 49, pp. 61-70.

Davies, I., Mason, R. & Lalwani, C. 2006, "Assessing the impact of ICT on UK general haulage companies", *International Journal of Production Economics,* vol. 106, no. 2007, pp. 12-27.

de Weerdt, M.M. 2003, *Plan Merging in Multi-Agent Systems*, Technische Universiteit Delft.

Ding, H., Guo, B. & Liu, Z. 2010, "Information sharing and profit allotment based on supply chain cooperation", *International Journal for Production Economics,* vol. 133, no. 2011, pp. 70-79.

Dinwoodie, J. 2004, "Rail freight and sustainable urban distribution: Potential and practice", *Journal of Transport Geography,* vol. 14, no. 2006, pp. 309-320.

Dullaert, W. & Van Landeghem, H. 2007, "The Promise of the real-time company concept: an exploratory study" in *The reality and dilemmas of globalisation*, ed. K. Dobrowolski, Institute of Maritime Transport and Seaborne Trade, Gdansk, pp. 27.

Dullaert, W., Neutens, T., Vanden Berghe, G., Vermeulen, T., Vernimmen, B. & Witlox, F. 2009, "MamMoeT: An intelligent agent-based communication support platform for multimodal transport", *Expert Systems with Applications,* vol. 36, no. 7, pp. 10280-10287.

Dutta, S. & Bilbao-Osorlo, B. 2012, *The Global Information Technology Report 2012*, World Economic Forum, Geneva.

Evangelista, P. & Sweeney, E. 2006, "Technology usage in the supply chain: the case of small 3PLs", *The International Journal of Logistics Management,* vol. 17, no. 1, pp. 55-74.

EXTR@Web consortium 2006, *River Information Services*, European Communities, Belgium.

Farooq Ahmad, H. 2002, "Multiagent systems: Overview of new paradigm for distributed systems", *7th IEEE International Symposium on High Assurance Systems Engineering*.

Finkeldey, J. 2012, *State of Logistics in Namibia Project questionnaires*, Polytechnic of Namibia, Windhoek.

Francis, M. 1998, "Lean Information and Supply Chain Effectiveness", *nternational Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management,* vol. 1, no. 1, pp. 93-108.

Franklin, J.R. 2012, 19-09-2012-last update*, "Cloud Based" Collaboration Platform for Transport & Logistics Business Networks*. Available: ttp://www.the-klu.org/news/newsevents/events-single-view/article/klu-lecture-series-cloud-based-collaboration-platform-for-transport-logistics-business-netw/ [2012, 10/29].

Fransman, L. 2013, "Multi-agent collaboration platforms: Are they feasible for the Namibian Transport industry", *International Conference on Engineering & Business Education, Innovation and Entrepreneurship*, 07-10 October.

Gomes-Casseres, B. July-Aug 1994, "**Group vs. Group: How Alliance Networks Compete**", *Harvard Business Review,* vol. 94402.

Graham, L. 2011, *Transport Collaboration in Europe*, ProLogis Research Insight.

Grand Alliance 2014, *, MarineLink.com: Grand Alliance*. Available: http://www.marinelink.com/maritime/grand-alliance [2014, 03/30].

Green, K.W.J. & Whitten, D. 2007, "The impact of time information on organisations performance in a supply chain", *Production Planning and Control,* vol. 18, no. 4, pp. 274-282.

H&M 2013, *Conscious Actions: Sustainability Report 2013*, H&M.

Harris, I., Wang, Y. & Wang, H. 2012, *, ICT in multimodal transport and technological trends: unrivalled potential for the future*. Available: http://www.medifas.net/IGLS/Papers2012/Paper111.pdf [2013, 09/12].

Hewitt, C. 1977, "Viewing Control Structures as Patterns of Passing Messages", *Artificial Intelligence,* vol. 8, no. 3, pp. 323-364.

Himoff, J., Skobelev, P. & Wooldridge, M. 2005, "Magenta Technology: Multiagent systems for industrial logistics", *AAMAS'05*, July 25-29.

Hofstrand, D. & Holz-Clause, M. 2009, *, Feasibility and Business Plans* [Homepage of IOWA State University], [Online]. Available: http://www.extension.iastate.edu/agdm/wholefarm/html/c5-66.html [2013, 08/01].

Holland, C.P. 1999, "A critical success factors moders for ERP implementation", *Software, IEEE,* vol. 16, no. 3, pp. 30-36.

Hong, K. & Kim, Y. 2002, "The critical success factors for ERP implementation: an organisational fit perspective", *Information & Management,* vol. 40, no. 1, pp. 25-40.

Huckridge, J., Bigot, S. & Naim, M. 2011, "ICT in multimodal transport operations: A framework for future research", *17th International Annual EuroMA Conference*.

Imperial Logistics 2013, *, We partner with Transnet Freight Rail in Road to Rail Migration*. Available: http://www.imperiallogistics.co.za/node/445 [2014, 03/28].

Internet Truckstop 2013, *, Trans4Cast*. Available: http://www.trans4cast.com/ [2013, 08/01].

Jacobs, A. 2010, *Project between Polytechnic of Namibia and Unam on training for the Government*, Windhoek.

Keskinen, A., Delache, X., Cruddas, J., Lindjord, E.J. & Iglesias, C. 2001, *Impacts of e-commerce on transport and the environment*, European Commission Joint Expert Group.

Kilcarr, S. 2013, *, Shipper/Carrier collaboration key to capacity and cost control*. Available: http://fleetowner.com/fleet-management/shippercarrier-collaboration-key-capacity-and-cost-control [2014, 03/20].

Klaus, P. 2003, *Die 'TOP 100' der Logistik: Berichtszeitraum 2001/2002*.

Kumar, K. & Vin Dissel, H.G. 1996, "The merchant of Prato-revisited: Toward a third rationality of information systems.", *MIS Quarterly,* vol. 22, no. 2, pp. 199-226.

Kwon, O., Im, G.P. & Lee, K.C. 2007, "MACE-SCM: A multi-agent and case-based reasoning collaboration mechanism for supply chain managment under supply and demand uncertainties", *Expert Systems with Applications,* vol. 33, pp. 690-705.

Kwon, O., Im, G.P. & Lee, K.C. 2001, "An agent-based web service approach for supply chain collaboration", *Scientia Iranica,* vol. 18, no. 6, pp. 1545-1552.

laaimylorrie.com 2014, *, Laaimylorrie Transport Brokers*. Available: http://www.laaimylorrie.com/ [2013, 08/01].

Lambert, D.M. & Cooper, M.C. 2000, "Issues in Supply Chain Management", *Industrial Marketing Management,* vol. 29, no. 1, pp. 65-83.

Lee, H.L. & Padmanabhan, V. 1997, "Information distortion in a supply chain: The bullwhip effect", *Management Science,* vol. 43, no. 4, pp. 546.

Leitao, P. 2009, "Holonic Rationale and Bio-inspiration on Design of Complex Emergent and Evolvable Systems", *Transactions on Large-Scale Data- and Knowledge Centered Systems,* , pp. 243-266.

Leitão, P. & Vrba, P. 2011, "Recent developments and future trends of industrial agents", *HoloMAS 2011*Springer, , pp. 15-28.

Lo, S.K.C. 2012, "A collaborative multi-agent message transmission mechanism in intelligent transportation systems - A smart freeway example", *Information Sciences,* vol. 184, pp. 246-265.

Long, B. & Baecker, R. 1997, *Taxonomy of the Internet Communication Tools*.

Luck, M. 2005, *, 50 facts about agent-based computing* [Homepage of AgentLink], [Online]. Available: http://www.dcs.kcl.ac.uk/staff/mml/docs/AgentLink_Fifty_Facts.pdf [2014, 03/07].

Malhotra, R. & Temponi, C. 2010, "Critical decisions for ERP integration: Small business issues", *International Journal of Information Management,* vol. 30, no. 1, pp. 28-37.

Malone, R. 2001, *, Simple Collaboration: The Focus is Transportation* [Homepage of inbound logistics], [Online]. Available: http://www.inboundlogistics.com/cms/article/simple-collaboration-the-focus-is-transportation/ [2012, 11/12].

Manuere, F., Gwangwava, E. & Gut, K. 2012, "Barriers to the adoption of ICT by SMES in Zimbabwe: An exploratory study in Chinhoyi district", *Interdisciplinary Journal of Contemporary Research in Business,* vol. 4, no. 6, pp. 1143-1156.

Marchet, G., Perego, A. & Perotti, S. 2009, "An exploratory study of ICT adoption in the Italian freight transporation industry", *International Journal of Physical Distribution & Logistics Management,* vol. 39, no. 9, pp. 785-812.

Mason, R., Lalwani, C. & Boughton, R. 2007, "Combining vertical and horizontal collaboration for transport optimisation", *Supply Chain Managment: An International Journal,* vol. 12, no. 3, pp. 187-199.

Mason, S.J., Ribera, P.M., Farris, J.A. & Kirk, R.G. 2003, "Integrating warehousing and transportation functions of the supply chain", *Transportation Research Part B,* vol. 39, pp. 141-159.

Matzen, H. 2013, *Site visit to 17111 LSP Kiel Germany*.

McKinnon, A.C. & Ge, Y. 2006, "The potential for reducing empty running by trucks: a retrospective analysis", *International Journal of Physical Distribution & Logistics Management,* vol. 36, no. 5, pp. 391-410.

McKinnon, A. 2004, "Transport is the "Integrator" of the Supply Chain", *Microlise Intelligent Transport Conference*, Oktober 2004.

McKinnon, A.C., Cullinane, S., Browne, M. & Whiteing, A. 2010, *Green Logistics: Improving the environmental sustainability of logistics,* Kogan Page Limited, London.

Miller, R.L. 2008, "Research Ethics: Issues and Resources" in *Developing, Promoting, & Sustaining the undergraduate Research Experience in Psychology*, eds. R.L. Miller, R.F. Rycek, E. Balcetis, et al, Society for the Teaching of Psychology, , pp. 48-52.

Moonen, J.M. 2009, *Multi-Agent Systems for Transportation Planning and Coordination*, PHD edn, Erasmus Universiteit Rotterdam, Rotterdam.

Nadin, S. & Cassell, C. 2004, "Using Data matrices" in *Essential guide to qualitative methods in organisational research*, eds. C. Cassell & G. Symon, Sage Publications, London.

Namibian Logistics Association 2011, *, OUR MEMBERS*. Available: http://www.nla.org.na/ [2012, 11/12].

NASSTRAC 2013, *Freight Transportation 2013: State of the Industry Report*, National Shippers Strategic Transportation Council (NASSTRAC).

NEPRU 2003, *Trade Assessment: Namibia and Angola*, NEPRU, Windhoek.

North Star Alliance 2013, *, Partnership between TNT and UNWFP*. Available: http://www.northstar-alliance.org/about-us/our-mission/ [2014, 03/27].

Nwana, H.S. 1996, "Sotware Agents: An Overview", *Knowledge Engineering Review,* vol. 11, no. 3, pp. 1-40.

Nyaungwa, N.F. 2012, *Inflation continues to surprise*.

Odell, J.J., Van Dyke Parunak, H., Fleischer, M. & Brueckner, S. 2002, "Modeling Agents and their Environment", [Online], . Available from: http://jamesodell.com/Agents_and_environment.pdf.

O'Flaherty, C.A. (ed) 1997, *Transport planning and traffic engineering*, Butterworth-Heinemann, The Netherlands.

ohorongo-cement.com 2014, *, About Ohorongo*. Available: http://www.ohorongo-cement.com [2014, 01/30].

Olfati-Saber, R. & Murray, R.M. 2004, "Consensus Problems in Networks of Agents with Switching Topology and Time-Delays", *IEEE Transactions on automatic control,* vol. 49, no. 9, pp. 1520-1533.

Pencheon, D.C. 2011, "Managing the environmental impact of research", [Online], . Available from: http://www.trialsjournal.com/content/12/1/80.

Perego, A., Perotti, S. & Mangiaracina, R. 2011, "ICT for logistics and freight transportation: a literature review and research agenda", *International Journal of Physical Distribution & Logistics Management,* vol. 41, no. 5, pp. 457-483.

Pergl, R. 2010, "Feasibility study inputs based on requirements engineering", *CAiSE 2010 Workshop EOMAS*, eds. J. Barjis, M.M. Narasipuram, G. Rabadi, J. Ralyte & P. Plebani, , pp. 121-132.

Piecyk, M.I. & McKinnon, A.C. 2009, "Forcasting the carbon footprint of road freight transport in 2020", *International Journal for Production Economics,* vol. 128, no. 2010, pp. 31-42.

Pokharel, S. 2005, "Perception on information and communication technology: perspective in logistics", *The Journal of Enterprise Information Management,* vol. 18, no. 2, pp. 136.

Poole, D. & Mackworth, A. 2010, *Artificial Intelligence: Foundations of Computational Agents,* Cambridge University Press.

Porfiri, M. & Stilwell, D.J. 2007, "Consensus seeking over random weighted directed graphs", *IEEE Transactions on automatic control,* vol. 52, no. 9, pp. 1767-1773.

Premkumar, G. & Roberts, M. 1999, "Adoption of new information technologies in rural small businesses", *Omega,* vol. 27, no. 4, pp. 467-484.

Ramanathan, U. & Gunasekaran, A. 2012, "Supply chain collaboration: Impact of success in long-term partnership", *International Journal for Production Economics,* , pp. DOI.

Ren, W. & Beard, R.W. 2005, "Consensus seeking in multiagent systems under dynamically changing interaction topologies", *IEEE Transactions on automatic control,* vol. 50, no. 5, pp. 655-661.

Robu, V., Noot, H., La Poutre, H. & Schijndel, W. 2011, "A multi-agent platform for auction-based allocation of loads in transportation logistics", *Expert Systems with Applications,* vol. 38, pp. 3483-3491.

Rudd, M. & Bishop, O. 2013, *, Northern Haulage targets further success in the SADC transportation industry*. Available: http://www.africanbusinessreview.co.za/reports/northern-haulage [2014, 03/28].

Rzevski, G., Himoff, J. & Skobelev, P. 2006, "Magenta Technology: A Family of Multi-agent Intelligent Schedulers", .

Sales, B.D. & Folkman, S. (eds) 2000, *Ethics in Research with Human Participants*, American Psycological Association, Washington.

Savage, C.J. 2013, "Becoming a regional gateway by developing logistics hubs: a blessing or a curse?", *Biennial International Conference of Business Innovation and Growth*University of Botswana, Gaborone.

Savage, C.J., Jenkins, A.K. & Fransman, L. 2012, *Logistics in Namibia: Issues and challenges,* Polytechnic of Namibia, Windhoek.

Schleiffer, R. 2004, "An intelligent agent model", *European Journal of Operational Research,* vol. 166, pp. 666-693.

Schmidt, T., Mbai, N. & Fransman, L. 2011, *Challenged by Economic Growth: Logistics in Namibia*.

Schuchard, R. 2014, *, Transforming transportation fuel for a low-carbon future: A new BSR guide*. Available: http://www.bsr.org/en/our-insights/bsr-insight-article/transforming-transportation-fuel-for-a-low-carbon-future-a-new-bsr-guide [2014, 04/24].

Semsar-Kazerooni, E. & Khorasani, K. 2009, "Multi-agent team cooperation: A game theory approach", *Automatica,* vol. 45, no. 2009, pp. 2205-2213.

Serna, M.D.A., Uran, C.A.S. & Uribe, K.C.A. 2011, "Collaborative autonomous systems in models of urban logistics", *Dyna,* vol. 79, no. 172, pp. 171-179.

Shoham, Y. & Leyton-Brown, K. 2008, *Multiagent systems: Algorithmic, Game-Theoretic and Logistical Foundations,* Cambridge University Press.

Sigala, M. 2005, "Collaborative supply chain management in the airline sector: The role of global distribution systems (GDS)", *Advances in Hospitality and Leisure,* vol. 1, pp. 103-121.

Singh, N., Lai, K. & Cheng, T.C.E. 2007, "Intra-Organizational Perspectives on IT-enabled Supply Chains", *Communications of the ACM,* vol. 50, no. 1, pp. 59.

System Alliance Europe 2014, *, System Alliance Europe Agency*. Available: http://www.systemallianceeurope.net/en/home.html [2014, 03/30].

Tian, Y. & Liu, C. 2008, "Consensus of multi-agent system with diverse input and communication delays", *IEEE Transactions on automatic control,* vol. 53, no. 9, pp. 2122-2128.

Tlhage, O. 2014, *Trading at fresh produce hubs exceeds million dollar mark*.

Transnova 2014, *, The Transnova transportation network*. Available: http://www.transnova.co.za/ [2014, 04/01].

Tsoulfas, G.T. & Pappis, C.P. 2005, "Environmental principles applicable to supply chains design and operation", *Journal of Cleaner Production,* vol. 14, no. 2006, pp. 1593-1602.

United Shippers Alliance 2014, *, United Shippers Alliance Homepage*. Available: http://unitedshippers.org/ [2014, 03/30].

Usacanadaloadup.com *, Loadup Backhaul Load Board*. Available: http://www.usacanadaloadup.com/ [2013, 08/01].

Walvis Bay Corridor Group 2013, *, The leading trade route in Southern Africa*. Available: http://www.wbcg.com.na/fileadmin/user_upload/images/May-_June_Newsletter_2013.pdf [2014, 04/15].

Waters, D. (ed) 2007, *Global Logistics: New directions in Supply Chain Management*, Fifth Edition edn, Kogan Page Limited, London.

Weiss, G. 1999, *Multiagent systems: A modern approach to distributed modern approach to artificial intelligence,* Massachusetts Institute of Technology, London, England.

Weisstein, E.W. 2014, *, Asymptotic*. Available: http://mathworld.wolfram.com/Asymptotic.html [2014, 04/30].

Weyns, D. & Holvoet, T. 2005, "On the Role of Environments in Multiagent Systems", *Informatica,* vol. 29, pp. 409-421.

Weyns, D., Schumacher, M., Ricci, A., Viroli, M. & Holvoet, T. 2005, "Environments in multiagent systems", *Knowledge Engineering Review,* vol. 20, no. 2, pp. 127-141.

Wooldridge, M. 2007, *Responding to Real-World Complexity: Introduction to Multi-Agent Technology*, A Magenta Technology Winter Whitepaper, Liverpool.

Wooldridge, M. & Jennings, N.R. 1995, "Intelligent Agents: Theory and Practice", *Knowledge Engineering Review,* vol. 10, no. 2, pp. 115-152.

World Bank 2012, *Regional transport & trade logistics in Namibia: A Policy Note*.

Wu, Q., Xue, D. & Yao, J. 2010, "Consensus Analysis of Networked Multi-agent Systems", *Physics Procedia,* vol. 3, no. 2010, pp. 1921-1931.

Xiao, F., Wang, L., Chen, J. & Gao, Y. 2009, "Finite-time formation control for multi-agent systems", *Automatica,* vol. 45, no. 2009, pp. 2605-2611.

Yilmaz, O. & Savasaneril, S. 2012, "Collaboration among small shippers in a transportation market", *European Journa of Operational Research,* vol. 218, no. 2, pp. 408-415.

Zhu, J., Tian, Y. & Kuang, J. 2009, "On the general consensus protocol of multi-agent systems with double-integrator dynamics", *Linear Algebra and its Applications,* vol. 431, no. 2009, pp. 701-715.

10 Appendix UNISA ethical clearance certificate

Mr Logan Fransman (49941054) 2014-05-08

College of Science, Engineering and Technology

UNISA

Johannesburg

Permission to conduct research project

Ref: 123/LF/2014

The request for ethical approval for your MTech (Information Technology) research project entitled "A multiagent based system to promote collaboration among transport stakeholders in order to reduce empty runs" refers.

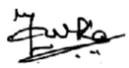
The College of Science, Engineering and Technology's (CSET) Research and Ethics Committee (CREC) has considered the relevant parts of the studies relating to the abovementioned research project and research methodology and is pleased to inform you that ethical clearance is granted for your study as set out in your proposal and application for ethical clearance.

Therefore, involved parties may also consider ethics approval as granted. However, the permission granted must not be misconstrued as constituting an instruction from the CSET Executive or the CSET CREC that sampled interviewees (if applicable) are compelled to take part in the research project. All interviewees retain their individual right to decide whether to participate or not.

We trust that the research will be undertaken in a manner that is respectful of the rights and integrity of those who volunteer to participate, as stipulated in the UNISA Research Ethics policy. The policy can be found at the following URL:
http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Please note that if you subsequently do a follow-up study that requires the use of a different research instrument, you will have to submit an addendum to this application, explaining the purpose of the follow-up study and attach the new instrument along with a comprehensive information document and consent form.

Yours sincerely



Deputy Chair: College of Science, Engineering and Technology Ethics Sub-Committee

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11 Appendix B Turnitin Digital Certificate

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Digital Receipt

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A multi-agent based system to promote collaboration among Namibian transport stakeholders in order to reduce empty runs

By

Logan Fransman

Student number: 49941054

Submitted in fulfilment of the requirements for the degree of Master of Technology in Information Technology

University of South Africa

Supervisor: Prof E. Mnkandla

June 2014

12 Appendix C Questionnaire to Stakeholders

A multiagent based system to promote collaboration among transport stakeholders in order to reduce empty runs

Participant consent form

This is to get consent for your participation in the research conducted by Logan Fransman. The research is for a Master of Technology in Information Technology at Unisa, under the supervision of Professor Ernest Mnkandla (Email: mnkane@unisa.ac.za.) The purpose of this research is to: formulate and test a Multiagent based system that could achieve collaboration and reduce empty runs in the Namibian transport environment.

The questionnaire will require approximately *40 minutes* of your time. It is divided into 5 sections with the sections 1 and 2, aimed at gathering specific information about your organisation and it operations in the Logistics and Transport sector. Sections 3 & 4 focuses on the 'Cost and Time Management' and infrastructure of your organisation, while Section 5 gathers a future view from your organisation on logistics and transport. You will be required to complete the Sections 1 and 2 alone, while the researcher will interview Sections 3-5.

The input you provide will be treated with confidentiality in accordance with the Unisa ethics policy and will only be used towards the completion of the afore-mentioned qualification. All data will be used anonymously in summary form without reference to any individual.

Participation in this research study is voluntary, and you have the right to, at any time, withdraw or refuse to participate. There are no risks or discomforts associated with your participation. All answers from you and other participants will be analysed collectively. Individual answers will therefore not be linked to any names of participants.

State of Namibian Logistics

Question Set (Semi-Structured) (v2.3) in 2012

General Company Info question

1. Can you please tell me about your organisation/firm? (history, location, number of employees, key products and services, turnover etc.)

History	Location	No. of Employees	Business	Turnover

2. What is your job title and what is your main line of work?

Answer

3. How long have you held this position?

Answer

4. Some discussion to determine the interviewees understanding of the term “logistics”. It is difficult to pre-structure this as, I think, they will vary with the person and so will have to be left to the interviewer to evolve.

1	2	3	4	5
Thinks its just “trucking”	Outbound distribution only	Procurement and distribution	Manufacturing and distribution	Sound understanding of the logistics and supply chain concepts

……

…….

Management & Operations

5. How do you measure / manage logistics performance?

Answer

6. **To what extent do you use third parties in your supply chain or distribution operations?**

1	2	3	4	5
Don't (Own account only)	Buy in transport **or** warehousing	Buy in transport & warehousing	Contract out some of your logistics management (to a 3pl)	Contract out all supply chain / logistics management (to a 3/4pl)

7. How do you integrate your company with the other supply chain members including customers and vendors?

1	2	3	4	5
Adversarial approach (especially with suppliers)	Transactional (arms length) relationships – traditional buyer / seller	Coordination and planning of activities only on a limited basis with other S/C organisations	Organisations progress beyond coordination to integration of activities and partial partnerships	Share significant level of operational integration with partners. A "no end" view where each party sees other as an extension of their own firm

NB Some of these have been adapted from Lambert, D., Emmelhainz, M., and Gardner, J., (1996), "Developing and implementing supply chain partnerships", The International Journal of Logistics Management, vol 7, n°2, 1-17.p. 2). Should be cited should we use in any report.

8. How important is sustainable logistics in your organisation?

Answer

……

……

……

9. How do you encourage innovation in your firm/organisation?

Answer

10. Do you manage reverse logistics?

   a. Asset management (pallets, containers, etc.)

      N/A

   b. Returns, reworks & recycling

      Answer

   c. Recalls

      Answer

11. Do you make use of “backloading”.

Answer

12. **If you operate or control a fleet, what is the typical percentage of empty running?**

Answer

13. How do you manage unpredictable demand?

Answer

Cost and Time Management

……

…..

……

Technology and Infrastructure

14. What technology do you use in the supply chain:
    a. Mechanical handling and vehicles, routing and scheduling

       Answer

    b. Information Technology systems

       Answer

15. Do you have a stock management system?

Answer

16. To what extent do you rationalise stock and transhipments between sites?

Answer

…..

17. What are the most important logistics issues/areas to be addressed in Namibia in the next five years?

Answer

18. Are there any other logistics related issues that you would like to raise?

Answer

Appendix D Transport Collaboration Survey extraction

Namibian Transport Collaboration v1

Namibian Transport Collaboration Study

My name is Logan Fransman from the Namibian German Centre for Logistics (NGCL), and I am conducting research on the collaboration among transporters in Namibia. The research is for a Master of Technology in Information Technology at Unisa, under the supervision of Professor Ernest Mnkandla (Email: mnkane@unisa.ac.za. This research aims to get the industry's view on collaboration with/and among transporters, as well as the level of integration with transporters. This would form the basis to explore future collaboration initiatives in Namibia. By completing this survey, you will assist with the research.

The survey starts with a few simple questions about your organisation to enable us to classify your responses for future analysis. This questionnaire is totally anonymous and no information produced in reports or papers will be linked to any respondents.

There is a section where you could identify yourself if you wish to be part of any subsequent research and if you wish to see a summary of the results.

Thank you

Next

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Check out our sample surveys and create your own now!

Namibian Transport Collaboration v1

1. What would describe your organization the best, is it:

- ◯ Small and Medium Enterprise
- ◯ Large Enterprise
- ◯ Multinational Enterprise

Prev Next

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Namibian Transport Collaboration v1

✱ 2. Could you please select the category below best suited to your organisation relating to transport

- ◯ Freight Forwarder
- ◯ Transport Operator
- ◯ Logistics Service Provider
- ◯ User of Transport

Other: Please specify

Prev Next

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Namibian Transport Collaboration v1

5. In your day to day management of your fleet, what is the percentage of occurrences of the following in your organisation:

	Over 80%	50-80%	20-50%	Less than 20%	Zero
Empty runs					
Less-Than-Truckloads					
Full Truckloads					

6. If you experience more than 20% empty runs in your organisation, what would you say is the biggest reason for this?

Prev Next

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Namibian Transport Collaboration v1

9. To what extent is your organisation using the following as a means of collaboration with partners, customers and suppliers?

	To a large extent	To a moderate extent	To some extent	To little extent	Not at all
Arms-length/Transactional/Once-off					
Formal short/long term contracts					
Strategic Partnerships					
Integrated IT systems					
Internet portal communities					
Joint Tendering					
Alliance agreements					
Common Planning and information sharing					
Synchronization of activities					

Prev Next

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Namibian Transport Collaboration v1

13. This question tries to understand your organisations technological stance. Please select all technical equipment and/or software used by your organisation? Select all that apply.

- [ ] Computers (Desktops/Laptops)
- [ ] Servers
- [ ] Telephones/Fax
- [ ] Cellphones
- [ ] Smartphones/Tablets
- [ ] Voice over IP (Skype, Google Talk)
- [ ] Internet (3G/ADSL)
- [ ] Electronic Data Interchange (EDI)
- [ ] Social Media (Facebook/Twitter/LinkedIn)
- [ ] Cloud Services (Dropbox/iCloud/)
- [ ] Antivirus Software
- [ ] Document Processing (MS Office/iWork/Open Office)
- [ ] Transport Management system
- [ ] Freight Forwarding and Cargo Management software
- [ ] Global Positioning systems
- [ ] Route Planning Systems
- [ ] RFID/Barcoding Technology

Any other you wish to specify

Prev Next

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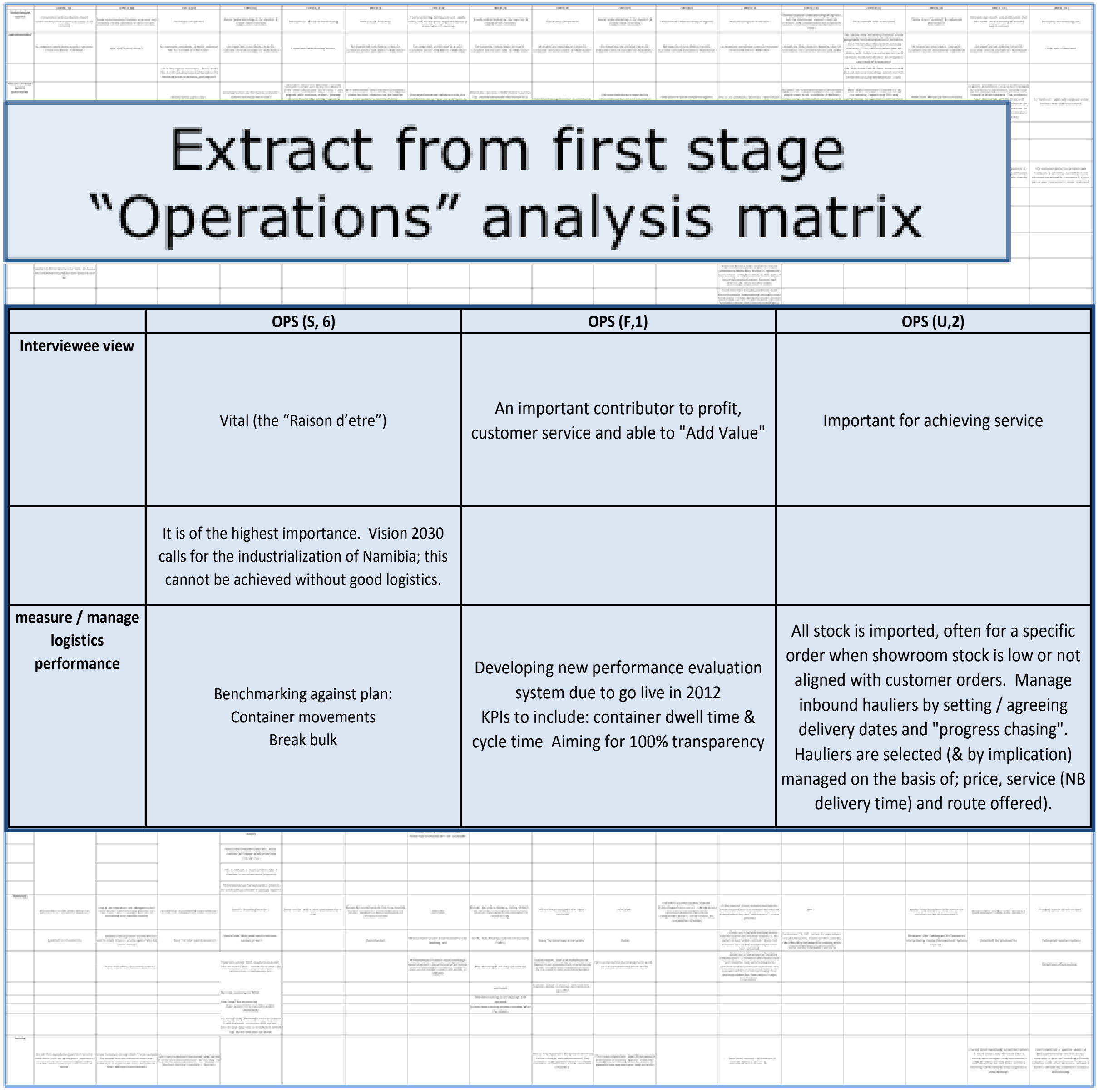
Appendix E Data Matrix Analysis example



	OPS (S, 6)	OPS (F,1)	OPS (U,2)
Interviewee view	Vital (the “Raison d’etre”)	An important contributor to profit, customer service and able to "Add Value"	Important for achieving service
	It is of the highest importance. Vision 2030 calls for the industrialization of Namibia; this cannot be achieved without good logistics.		
measure / manage logistics performance	Benchmarking against plan: Container movements Break bulk	Developing new performance evaluation system due to go live in 2012 KPIs to include: container dwell time & cycle time Aiming for 100% transparency	All stock is imported, often for a specific order when showroom stock is low or not aligned with customer orders. Manage inbound hauliers by setting / agreeing delivery dates and "progress chasing". Hauliers are selected (& by implication) managed on the basis of; price, service (NB delivery time) and route offered).