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Detection of shoreline changes at Kerteh Bay, Terengganu Malaysia remotely

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Abstract

Erosion has been a problem at the Kerteh Bay Coast of Malaysia for over a decade. Installation of three submerged breakwaters was put in place to mitigate the erosion problem in 1996. But unfortunately the projects has not been monitored to ascertain how well the problem has been mitigated. Actual field monitoring only commenced in 2011 after about 14 years. This paper discusses the performance of the installed submerged breakwater being monitored using a waterline technique of remote sensing. Satellite imageries of the study area of years, 2006, 2008 and 2009 were acquired for the purpose of monitoring.

1. Introduction

Coastal erosion is a global problem; at least 70% of sandy beaches around the world are recessional (Bird, 1985). Approximately 86% of U.S East Coast barrier beaches (excluding evolving spit areas) have experienced erosion during the past 100 years (Galgano et al., 2004). Widespread erosion is also well documented in California (Moore et al., 1999) and in the Gulf of Mexico (Morton and McKenna, 1999). This natural phenomenon is said to be reported in Asian and other countries along the ocean. Erosion has been reported in China (Bilan, 1993), also in Vietnam by Mazda et al. (1997).

Shoreline changes are an important consideration for coastal scientist, engineers, and those engaged in coastal management and engineering design. The location of the shoreline and its historical rate of change can provide important information for the design of coastal protection, plans for coastal development, and the calibration and verification of numerical models, etc. (Hanson et al, 1998). To
analyze shoreline variability and trends, both the temporal and spatial changes of a shoreline must be investigated based on a functional definition of the “shoreline,” (Boak and Turner, 2005).

A shoreline is idealistically defined as the interface of land and water (Dolan et al; Horikawa, 1988). Actually, the shoreline position changes continually with time because of beach variation that results from on-offshore and alongshore sediment transport, and it also changes because of the dynamic nature of water levels at the coastal boundary, such as waves and tides, Boak and Turner (2005) pointed out that the instantaneous shoreline used by some investigators is problematic because it represents the position of the land-water interface at one instant in time rather than ‘normal’ or ‘average conditions.

Previous studies of monitoring topography and morpholodynamics of coastal flats using an optical remote sensing imagery have focused on ‘waterline’ extraction. The waterline is defined as the instantaneous land-water boundary at the time of the imaging process, while the coastline or shoreline is the waterline at the highest possible water level (Niedermeier et al., 2005). The sea may be treated as an altimeter in this method, and the sea level may be determined by the data on tide height collected from original tide gauge records. Records of the waterline positions from images at different tidal stages can be used to construct a Digital Elevation Model (DEM) of the intertidal zone (Lohani and Mason, 1999).

Over the past decades, many studies have used satellite-derived data to sketch waterline at coastal areas and water bodies using both active and passive sensors, including synthetic aperture radar (SAR), near infra-red, shortwave infrared and thermal infrared images. (Yamano et al., 2006). Among these satellite-based sensors, SAR shows prominent advantages in the waterline technique (Mason and Davenport, 1996), which can provide ground information regardless of cloud presence. Archived SAR data are however, less available than commercial optical sensors (such as Landsat TM/ETM, Terra ASTER, SPOT, and IKONOS/QuickBird). SPOT multi-temporal images of the years 2006, 2008 and 2009 were used for the analysis in this paper.

The waterline technique is relatively sophisticated, but it still faces the problem that the different waterlines acquired in fluctuating tidal conditions are not comparable along time frame. This paper elaborates a waterline technique that involves the detection of shoreline and beach evolution of Kerteh Bay. The shoreline position extracted from a satellite image is a water-line or a wet/dry line that describe the instantaneous land-water boundary at the time of imaging, which is similar to the first kind of shoreline (Foody et al., 2005; Niedermeier et al, 2005; Yamano et al., 2006; Zhao et al., 2008). However,
to accurately assess the movement trends of the beach, an MSL tidal-datum-based shoreline indicator is practically necessary.

2.0 Materials and Methods

2.1 Study area

The study area is located within a town called Kerteh in the district of Kemamam in Southern Terengganu, Malaysia, about 30 km or 20 minutes’ drive north of Chukai. Kerteh is the base of operations for Petronas in Terengganu, overseeing the oil platform operations off the state’s coast. Kemamam is a district of 2,536 km² area with a population of 174,876. It geographical location is 4° 31' 38" N and 103° 28' 9" E. The stretch of the beach protected is approximately 2100m.

Figure 1.0: Map of study area

The study area is characterized with much of its coast to be a series of large and small hook-shaped bays, fully exposed to direct wave attack (especially during the NEmonsoon) from the South China Sea. The geomorphologic feature of Kerteh bay is such that its development is controlled by protruding headlands. Most of the bays along this region are considered to be in dynamic equilibrium; this is when constant supply of material from upcoast or within its embayment is passing through the bay and beyond the
downcoast headland. The littoral drift rate, associated with the dynamically stable configuration of Kerteh Bay, has been computed to be some 210,000 m³/yr of which more than 80% is transported during the NE-monsoon period.

The cause of the coastal erosion at the study area Kerteh bay, was studied by Tilmans et al. (1992). Some major causes were highlighted by the researchers. The beach platform at Kerteh bay is such that there exists a continual longshore sediment transport from upcoast to downcoast, disruption of this dynamic stability may easily occur when upcoast sediment supply is (partly) cut off which can result into erosion of the coast leading to a larger indentation of the bay configuration. If the entire upcoast sediment supply is cut off, the bay would become even more indented until littoral drift ceases.

### 2.2 DETERMINATION OF SHORELINE

In coastal engineering, the change in shoreline positions is commonly used to evaluate practical beach change. The sophisticated method is called the one-line model or shoreline change model. It is assumed that the beach moves offshore or onshore with one bottom profiles as shown in Figure 2. The figures shows three beach profiles at three different: $t_i \ (i = 1,2,3)$. At time $t_i$, the waterline is located at $x_i$, away from the origin of the transformed coordinates, and the corresponding water depth is $h_i$ above or below MSL, when the sea surface is at MSL, the MSL-datum-based shoreline is located at $z_i$ away from the origin. Figure 2 illustrates an example of a beach profile moving from right to the left. If the extracted waterlines from satellite images at time $t_2$ and $t_3$ are located at $x_2$ and $x_3$, respectively, $x_3 > x_2$. Extracted waterlines ($x_2$ and $x_3$) without consideration of tidal effect imply that the beach moves from the left to the right. This inference conflicts with the assumption figures 2. Shifting the extracted water to the MSL-datum-based shoreline position is necessary to accurately estimate the beach movement. (Wei and Hsien, 2009)
The Gaussian algorithm was first applied on the satellites images to improve the quality of the images, the three satellite images is geo-refenced using image-image registration method. Classification image is classified using ISODATA (unsupervised) method of classification. Subsetting, reducing the area of interest was also performed on each of the images for a more detailed analysis. The flow chart for the procedure applied to extract the shoreline is given in Figure 3.
Figure 3.0: Flow chart of procedure for shoreline extraction

3. Results and Discussion

Images were acquired as in Figure 3.0, subsetting was performed to reduce the area of interest as in Figure 3.1.
The study area was reduced to 10 region of areas to improve the analysis on each area. Each of the smaller areas was classified as shown in Figure 3.2 using the ISODATA method of classification.
The tidal heights were applied to correct the extracted shoreline and then overlaid to measure erosion at the study area. Based on the analysis from the images processed, erosion were observed in some part of the study area.

References


Appendix

![Graph of Max Tardiness](image)

Figure 1: Maximum Tardiness (example)
Research Article

Assessing the Perceptions of Regional Stakeholders on benefits of PFI for infrastructure provision
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Abstract

The Private Finance initiative (PFI) has been touted as providing value for money (VFM) than any other form of public procurement. While it cannot be denied that PFI has helped provide infrastructures faster than would have been possible relying solely on public budget, the VFM argument which is the most claimed benefit has continued to be elusive. This study which sought the perceptions of stakeholders attending two (2) PFI-focused conferences held in Malaysia through survey questionnaires, on the benefits of PFI in infrastructure since its introduction into the public sphere found, consistent with earlier commentators, that among the major benefits achieved so far, value for money fails to rank among the most important benefits of PFI procurement strategy. The delegates ranked 1) encouraging a more innovative public sector, 2) Improved business confidence, 3) Contribution to economic growth, 4) Better accountability, 5) increased investment in infrastructure, and 6) helping government spread payment over life of the asset, as the most important benefits derived so far from PFI procurement strategy out of 20 identified benefits, with value for money coming a distant 14th place on the list.

1. Introduction

The involvement of private participation in infrastructure provision has been on-going for a long time under the traditional procurement method. However, their involvement was limited to advisory roles/consultancy, design, planning, environmental impact assessment, representing the client as an independent umpire, construction and maintenance. However, since the advent of the public sector reform tagged ‘New public Management (NPM), which is the attempt to implement management ideas from business and private sector into the public services (Haynes, 2003); there has occurred a dramatic change in the form and substance of private involvement in the provision of public infrastructure. Faced with increasing external debt, shortage
of funds, population explosion in developing countries, there evolved an urgent need for other means of providing public services so that government can turn its attention to more critical areas requiring funding. This urgent need for an alternative source of financing infrastructure led to the evolution of what is today known in many climes as Public private Partnerships (PPP) or Private Finance Initiatives (PFI). In some jurisdictions, the PFI is synonymous with the PFI (CBI, 2007) but in the UK, the PFI is considered a special case of PPP where all finances for the asset including the design, construction and maintenance thereof is included in the contract arrangement for the duration of the contract in return for a service charge (Fewings, 2005, p. 280). While this is not the first time governments have been known to undertake this complex method of infrastructure provision, (Hodge & Greve, 2007) highlights five different ‘families’ of this partnership between government and the private sector. They include:

1. Institutional co-operation for joint production (Netherlands Ports Authority)
2. Long-term infrastructure contracts (UK PFI)
3. Public policy Networks (in which loose stakeholder relationships are emphasised)
4. Civil society and community development
5. Urban renewal and Downtown Economic Development (USA)

Outsourcing is also a form of this partnership if the subject of the deal is a public infrastructure, so also are a number of privatisations undertaken in the past like the Malaysian PLUS Highway contract which connects the North and South of peninsula Malaysia. It is difficult to really say which is a total privatisation or a partnership in the sense in which governments want the electorates to understand them. However (Broadbent & Laughlin, 2003) provide a simple measure which in our opinion sufficiently differentiate between core privatisation and the present day partnerships being bandied around the globe, they observed that the simple difference between the two concepts is the presence of ‘a regime of state price regulation’. This does not mean that network infrastructures which are monopolistic in nature were not privatised in the early days of the privatisation exercise in many countries, however the loss of democratic control and exorbitant increases in service fees led to takeovers by various government wanting to avoid the political backlash that ensued. In response to how citizens viewed privatisation (Hodge & Greve, 2009) observed that a number of governments have tried to avoid using the term ‘privatisation’ or ‘contracting out’ in favour of speaking about ‘partnerships’. The push for market mechanism in the provision of infrastructure were also as a result of particular interest groups like the multi-lateral financial institutions who made the involvement of private operators a condition for extending loans to governments. For example, the world bank provided a $20 million loan to the government of Bolivia on the condition that it privatised its water and sewerage utilities in La Paz and Cochabamba, this the government did but due to exorbitant rate hikes the residents took to the streets and eventually the concession was revoked (Bonnardeaux, 2009). Latin America has been the most active in term of private involvement in network infrastructure, however, they also contain the most amount of renegotiated contracts which (Guasch, 2004)
puts at 50%. Lobbying pressure and support for Private involvement in infrastructure also come from interest groups likely to benefit from the policy, including banks, lawyers and contractors (Parker & Hartley, 2003), this position was also echoed by (Dombkins, 2006) who argues that “We are not seeing any public push for more PFIs, nor are we seeing Audit Offices finding and reporting on the benefits that PFIs are delivering to society. Unfortunately, all too often PFI are promoted by merchant banks which see PFI as pots of gold. However, the benefits that are attributed to the PFI are not unique. Other forms of procurement have the potential to deliver many of the benefits claimed by the PFI, however because of the insistence and pressure by the central government to use only the PFI for new capital projects there has been little opportunity to develop these” (Cartlidge, 2004). A situation was reported by (Cohn, 2008) where a regional government had to create a self-inflicted financial crisis just to get the public to support the use of PFI. In spite of the horrid experiences, PFIs are “attractive to governments because they provide for the construction of the essential infrastructure without direct capital outlay and the delivery of related services without the need for the public sector employees to maintain and operate infrastructure projects” (English & Guthrie, 2003). Therefore following on the heels of (Hodge & Greve, 2009) question on ‘how have Long Term Infrastructure Contracts (LTIC-Type) PPPs performed according to historical evidence till date? And the assessments of (Estache, 2005), questions if we are switching to Private Participation in Infrastructure Divorces? This paper seeks to assess, from the perceptions of stakeholders across five regions that filled out survey questionnaires, if the main benefits promised by PFI are being achieved?

2. The state of the practice

The public sector has always been criticised for its inefficiency in providing public services efficiently, instead of giving thoughts to how to overcome this problem their jobs were outsourced to the private sector in the form of Public private partnerships (PPP) or Private Finance Initiatives (PFI). a number of reasons have been put up to support the need for private involvement in infrastructure, (Hodge & Greve, 2009) observed that some of the reasons presented under John Major’s government for adopting the PFI include 1) get around public sector debt restrictions, 2) reduce pressure on public sector budget, 3) better value for money for taxpayers, 4) Better accountability, 5) Better On-time and On-Budget delivery, 6) Greater Innovations in service delivery, 7) Encouraging a more innovative public sector, 8) Improved business confidence and 9) Boost sales of professional PPP services abroad. The (MOF, 2004) also claims that the main aims of implementing PPPs in Singapore include: (a) allowing the public sector to get better value for money in the delivery of public services; (b) offering the private sector more business opportunities and more room to innovate and offer efficient solutions for public services; and (c) combining the expertise of the government and the private sector to meet the needs of the public effectively and efficiently. Other studies observed that the PFI was adopted to reduce pressure on public finances (Asenova & Beck, 2010), faster provision of services than would have been possible relying solely on the government (Parker &
Hartley, 2003), private sector expertise, innovations and operational efficiency (Zhang & Kumaranawamy, 2001) & (Siang, 2008), technology transfer (Li, Akintoye, Edwards, & Hardcastle, 2005), value for money (VFM) (Parker & Hartley, 2003), (Cartlidge, 2004) and costs savings (The Commission on PPP, 2001). (Fewings, 2005, p. 280) Also observed that, the PFI helps manage the twin risks of time and cost overruns, however, under the traditional procurement these two risks are taken care of under the Liquidated and Ascertained Damages (LAD) clauses in the conditions of contract. Therefore, the claims are not specific to the PFI alone. The major risks in a PFI are construction risks which only occur during the initial period of asset provision and this may fall within the first 3 years of the contract and after construction most of the risks are no longer there, however, with the improved technology in the industry, these risks have been greatly reduced to be of any significant threat. Some consortia have used this period to renegotiate the terms of their loans with their financiers resulting in huge gains from refinancing which, in spite of the provision for refinancing gains sharing, consortium are still reluctant to share the gains with the public sector client. (Shaoul, 1999) points out that, in the Greenwich Hospital Scheme, seven of the eight risks said to be transferred to the private investors related to the construction phase of the project and therefore could not threaten the income of the investors during the operational phase of the project. As the PFI becomes more and more used in practice, problems and failures have been observed in the management of many projects like the Eurotunnel, Railtrack, motorways concessions in Mexico or Urban motorway TEO in Lyon (Meunier & Quinet, 2010). The problems and criticisms being encountered has resulted in reduced adoption of the PFI approach. (Estache, 2005) Cites a PriceWaterHouseCoopers’ report (PwC, 2005) where it is claimed that there appears to be a significant drop in private involvement in infrastructure from a peak of $131 billion in 1997, to less than $50 billion in 2003. The situation has seen large infrastructure projects which would otherwise have been contracted to the private sector being retained in-house, for example the state of California in the U.S recently approved a whopping $68 billion of public funds in the form of bonds for the provision of a proposed high speed rail (Lin, 2012), this is coming from a country that has been at the fore of pushing for private involvement in infrastructure provision. (Nickson & Vargas, 2002) argue that infrastructure concessions bring about five problems namely, 1) Moral hazard where one party behaves opportunistically after signing the contract, 2) Asymmetric information, where one party has more information about quality and cost of inputs than the other party, 3) Problem of ‘first mover’, where the winning bidder has the advantage of securing future contracts with the same party, 4) High participation costs which limits competition and costs are passed onto the users and finally 5) The presence of monopoly where the franchise is protected from market forces by an excessively long period of more than 10 years. This is especially more serious in network utilities. (Gaffney, Pollock, Price, & Shaoul, 1999) argue that investment under the private finance initiative cost more than the public sector procurement, the position is also supported by (Blanc-Brude, Goldsmith, & Välilä, 2009) who found that the PFI was 24% more expensive than the traditional procurement on roads, however, they asserted that the extra cost was for risks
being borne by the private sector. But (Gaffney, Pollock, Price, & Shaoul, 1999) countered the risk transfer argument by claiming that the amount of risk transfer to the private sector under the PFI was exaggerated. In order to limit the criticisms levelled against the PFI, governments and the PFI policy advocates came up with the Public Sector Comparator (PSC), a hypothetical control project assumed to be representative of how the public sector ‘would have financed the project’ under consideration, that is used to assess if the PFI option would deliver better value for money than if the project were done traditionally. However, (Pollock, Shaoul, & Vickers, 2002) point out that the discount rate adopted has a crucial impact on whether PFI offers better value that the traditional grant system. While the PSC being used employs a discount rate of 6%, generally it has been shown that 3% is used for public sector borrowing hence would make the project cheaper if financed through public borrowing. (UNISON Scotland, 2007) observed that obsessive secrecy and claims of commercial confidentiality has made it difficult to obtain figures to properly assess the validity of value for money (VFM) claims being espoused by the government. Relevant documents have frequently either not been published or have had key financial information withheld. (Shaoul, Stafford, & Stapleton, 2012) Supported this view by arguing that there is a need for information to be accessible to the public, and in particular a stream of information between the public and private sector partners needs to be developed and disseminated to achieve accountability for public money that is increasingly spent in the private sector. In conclusion, the experiences on the Balmoral high school, Cochabamba (Nickson & Vargas, 2002), Indah water Konsortium (Abdul-aziz, 2001) and the Buy-backs of Skye Bridge (bought back at 26.7 million pounds), Inverness Airport (bought back in 2005 at 25 million pounds only 1.6% cheaper than PSC figures), and West Lothian College (UNISON Scotland, 2007) seem to portray a different story from what was promised at the inking of the various contracts. (Mehra, 2005) Has also presented a list of 100 PFI projects (in Canada, Australia and the UK) which have faced at least one of the risks the PFI was said to prevent (time overruns, cost overruns, service cuts, design problems etc). The best reading of the situation is that private involvement in infrastructure (Budds & McGranahan, 2003) has achieved neither the scale nor benefits anticipated. This leads to the question, has the PFI delivered on its promises?

3. Research methodology

A literature review was carried out to identify the basic assumptions upon which governments have decided to adopt the PFI procurement strategy in the belief that knowledge accumulates and one can learn from and build on what others have done in the past (Webster & Watson, 2002). In total 20 benefits of PFI were identified from the literature and included in the survey questionnaire. The survey questionnaires were targeted at delegates at 2 PFI/infrastructure-focused conferences in Kuala Lumpur, Malaysia with a combined total of 300 delegates from 28 countries. 165 questionnaires were successfully distributed, but only 44 were returned resulting in a return rate of about 26.6%. This is comparable with (Proverbs, Holt, & Olomoaiye, 1999)’s 21% achieved in the UK. The collected data were entered into SPSS statistical software.
version 17.0 and analysed to draw inferences, while the relative importance index (RII) was used to rank the benefits as perceived by the respondents. The index generates values between 0 to 1 and the closer to 1 a value gets the more important it is perceived to be. The relative importance index (RII) was used by (Odusami, 2002) to rank the skills of effective project leaders as perceived by Construction Professionals, while (Enshassi, Mohamed, & El Karriri, 2010) used the RII to rank factors affecting the Bid/No Bid Decision in the Palestinian construction industry and was also used by (Fugar & Agyakwah-Baah, 2010) to rank delay factors in construction projects in Ghana.

4. Results and Discussion
The results reveal that 8 of the respondents were delegates from Africa, 27 from Australasia (a grouping of Asia and Australia), 6 from the Middle East, 1 delegate from Europe and 2 delegates from North America. In terms of sector, 28 of the delegates belonged to the public sector while 16 were in the private sector. The reliability test carried out on the data returned a Cronbach’s alpha of 0.947, using the guide provided by (George & Mallery, 2003, p. 231) an alpha Greater than 0.9 = Excellent; this shows that the data collection instrument was reliable. In terms of validity, a generally accepted rule of thumb for explaining construct validity was provided by (Hinton, Brownlow, McMurray, & Cozens, 2004) who pointed out a validity test score of more than 0.90 is statistically considered excellent; 0.70 - 0.90 is high, 0.5 - 0.7 is moderate while below 0.50 indicates a low validity rate of the variables, meaning that the questionnaire did not measure what it was constructed to measure. However, for this data, the average extracted value obtained was 0.76 which indicates a high overall validity of the data; hence, the high validity value obtained is a clear indication that the questionnaire measured what it was constructed to measure (Dewberry, 2004).

The Spearman Rank Correlation Coefficient may be employed as a test statistic to test a hypothesis of no association/no agreement between pairs of measurements from two populations. For a given value of alpha (level of significance) and for a two-tailed test, the rejection region of null hypothesis (Ho) occurred if \( r_s \geq r_o \) or if \( r_s \leq -r_o \), where \( r_o \) is the critical value of Spearman’s Rank Correlation Coefficient (Mendenhall, Reinmuth, & Beaver, 1993, p. 1006). The degree of agreement is expressed as a “correlation coefficient”. In terms of the correlation in their ranking, the guide provided by (Cohen, 1992) was employed in explaining the results of the spearman’s correlation coefficient tests. According to his guide, the correlations are either positive or negative depending on the direction. If the value carries a negative value, then there might be a strong, weak, moderate or perfectly negative correlation; the same goes for positive values. His guide is as follows, 0.0=none/trivial, 0.1/-0.1=weak/small, 0.3/-0.3=moderate/medium, 0.5/-0.5=strong/large and 1.0/-1.0= perfect, hence the closer to 1.0 the value gets, the stronger the correlation. On the correlation in terms of ranking between the three regions under consideration, The spearman’s correlation coefficient between the ranking of African/Australasian delegates was found to be (rho) \( \rho=0.31 \) which suggests a moderate/medium positive correlation; that between Australasian/Middle East delegates
was \( \rho = 0.48 \) which indicates strong/large positive correlation while between Middle East/African delegates was \( \rho = 0.07 \) indicating a weak/small positive correlation. However, (Corder & Foreman, 2009, p. 123) observed that “the correlation strength assignments vary for different types of statistical tests and that the \( r \) values are not based on a linear scale”.

Table 1: RII of the perceived benefits of PFI as ranked by Respondents

<table>
<thead>
<tr>
<th>Benefits from adopting PFI</th>
<th>Africa Ranking</th>
<th>Aus/Asia Ranking</th>
<th>M/East Ranking</th>
<th>Overall Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Encouraged a more innovative public sector</td>
<td>0.83 7</td>
<td>0.73 10</td>
<td>0.83 2</td>
<td>0.80</td>
</tr>
<tr>
<td>2 Improved business confidence</td>
<td>0.85 3</td>
<td>0.75 4</td>
<td>0.80 3</td>
<td>0.80</td>
</tr>
<tr>
<td>3 Contribution to economic growth</td>
<td>0.80 10</td>
<td>0.75 5</td>
<td>0.83 1</td>
<td>0.79</td>
</tr>
<tr>
<td>4 Better accountability</td>
<td>0.85 4</td>
<td>0.72 12</td>
<td>0.80 6</td>
<td>0.79</td>
</tr>
<tr>
<td>5 Increased investments in infrastructure</td>
<td>0.80 11</td>
<td>0.76 3</td>
<td>0.77 7</td>
<td>0.78</td>
</tr>
<tr>
<td>6 Help government spread payment for asset</td>
<td>0.83 8</td>
<td>0.78 1</td>
<td>0.73 11</td>
<td>0.78</td>
</tr>
<tr>
<td>7 Greater innovation in service delivery</td>
<td>0.78 12</td>
<td>0.74 7</td>
<td>0.80 4</td>
<td>0.77</td>
</tr>
<tr>
<td>8 Improved efficiency through competition</td>
<td>0.78 13</td>
<td>0.74 8</td>
<td>0.80 5</td>
<td>0.77</td>
</tr>
<tr>
<td>9 On-time delivery of assets</td>
<td>0.85 5</td>
<td>0.76 2</td>
<td>0.70 12</td>
<td>0.77</td>
</tr>
<tr>
<td>10 On-budget delivery of assets</td>
<td>0.85 6</td>
<td>0.72 13</td>
<td>0.70 14</td>
<td>0.76</td>
</tr>
<tr>
<td>11 Reduce pressure on public budget</td>
<td>0.88 1</td>
<td>0.71 14</td>
<td>0.70 15</td>
<td>0.76</td>
</tr>
<tr>
<td>12 Helped achieve technology transfer</td>
<td>0.75 15</td>
<td>0.74 9</td>
<td>0.77 8</td>
<td>0.75</td>
</tr>
<tr>
<td>13 Helped overcome design and constrn risks</td>
<td>0.83 9</td>
<td>0.74 6</td>
<td>0.67 18</td>
<td>0.75</td>
</tr>
<tr>
<td>14 Provide better value for money</td>
<td>0.88 2</td>
<td>0.65 19</td>
<td>0.67 19</td>
<td>0.73</td>
</tr>
<tr>
<td>15 Boost sale of professional PFI services abroad</td>
<td>0.70 17</td>
<td>0.7 17</td>
<td>0.77 9</td>
<td>0.72</td>
</tr>
<tr>
<td>16 Better access and affordability for end-users</td>
<td>0.70 18</td>
<td>0.69 18</td>
<td>0.77 10</td>
<td>0.72</td>
</tr>
<tr>
<td>17 Improves governance</td>
<td>0.75 16</td>
<td>0.7 16</td>
<td>0.70 16</td>
<td>0.72</td>
</tr>
<tr>
<td>18 Help get around public sector debt restriction</td>
<td>0.70 19</td>
<td>0.73 11</td>
<td>0.70 13</td>
<td>0.71</td>
</tr>
<tr>
<td>19 Contribute to fiscal stabilisation</td>
<td>0.78 14</td>
<td>0.7 15</td>
<td>0.63 20</td>
<td>0.70</td>
</tr>
<tr>
<td>20 Helps eliminate corruption</td>
<td>0.70 20</td>
<td>0.62 20</td>
<td>0.70 17</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Table 1 below shows the benefits which have been ranked using their relative importance index (RII) values. The responses by the delegates from the various regions were assessed and ranked differently, and later an overall ranking was carried out. A cursory look at the ranking shows that African delegates had more consensus among their ratings, followed by Middle East delegates while the Australasian delegates had the least convergence within regions. As can be seen from the table, the overall ranking shows that ‘Encouraging a more innovative public sector’ was ranked as the most important benefit that has been achieved through the use of the PFI with an RII=0.80. However this benefit was ranked in 7\(^{th}\) place by African delegates, 10\(^{th}\) place by Australasia and 2\(^{nd}\) place by Middle East delegates. The reason is not far-fetched, the advent of the PFI has brought out the inadequacies in the public sector and governments across
the globe have responded by funding training programmes to enhance public sector skills hence the rating given to that factor.

In 2nd place was ‘improve business confidence’ which actually tied in RII values with the above benefit (RII=0.80). The spate of foreign participation in infrastructure contributed to this factor’s ranking, because most PFI projects were executed by foreign contractors with the technical know-how for complex projects. ‘Contribution to economic growth’ RII=0.79 ranked 3rd, this is not surprising because the link between infrastructure availability and economic growth have been established by researchers in economic development including (Thanh & Dapice, 2009) & (World Bank, 2007.). But in terms of region on this benefit, it was ranked by African delegates in 10th place, Australasia 5th place and Middle East delegates ranked it in 1st place.

Better accountability tied in 3rd place with an RII=0.79, this points to the fact that PFI has helped achieve better accountability owing to the limited amount of money spent by the public sector to get such complex projects. The costs incurred are mostly in relation to hiring of consultants and in contract management. The respondents’ ranked ‘increased investments in infrastructure’ in 4th place overall, while African delegates ranked it in 11th place, Australasia 3rd place and 7th place by Middle East delegates. Generally, using PFI, the government can afford to approve multiple contracts running into billion since they are not required to make any contributions to the project in ‘theory’, hence the favourable ranking. In 5th place is ‘help government spread payment over the life of the project’, this is especially through of the UK and some countries in Europe where for example Shadow Tolls are used on motor ways. But African delegates ranked this benefit in 8th place, Australasia 1st place and 11th place by Middle East delegates. The ranking given to this benefit by the Australasia delegates seem to reflect their longer experiences with the PFI. The most surprising ranking on the table is the benefit ‘Provide better value for money (VFM), while the overall ranking placed it at 14th place which is not enviable since it is the most often cited reason for PFI adoption by the proponents, even more surprising is the ranking attributed to it by Australasia and Middle East delegates, they both ranked it faraway 19th place. It would appear that their experiences with failed PFI projects like Indah water Konsortium in Malaysians which changed ownership 3 times in seven years before the government took it over and Sydney Airport rail and the Cross Sydney tunnel in Australia may have influenced their perception of Value for Money in PFI. This finding is consistent with the arguments put forward by (Pollock, Shaoul, & Vickers, 2002) & (Hodge & Greve, 2009) that so far the evidence of value for money on current PFI projects cannot really stand up to public scrutiny. But from the response of the African delegates ‘provide better value for money’ and ‘reduce pressure on public budget’ tied in 1st place. This is not surprising though, considering that Africa has not had much experience with PFI and tend to attribute the high levels of infrastructure development they witness in more developed climes as resulting from the PFI. The 3 regions surprisingly only tied in one ranking only, that is benefit number 17, ‘improve governance’ which they all ranked in 16th place. Interestingly, the least ranked benefit of the PFI was ‘help
eliminates corruption’ RII=0.67, this was also the position the African and Australasian delegates consigned the benefit to-20th place while the middle East delegates ranked it in 17th place. However, the import of this ranking of corruption seem to suggest that new channels of corruption evolved to replace the ones which existed under the traditional procurement era

5. Conclusions
The PFI procurement strategy was said to promise a lot of benefits for the adopting government and its citizens and hence achieved great growth in the last two decades. However, recent experiences seem to show that the promised benefits are not being achieved and the various governments across the globe have learnt a new trick of shifting emphasis on some benefits more than others. The value for money being emphasized as the most important benefit of the PFI is being shown not to exist from the view point of many professional and academic analyses. The findings from this study have further reinforced that position. Therefore, it has become pertinent for governments to reappraise their reasons for adopting the PFI procurement strategy. The purported benefits of the PFI can be provided by other procurement methods if well implemented. In terms of cost, governments should look towards what Malaysian is doing on their 2nd Penang Bridge. As for practitioners, it is high time, they re-asses the rationale for the PFI as all its selling points have been erased leaving a battered procurement strategy open to credible criticism from even the most unlearned.

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Research Article

QoS Performance for Monitoring and Optimization of Data and VoIP traffic in WiMAX Network Mac Layer
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Abstract
In this paper we are providing a concept of Worldwide Interoperability for Microwave Access (WiMAX) network performance for QoS monitoring and optimization solution for Base Station (BS) with multimedia application to equate quality and cost. The Physical and MAC layer of WiMAX Technology refer to the IEEE 802.16 standard defines five different data delivery service classes that can be used in order to satisfy Quality of Service (QoS) requirements of different applications such as VoIP, videoconference, FTP, Web, etc. We have developed six scenarios to compares the performance obtained using two different types of MAC layer delivery service class used to transport VoIP traffic the Unwanted Grant Service (UGS) and real-time polling service (rtPS). In each scenario the number of fixed BS and SS has been increased from one to six in the BS and four to twenty four in the SS to cover more required users. All the simulation results are optimized based on networks and area, and the results indicate that the delay sensitive traffic fluctuates beyond its nominal rate, having the possibility to give back some of its reserved bandwidth; rtPS has the advantage to permit the transmission of Best effort (BE) traffic than UGS and also the traffic priority for UGS is high as compared to rtPS.

1. Introduction

Due to its large coverage area, low cost of deployment and high speed data rates, WiMAX is a promising technology for providing wireless last-mile connectivity. Worldwide Interoperability for Microwave Access (WiMAX) is one of the most important broadband wireless technologies and is anticipated to be a viable alternative to traditional wired broadband techniques due to its cost efficiency. Being an emerging technology, WiMAX supports multimedia applications such as voice over IP (VoIP), voice conference and online gaming since it is necessary to provide Quality of Service (QoS) guaranteed with different characteristics. Therefore, an effective scheduling is critical for the WiMAX system. Many traffic scheduling algorithms are available for wireless networks, e.g. Round Robin, Proportional Fairness (PF) scheme and Integrated Cross-layer scheme (ICL). Among these
conventional schemes, some cannot differentiate services, while some can fulfill the service differentiation with high-complexity implementation (Xiaodong and Georgious, 2004).

WiMAX has undoubtedly emerged as the most promising leading technology for broadband connection in wide area networks. Its light infrastructure makes it very cheap and easy to deploy and thus WiMAX becomes an effective solution to the last mile wireless connection problem which include multipath fading, environmental factors (such as heavy rains), interference and varying SLA demands amongst a host of other problems. It is especially effective in rural areas where wired infrastructures are difficult to install (Jha et al, 2010).

WiMAX quality of service (QOS) depends generally on the 802.16 Layers 1 and 2, as these provide all important base station with an inherently difficult environment compared to, say, a wire line broadband network. In particular, 802.16d used Orthogonal Frequency Division Multiplexing. The capabilities of these technologies have a direct impact on end-user services and QOS (Vinit and Ajay 2010).

Generally speaking, OFDM provides a simple, relatively straightforward scheduler design, giving best performance for larger packet sizes, as the overhead/padding problem isn’t so important. This makes it better for the needs of certain data services, such as legacy TDM (Vinit and Ajay 2010).

WiMAX has undoubtedly emerged as the most promising leading technology for broadband connection in wide area networks. Its light infrastructure makes it very cheap and easy to deploy and thus WiMAX becomes an effective solution to the last mile wireless connection problem which include multipath fading, environmental factors (such as heavy rains), interference and varying SLA demands amongst a host of other problems. It is especially effective for rural areas where wired infrastructures are difficult to install as shown in Figure 1 below (IEEE Standard 802.16, 2004).
1.1 WiMAX QoS and Scheduling Services

The organizing service plays a huge role in determining the QoS in WiMAX. It determines the information-handling systems using the MAC scheduler for data transport around the connection. Each connection is indicated an association identifier (CID) and several QoS parameters. The organizing service determines the quantity of the UL and DL transmission options, in addition to BW allocation systems. Initially, four different service types were supported in the 802.16 standard: Unsolicited Grant Service (UGS), real-time polling service (rtPS), non-real-time polling service (nrtPS) and Best Effort (BE) (Lee et al, 2006 and Jha et al, 2010).

1. The UGS (Unwanted Grant Service) resembles the CBR (Constant Bit Rate) service at (Asynchronous Transfer Mode) ATM, which produces a collection size burst periods. A reverse lookup might be accustomed to replacing T1/E1 wired line or possibly a continuing rate service. Furthermore, it might be accustomed to support real-time programs for instance Voice over IP or streaming programs. Even though the UGS, may possibly not function as the finest choice for the Voice over IP because it might waste bandwidth through the off amount of voice calls Lee et al, 2006 and Jha et al, 2010).

2. The rtPS (real-time polling service) is ideal for an adaptable bit rate real-time service for instance Voice over IP. Every polling interval, BS polls as well as they asked to transmit between requests (bandwidth request) whether or not this has data to provide. The BS grants or loans or financial loans the data burst using UL-MAP-IE upon its reception.
3. The nrtPS (non-real-time polling service) is much like the rtPS with the exception that it enables contention based polling.

4. In Best Effort (BE) Service can be used as programs for example e-mail or FTP, by which there's no strict latency requirement. The allocation mechanism is a continuation based while using varying funnel. Another service type known as ertPS (extended rtPS) was brought to support variable rate real-time services for example Voice over internet protocol and video streaming (Poulin, 2006). We have an edge on UGS and rtPS for Voice over internet protocol applications since it carries lower overhead than UGS and rtPS as showed in table 1.

### TABLE 1: WiMAX QoS and Scheduling Services

<table>
<thead>
<tr>
<th>Service Flow</th>
<th>Definition</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>UGS</td>
<td>Real time data streams with fixed size data packets issued at periodic intervals</td>
<td>T1/E1, VoIP without silence suppression.</td>
</tr>
<tr>
<td>rtPS</td>
<td>Real time data streams with variable size data packets issued at periodic intervals</td>
<td>MPEG video, VoIP with Silence suppression</td>
</tr>
<tr>
<td>nrtPS</td>
<td>Delay Tolerant data streams with variable size data packets issued at periodic intervals</td>
<td>FTP, Telnet</td>
</tr>
<tr>
<td>BE</td>
<td>Delay Tolerant data streams, background traffic or any either application without significant QoS constrains</td>
<td>HTTP, E-mail</td>
</tr>
</tbody>
</table>

**1.2 Voice over IP (VoIP)**

A VoIP application typically works as follows. First, a voice signal is sampled, digitized, and encoded using a given algorithm/coder. The encoded data (called frames) is packetized and transmitted using RTP/UDP/IP. At the receiver’s side, data is de-packetized and forwarded to a play out buffer, which smooths out the delay incurred in the network. Finally, the data is decoded and the voice signal is reconstructed. The quality of the reconstructed voice signal is subjective and therefore is measured by the mean opinion score (MOS). MOS is a subjective quality score that ranges from 1 (worst) to 5 (best) and is obtained by conducting subjective surveys. Though these methods provide a good assessment technique, they fail to provide an on-line assessment which might be made use for adaptation purpose. The ITU-T E-Model
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(Poulin, 2006), has provided a parametric estimation for this purpose. It is an R-factor that combines different aspects of voice quality impairment. It is given by

\[ R = 100 - I_s - I_e - I_d + A \] …… (1)

Where \( I_d \) is the signal-to-noise impairments associated with typical switched circuit networks paths, \( I_e \) is an equipment impairment factor associated with the losses due to the codecs and network, \( I_d \) represents the impairment caused by the mouth to-ear delay, and \( A \) compensates for the above impairments under various user conditions and is known as the expectation factor.

The R-score is related to MOS through the following non-linear mapping (Vinit and Ajay 2010).

\[ MOS = 1 + 0.0345R + 6.5 \times 10^{-6}R(R - 50)(100 - R) \] …… (2)

For \( 0 \leq R \leq 100 \). If \( R < 0 \), MOS takes the value of 1 and similarly, if \( R > 100 \), MOS takes the value of 4.6.

Among all the factors in the equation (1), only the \( I_d \) and I are typically considered variables in VoIP (Dang, Prasad, and Niemegeers, 2007). Using default values for all other factors, the expression for R-factor given by equation (1) can be reduced to

\[ R = 93.5 - I_e - I_d \] …… (3)

**1.3 Network Dimensioning and Design**

WiMAX are operating in a combination of licensed and unlicensed bands. The unlicensed bands are usually both the 2.4 GHz and 5.8 GHz bands. Licensed spectrum provides operators the control of using the band, permitting them to develop a high-quality network. The unlicensed band, however, allows independents to supply backhaul services for hotspots (SRamachandran et al, 2002). Typical area licensed WiMAX spectrum allocations are:

- Lower 700 MHz (US) with 2x6 MHz channels
- GHz Multichannel Multipoint Distribution Service with 15.5 MHz in US and 72 MHz in Canada
- 3.5 GHz Wireless Local Loop with 2 x 2MHz channel blocks
- 5.8 GHz UNI (license exempt) with 80 MHz allocation (Parsae, Yarali, and Ebrahimzad, 2004)
WiMAX access networks will often be deployed in point to multipoint cellular fashion in which a single base station provides wireless coverage to some set of end user stations in the coverage area. The technology behind WiMAX have been optimized to offer both large coverage distances of up to 30 kilometers under Line of Sight (LOS) situations and a typical cell range of up to 8 kilometers under No LOS (NLOS) (Jha et al, 2010). In a NLOS, a signal reaches the receiver through reflections, scattering, and diffractions. The signals reaching the receiver includes many aspects of indirect and direct paths with various delay spreads, attenuation, polarizations, and stability compared to the direct path.

WiMAX technology solves or mitigates the challenge as a result of NLOS conditions by utilizing OFDM, Sub channelization, directional antennas, transceiver diversity, adaptive modulation, error correction and power control (C. Hoymann et al, 2007). The NLOS technology also reduces installation expenses by developing the under-the-eaves Customer Premise Equipment (CPE) installation possible and easing the problem of locating adequate CPE mounting locations. Both LOS and NLOS coverage conditions are controlled by propagation characteristics of the environment, radio link budget and path loss. In each case relays assist to extend the range of the BS footprint coverage permitting a cost-efficient deployment and service (Jha et al, 2010).

This paper discusses about the performance of the MAC Layer by applying different QoS applications using the OPNET Modeler Simulation Tool. The purpose of this study was to examine a case of QoS deployment over a WiMAX network and to examine the capability of a WiMAX network to deliver adequate QoS for voice and data applications. The concept of WiMAX network performance for QoS monitoring and optimization solution for Base Station (BS) with multimedia application to equate quality and cost was discussed. The methodologies taken include creating the WiMAX network, deploying the required applications, deploying QoS configurations within the WiMAX last-mile, adjusting the QoS configurations within a WiMAX network to meet voice requirements, and further adjusting the QoS configurations to improve data application performance, without degrading the performance of voice.

2. Related Literatures
The IEEE 802.16 technology (WiMAX) is a promising alternative to 3G or wireless LAN for providing last-mile connectivity by radio link due to its large coverage area, low cost of
deployment and high speed data rates. The standard specifies the air-interface between a Subscriber Station (SS) and a Base Station (BS). The IEEE 802.16- 2004 standard also known as 802.16d, was published in October, 2004 (IEEE Standard 802.16-2004). This was further developed into the mobile WiMAX standard referred to as IEEE 802.16e- 2005 or 802.16 (IEEE Standard 802.16e-2005) also according to Ramachandran et al (2002) it is design to support mobile users. IEEE 802.16 can be used not only as xDSL replacement for small business customers but also as a mobile internet access technology. There have been few studies focusing on performance evaluation of IEEE 802.16 WiMAX Networks using OPNET.

Rangel et al (2006) Studied performance evaluation of IEEE 802.16 for Broadband Wireless Access, however, they used OPNET’s DOCSIS models to simulate the IEEE 802.16 MAC.

Dang et al, (2007) Studied performance analysis of QoS scheduling in Broadband IEEE 802.16 Based Networks, Although using OPNET WiMAX models, they focused mainly on implementing their own scheduling algorithms. However, in the IEEE 802.16 standard, the scheduler is left open for implementation, thus creating an avenue for a healthy competition amongst manufacturers. While the standard defines the required procedures and messages for schedulers, it does not offer encouraging means to provide performance, reliability, or Quality of Service (QoS).

Also Dang et al, (2007). Studied performance of scheduling algorithms for WiMAX networks, some of their work is quite related to our works. However they focused mainly on implementing some existing scheduling algorithms.

3. Simulation Setup & Results
Model for Implementation in this experiment, we used OPNET Modeler version 16.0 with WiMAX Module capability (OPNET Modeler). We designed six scenarios to Improve Voice scenario and Improve Data scenario including one scenario with one BS only and rest of five scenarios has two three, four, and six base stations with four subscribers station around each. The network consist an IP backbone containing one server connected to the IP backbone. Subscriber station Transmission Power is set to 0.5 W. Base Station Transmission Power is set to be 5W. The Path loss and Multipath Model are set to Pedestrian. The parameters of Subscriber Station and Base Station can be seen at Table 1 and Table 2.
detailed explanation of the simulated network model together with configured traffic that was developed for the Mac Layer QoS Performance of UGS and rtPS are discussed.

Basic parameters associated with WiMAX Configuration attributes, Application Configuration, Application Profile, Task Definition, BSs configuration and Subscribers Station for the proposed Master-Slave model in fixed WiMAX are configured.

Table 1 shows the simulation setup parameters used in the scenario by including additional BS, SS, and number of master BS and simulation time.

### TABLE 2: Service flows supported in WiMAX

<table>
<thead>
<tr>
<th>Service-Flow Designation</th>
<th>Defining QoS Parameters</th>
<th>Application Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsolicited-Grant Service (UGS)</td>
<td>Maximum sustained rate, Maximum latency tolerance, Jitter tolerance</td>
<td>Voice over IP (VoIP) without silence suppression</td>
</tr>
<tr>
<td>Real-Time Polling Service (rtPS)</td>
<td>Minimum reserved rate, Maximum sustained rate, Maximum latency tolerance, Traffic priority</td>
<td>Streaming audio and video, MPEG (Motion Picture Experts Group) encoded</td>
</tr>
<tr>
<td>Non-Real-Time Polling Service (nrtPS)</td>
<td>Minimum reserved rate, Maximum sustained rate, Traffic priority</td>
<td>File Transfer Protocol (FTP)</td>
</tr>
<tr>
<td>Best-Effort Service (BE)</td>
<td>Maximum-sustained rate, Traffic priority</td>
<td>Web-browsing, Data transfer</td>
</tr>
<tr>
<td>Extended Real-Time Polling Service (ErtPS)</td>
<td>Minimum reserved rate, Maximum sustained rate, Maxi-mum latency tolerance, Jitter tolerance, Traffic priority</td>
<td>VoIP with silence suppression</td>
</tr>
</tbody>
</table>

### TABLE 3. Simulation Parameters

<table>
<thead>
<tr>
<th>Efficiency Mode</th>
<th>Mobility and Ranging Enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAC Service Class Definition (QoS)</td>
<td>1) UGS e.g. VoIP (IP Telephony)</td>
</tr>
<tr>
<td></td>
<td>2) rtPS e.g. MPEG (High Resolution Video)</td>
</tr>
<tr>
<td>Modulation Technique</td>
<td>Wireless OFDM</td>
</tr>
<tr>
<td>Number of Subcarriers</td>
<td>2048</td>
</tr>
</tbody>
</table>
Figure 2(a) and 2(b) below shows the Configuration of WiMAX Networks supporting Data and VoIP traffic and The WiMAX subscriber station parameters respectively.

The WiMAX Base station parameters were shown in Figure 3.
3.1 Scenarios of WiMAX Mac Layer QoS Performance for UGS and rtPS Model

3.1.1 Scenario_1
In this scenario, one WiMAX BSs were developed with four SSs around each BS as shows in Figure 4. All the BSs are connected to the IP backbone (Internet) using point-to-point protocol (ppp). Basic parameters associated with WiMAX Configuration attributes, Application Configuration, Application Profile, BS configuration and SS for the model are configured.

![Figure 4_ Mac Layer QoS Performance of UGS and rtPS (scenario_1)](image)

3.1.2 Scenario_2
In this scenario, two WiMAX BSs were developed with eight SSs around each BS as shows in Figure 5. All the BSs are connected with IP backbone (Internet) using point-to-point protocol (ppp). Basic parameters associated with WiMAX Configuration attributes, Application Configuration, Application Profile, BS configuration and SS for the model are configured. All parameters are same as scenario 1.
3.1.3 Scenario 3

In this scenario, three WiMAX BSs were developed with eight SSs around each BS as shown in Figure 6. All the BSs are connected to the IP backbone (Internet) using point-to-point protocol (ppp). Basic parameters associated with WiMAX Configuration attributes, Application Configuration, Application Profile, BS configuration and SS for the model are configured. All parameters are same as scenario 1.

3.1.4 Scenario 4

In this scenario, four WiMAX BSs were developed with eight SSs around each BS as shown in Figure 7. All the BSs are connected to the IP backbone (Internet) using point-to-point protocol (ppp). Basic parameters associated with WiMAX Configuration attributes,
Application Configuration, Application Profile, BS configuration and SS for the model are configured. All parameters are same as scenario 1.

3.1.5 Scenario_5
In this scenario, three WiMAX BSs were developed with eight SSs around each BS as shown in Figure 8. All the BSs are connected to the IP backbone (Internet) using point-to-point protocol (ppp). Basic parameters associated with WiMAX Configuration attributes, Application Configuration, Application Profile, BS configuration and SS for the model are configured. All parameters are same as scenario 1.

3.1.6 Scenario_6
In this scenario, five WiMAX BSs were developed with eight SSs around each BS as shown in Figure 9. All the BSs are connected to the IP backbone (Internet) using point-to-point protocol (ppp). Basic parameters associated with WiMAX Configuration attributes,
Application Configuration, Application Profile, BS configuration and SS for the model are configured. All parameters are same as scenario 1.

![Graph](image1)

Figure _9 Mac Layer QoS Performance of UGS and rtPS (scenario_2)

3.2 Results & Analysis

This section shows the results and analysis obtained through simulation in OPNET Modeler for average WiMAX, average WiMAX Delay and average WiMAX Load.

3. 2.1 Average WiMAX Throughput Results

Figure 10 shows the result obtained in the design of scenario 6 of the average Throughput graph.

![Graph](image2)

Figure 10 WiMAX average Throughput graph

3.2.2 Average WiMAX T Delay Results

The following Figure shows the result obtained from scenario 1 to 6 for the average Load.
3.2.3 Average WiMAX T Delay Results
The following Figure 12 shows the result obtained from scenario 1 to 6 for the WiMAX average delay.

3.3 Analysis of the Results
In this research, we have divided our work into six different scenarios with the help of OPNET Modeler. Here two types of MAC layer QoS are used and they are UGS and rtPS having application of Voice over IP (VoIP) and MPEG respectively. Also the traffic priority for UGS is high as compared to rtPS. In each scenario the number of Base Stations and Subscriber Stations are increased to enhance the performance. Through different scenario we
have compare the throughput, delay and load with respect to time. The simulation parameters used in this model are listed in Table 2.

Here the global analyses of all the scenarios are done and the comparison of average throughput (packets/sec), average load (packets/sec) and average delay (sec) are given.

Figure 10 indicates the comparison between Through-puts (packets/sec) Vs Simulation Time of all six scenarios. In all scenarios every SS can communicate simultaneously with each other through base station. Simulation time is taken as 60 seconds, after simulation we have observed that throughput of scenario 1 is nearly about 0.6 packets/sec, scenario 2 have 0.89 packets/sec, scenario 3 have 1.1 packets/sec, scenario 4 have 1.4 packets/sec, scenario 5 have 1.89 packets/sec and scenario 6 have 2.45 packets/sec. Figure 11 indicates the comparison between Loads (packets/sec) Vs Simulation Time in each scenario. Scenario 1 have 0.139 packets/sec, scenarios 2 have 0.219 packets/sec, scenario 3 have 0.21 packets/sec, scenario 4 have 0.168 packets/sec, scenario 5 have 0.242 packets/sec, and scenario 6 have the highest load of about 0.239 packets/sec.

Figure 12 indicates the result between Delays (sec) Vs. Simulation Time. We have seen that delay of scenario 1 has 0.00319 sec throughout the simulation time (constant delay). Similarly scenario 2 have 0.00168 sec initially and remains constant at 0.00148 sec, scenario 3 delay is vary from 0.0048 to 0.00379 sec, scenario 4 varies from 0.0015 to 0.0034 sec, scenario 5 varies between 0.00579 to 0.00538 sec and scenario 6 varies from 0.00392 to 0.00164 sec.

4. Conclusions

In this research we have discussed the concept of WiMAX network performance for QoS monitoring and optimization solution for Base Station with multimedia application to equate quality and cost. Six scenarios was developed to compares the performance obtained using two different types of MAC layer delivery service class used to transport VoIP traffic the UGS and rtPS. In each scenario the number of fixed BS and SS has been increased from one to six in the BS and four to twenty four in the SS to cover more required users. All the simulation results are based on optimized networks and area. The results indicate that the delay sensitive traffic fluctuates beyond its nominal rate, having the possibility to give back some of its reserved bandwidth; erPS has the advantage to permit the transmission of Best effort (BE) traffic than UGS and also the traffic priority for UGS is high as compared to rtPS.
References


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Research Article

Evaluation of Groundwater Interaction with Lake L5, Universiti Teknologi Petronas, Malaysia, using Seepage Meter and Mini-Piezometer

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Abstract
Malaysia has many abandoned mining lakes. These lakes are rarely used for raw water supply in water treatment despite their abundance. This is based on the general view that they are just mere retention ponds. However, there is growing acknowledgement that surface water features such as rivers and lakes can interact with underlying aquifers and this water movement can have significant implications on water quantity. This research investigated the interaction between mining lake water and groundwater using Lake L5 at the Universiti Teknologi PETRONAS, Perak, Malaysia, as a case study. Seepage meters and Mini-Piezometers were used to estimate the seepage flux rates, direction, and magnitude of water flow between the aquifer and the lake water within the months of August and November 2013. The seepage flux rates ranged from 2.47 Lm⁻²day⁻¹ to 7.33 Lm⁻²day⁻¹ for August and 3.45 Lm⁻²day⁻¹ to 11.08 Lm⁻²day⁻¹ for November and the Vertical Hydraulic Gradients (VHG) of the Mini-Piezometers was within the range of 0.016 to 0.190 in August and 0.022 to 0.196 November respectively. The results from these methods were all positive, and confirmed that groundwater was being discharge into the lake water; and that the farther the monitoring equipment from the shoreline, the lesser the groundwater discharge. More study is required to be carried out for a longer period, under different hydrological conditions and time of the year, and at several locations.

1. Introduction
Surface water such as river is the major source of water and accounts for 97% of drinking water supply for domestic, industrial and agriculture in Malaysia [1]. Abandoned tin mining lakes represent significant water body, particularly in the States of Perak, Selangor, and Negeri Sembilan. These mining pools are seldom used as sources of water for the treatment of public water supply despite their abundance. They have basically been used for irrigation, recreational activities, aquaculture activities and retention ponds. Perak State has about 63% of Malaysian ex-tin mining pools [2 & 3]. The reason is based on the general view that mining lakes are more of retention ponds which can easily be dried up when used for water supply. However, research has shown that lakes can exchange water with underlying aquifers and this water movement can have significant implications on water quantity and quality [4, 5, & 6]. The degree and nature of connectivity between lakes and groundwater resources influence the extraction, potential, contamination, and flow characteristics. The interaction between lakes and groundwater forms the basic framework in the estimation of water budgets for water supply and also groundwater transports of chemical solutes to the surface water bodies [4].

These exchange between groundwater and lakes can take place in three dimensions: some lakes recharge groundwater throughout the entire lake beds; others are being recharged by the groundwater...
throughout the beds; while some lakes receive groundwater inflows in some part of their beds and recharge groundwater through the other parts [5 & 6].

There are different measures of evaluating fluxes between a lake and aquifer. These include Mini-Piezometer, seepage flux, heat tracer methods, monitoring wells, pumping tests, hydraulic conductivity, isotopes and chemical tracers, and host of others. This research used Seepage meters and Mini-piezometers for its findings. These instruments are inexpensive and have direct measurement of seepage flux at the interface between lake and groundwater. The performance of Seepage Meter and Mini-Piezometer has been tested in several studies [4, 5, & 7 - 12]. This research sought to estimate in details the interaction between aquifer and Lake L5 (4°23′08.46″N & 100°58′45.36″E). Its objectives were to (i) determine the locations, rates and directions of groundwater seepage; and (ii) to compare the results of these methods.

2. Materials and Methods

2.1 Description of Lake L5

The eight lakes found on the campus of the Universiti Teknologi PETRONAS (UTP) in Seri Iskandar, Perak, Malaysia are labeled as L1, L2, L3, L4, L5, L6, L7, and L8. These lakes can be identified in Figure 1. Lake L2, L3, L4, and L8 are the upstream lakes of Lake L7, which in turns flows into Lake L6. UTP Lake L5 has a total rough surface area of 68,739.52 m² (6.874 ha). It is located near the Security gate of the University. The lake is also bounded on the North by the security gate, road, and mini sports complex; in the East by jogging tracks, small landscaped field with grasses and few trees, an impervious road that leads to the PETRONAS filling station, and car park; it is also bounded on the South by Lake L6; and on the West by a large landscaped field with grasses and trees. The lake is part of the UTP chain of lakes which flows into Lake L6. The overall water that flows into Lake L6 is finally discharged to other lakes outside the campus through a weir. Despite the fact that a formal wildlife survey has not been carried out, it can be deduced that the lake supports a diverse wildlife community. During the study period, wildlife observed included alligators and several species of fish.

Fig. 1: Map of the Universiti Teknologi PETRONAS, UTP (4°23′08.46″N & 100°58′45.36″E) showing various Mining Lakes (Source: Maintenance Dept., UTP)
2.2 Methods

Two experiments were conducted within the study area in August and November 2013. The experiments include measuring the groundwater discharge using seepage meters and mini-piezometers. These two months fall in dry and rainy seasons in Perak, Malaysia.

2.2.1 Groundwater Seepage Meter

The quantity of groundwater seepage into the lake and vice versa was estimated using seepage meters. These meters were designed, constructed and installed at four different locations (T1 to T4) on the lake bed (Figure 2a & c). Seepage flux of the lake’s groundwater was then measured by enclosing a particular area of the lake bottom with a cylinder vented to a plastic bag [4, 9, 10, & 13]. The meter was constructed using a 200 L steel drum (diameter = 0.57 m) that was cut into halves. Four flanges were welded at the top of the closed end of the drum and each flange was tied to a 6kg of rock. This was done to ensure that during installation, the drum moved down to the bottom of the lake without interference. The drum’s bung hole whose diameter was 0.5 inch was fitted with a watertight connector that was connected to a 10L polyethylene bag through a 2 meter hose (diameter = 15 mm) and was tightened using hose clamps and rubber bands. Prior to the installation of the seepage meter, 1L of water was introduced into the polyethylene bag and tied to the hose. This was recorded as the initial volume of water in the bag. The seepage meter equalized with the groundwater for twenty four hours before data collection. The collected water in the bag over the twenty four hours represented the amount of groundwater seepage which could enter or exit the lake through the lake’s bottom. The seepage flux was calculated as follows:

\[
Q = \frac{V_f - V_i}{tA}
\]  

Where,

- \( Q \) = Seepage flux or seepage volume per area (\( \text{m}^2 \text{day}^{-1} \))
- \( V_f \) = Final Volume of water in the bag (l)
- \( V_i \) = Initial Volume of water in the bag (l)
- \( t \) = Time elapsed between when the bag was connected and disconnected (day)
- \( A \) = Surface Area of the chamber (0.255 m²).

The values of seepage flux were multiplied by a correction factor of 1.05, which was introduced by Belanger and Montgomery [14] to take care of all the possible errors due to flow resistance to the drum and the plastic bag during the measurements.

2.2.2 Mini Piezometers

Mini-Piezometer is used to measure the direction of water flow between surface water body such as a lake, stream or river and aquifer (Figure 2b). It determines the characterization of the magnitude and direction of vertical hydraulic gradient (VHG) [15 &16]. The Vertical Hydraulic Gradient (VHG) values at certain depths in a single point between a lake and groundwater were computed using the formula:

\[
VHG = \frac{dh}{dl}
\]

Where,
\[
dh = \text{hydraulic head difference between the mini-piezometer and lake stage (cm)}
\]
\[
dl = \text{vertical distance between the lake bed and the midpoint of the perforated screen mini-piezometer (cm)}\ [5 &17].
\]

Four piezometer stations (P$_1$ to P$_4$) were installed at different locations of the lake (Figure 2a). The PVC piezometer has an outer diameter of 2 cm. There were 12 mini-piezometers used for the study and had perforated screens of various lengths. They were installed by a hand auger, and drilling of 10 cm wide borehole. The auger material was used to backfill the borehole after installation. The lake water levels (h$_2$) were measured with a meter rule, midpoints of the perforated areas marked, and groundwater levels obtained using the water level meter (YAMAYO Million Rope Water Level Measure – 50 m). A positive value of VHG indicates groundwater recharges the lake while a negative value shows the opposite. Three mini-piezometers were installed perpendicular to the shoreline at each station so as to measure the head differences and to characterize the magnitude and directions of the VHG.

**Fig. 2:** (a) UTP Lake L5 showing Mini-Piezometer and Seepage meter Stations (b) Vertical Hydraulic gradient in a down welling and upwelling region of the lakebed (Adapted from Anne & Kirsti, 2011) and (c) Seepage Meter

### 3. Results and Discussions

#### 3.1 Seepage Meter

The various volumes of water obtained using seepage meters in these four locations are shown in Table 1. The seepage flux rates ranged from 2.47 Lm$^{-2}$day$^{-1}$ to 7.33 Lm$^{-2}$day$^{-1}$ for August and 3.45 Lm$^{-2}$day$^{-1}$ to 11.08 Lm$^{-2}$day$^{-1}$ for November. The highest seepage flux for the seasons was obtained near the shoreline. The research indicated that the seepage fluxes decreased with increasing distance from the shoreline. It also revealed that all the four locations for the two seasons experienced recharge of groundwater into the lake (Figure 3a). Anne & Kirsti, 2011 and Kelvin et al, 1997 obtained similar results [5 &17].
## Table 1: Summary of Seepage Meter Data Obtained at UTP Lake L5 in August and November 2013

<table>
<thead>
<tr>
<th>Month (2013)</th>
<th>Location</th>
<th>Lake’s Depth (m)</th>
<th>Date</th>
<th>n</th>
<th>Initial Volume (L)</th>
<th>Final Volume (L)</th>
<th>Change in Volume (L)</th>
<th>Seepage Flux (L m⁻² day⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td>T1</td>
<td>1.85</td>
<td>28/8/13</td>
<td>1.05</td>
<td>3.65</td>
<td>1.0</td>
<td>2.78</td>
<td>1.78</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>5.0</td>
<td>29/8/13</td>
<td>1.05</td>
<td>11.0</td>
<td>1.0</td>
<td>10.0</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>T3</td>
<td>7.19</td>
<td>30/8/13</td>
<td>1.05</td>
<td>28.10</td>
<td>1.0</td>
<td>16.5</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>T4</td>
<td>8.3</td>
<td>31/8/13</td>
<td>1.05</td>
<td>99.00</td>
<td>1.0</td>
<td>98.00</td>
<td>0.60</td>
</tr>
<tr>
<td>November</td>
<td>T1</td>
<td>2.6</td>
<td>12/11/13</td>
<td>1.05</td>
<td>3.80</td>
<td>1.0</td>
<td>2.80</td>
<td>2.60</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>5.47</td>
<td>13/11/13</td>
<td>1.05</td>
<td>10.54</td>
<td>1.0</td>
<td>9.54</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>T3</td>
<td>7.8</td>
<td>14/11/13</td>
<td>1.05</td>
<td>30.06</td>
<td>1.0</td>
<td>29.06</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>T4</td>
<td>10.03</td>
<td>15/11/13</td>
<td>1.05</td>
<td>98.12</td>
<td>1.0</td>
<td>97.12</td>
<td>0.84</td>
</tr>
</tbody>
</table>

I = distance from shoreline (m), n = correction factor

![Fig. 3a: Relationship between groundwater recharge and distance from shoreline at Lake L5, UTP with seepage meter](image)

### 3.2 Mini Piezometer

It can be shown from Table 2 and Figure 3b-e that there were upward flows of groundwater in the experimental hydraulic head differences \((dh)\) within the four stations. The results obtained for the vertical hydraulic gradients (VHG) were all positive for August and November. The results also showed that more water was recharged from groundwater into the lake in November (rainy season) than August (dry season). This could be as result of the increase in groundwater table due to precipitation. It was also deduced from the study that the greater the installation depth of the mini-piezometer, the higher the level of groundwater in the pipe \((h_1)\). The results from the study were
similar to the ones obtained by Anne and Kirsti, 2011 and Rosenberry and LaBaugh, 2008 in which their hydraulic head differences ($dh$) did not exceed 30 cm. It also confirmed what was obtained using the seepage meter in relation to shoreline distance and amount of groundwater recharge.

Table 2: Mini-Piezometer Data collected at Lake L5, for August and November, 2013

<table>
<thead>
<tr>
<th>Month</th>
<th>Station</th>
<th>Locations</th>
<th>$I$(m)</th>
<th>$dl$(cm)</th>
<th>$h_1$(cm)</th>
<th>$h_2$(cm)</th>
<th>$dh$(cm)</th>
<th>VHG</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 2013</td>
<td>1</td>
<td>A1</td>
<td>0.8</td>
<td>52</td>
<td>16</td>
<td>11</td>
<td>5</td>
<td>0.096</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A2</td>
<td>2</td>
<td>97</td>
<td>19</td>
<td>14</td>
<td>5</td>
<td>0.052</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A3</td>
<td>3</td>
<td>150</td>
<td>50</td>
<td>47</td>
<td>3</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>B1</td>
<td>0.8</td>
<td>120</td>
<td>23</td>
<td>12</td>
<td>11</td>
<td>0.092</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B2</td>
<td>2</td>
<td>120</td>
<td>33</td>
<td>28.7</td>
<td>4.3</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B3</td>
<td>3</td>
<td>120</td>
<td>38</td>
<td>35.8</td>
<td>2.2</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>C1</td>
<td>0.8</td>
<td>160</td>
<td>104.1</td>
<td>73.6</td>
<td>30.5</td>
<td>0.190</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2</td>
<td>2</td>
<td>172</td>
<td>105</td>
<td>82</td>
<td>23</td>
<td>0.133</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C3</td>
<td>3</td>
<td>185</td>
<td>106</td>
<td>86.3</td>
<td>19.7</td>
<td>0.070</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>D1</td>
<td>0.8</td>
<td>100</td>
<td>33.3</td>
<td>30.5</td>
<td>2.8</td>
<td>0.028</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D2</td>
<td>2</td>
<td>146</td>
<td>47</td>
<td>44</td>
<td>3</td>
<td>0.021</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D3</td>
<td>3</td>
<td>135</td>
<td>47.5</td>
<td>45.4</td>
<td>2.1</td>
<td>0.016</td>
</tr>
<tr>
<td>November 2013</td>
<td>1</td>
<td>A1</td>
<td>0.8</td>
<td>50</td>
<td>20</td>
<td>13</td>
<td>7</td>
<td>0.140</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>100</td>
<td>23</td>
<td>17</td>
<td>6</td>
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</tr>
<tr>
<td></td>
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<td></td>
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<td>120</td>
<td>35.2</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>B3</td>
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<td>120</td>
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<td>0.022</td>
</tr>
<tr>
<td></td>
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<td>C1</td>
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<td>168</td>
<td>109</td>
<td>76</td>
<td>33</td>
<td>0.196</td>
</tr>
<tr>
<td></td>
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<td>84</td>
<td>26</td>
<td>0.153</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C3</td>
<td>3</td>
<td>189.4</td>
<td>114.5</td>
<td>91</td>
<td>23.5</td>
<td>0.124</td>
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<tr>
<td></td>
<td>4</td>
<td>D1</td>
<td>0.8</td>
<td>103</td>
<td>37.5</td>
<td>34</td>
<td>3.5</td>
<td>0.034</td>
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<td>0.031</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D3</td>
<td>3</td>
<td>136</td>
<td>53.5</td>
<td>51</td>
<td>2.5</td>
<td>0.018</td>
</tr>
</tbody>
</table>

$I$ = distance from shoreline (m), $dl$ = the vertical distance between the lakebed and the midpoint of the perforated mini-piezometer (cm), $h_1$ = the level of groundwater in the mini-piezometer, $h_2$ = the lake water level, $dh$ = head difference (cm), VHG = Vertical Hydraulic Gradient
Fig. 3b-e: Relationship between groundwater recharge and distance from shoreline at Lake L5, UTP with mini-piezometers \([l = \text{Distance from shoreline}]\)

**Conclusion**

This research was to examine the groundwater–lake water exchange. The goal was characteristically to investigate the directions and rates of groundwater seepage with mini-piezometers and seepage meters. This was realized from the conducted experiments. The results above showed that water was being recharged from groundwater to the lake. The average seepage flux of the lake was 4.15 Lm\(^{-2}\)day\(^{-1}\) and VHG was 0.080 for August; and 6 Lm\(^{-2}\)day\(^{-1}\) and VHG was 0.080 for November. This showed that later water recharge was higher in rainy season than dry season due to precipitation. However, directions and flow rates between the lake water and groundwater could be dynamic and change over time and space due to response to seasonal weather conditions and water flow. In order to fully ascertain the groundwater – surface water interactions of Lake L5, it is recommended that a longer period of study be conducted under different hydrological conditions and time of the year and at several locations.

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**References**


Research Article

Towards Safer Laboratories: An Incident-Report Safety Knowledge Transfer Model
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Abstract
Accidents in academia, although seldom reported, happen all the time due to the nature of the materials academic institutions have to work with in their research projects. The Incident Report-Based Safety Knowledge Transfer (IRSKT) model we advocated in this paper identifies the elements necessary for social systems in academia to extract, disseminate and use new safety knowledge emanating from incident reports. The purpose of the paper is to understand how developments in systems thinking and materiality of knowledge can influence understanding of safety knowledge transfer (SKT); and to propose a new systems-based safety knowledge transfer model founded on incident reports. The paper is a review of the literature on safety knowledge transfer, materiality of knowledge and systems thinking; leading to the proposal of a new SKT paradigm. The paper shows that the IRSKT model is well suited to analyzing safety knowledge transfer in both complex and small-scale systems in academia. The paper argues that in academic institutions where safety of students and researchers is important, the ability to extract knowledge from incidents reports – which is an assessible and ready estimate of safety situations in organizations - is vital for establishing safe laboratories and learning environments. The capacity for effective exchange and utilization of safety information inherent in incident reports by employees, equipment manufacturers, professional bodies and government agencies as reflected in IRSKT will inform the decisions to build in safety in machinery, better safety rules, effective safety campaigns and enhance safety conscious behaviours in academia.

Introduction
Incidents – even catastrophic ones – are not uncommon in research laboratories in the academia. The nature of research institutions constrains them to work with machinery and materials that are Gordian in complexity and that could be fatal when mistakes occur or when materials and machine behave in unpredictable ways. This complexity makes accidents and fatalities almost inevitable.
Incidents in academia could emanate from chemical inhalation, contamination with biological fluids, electric shock, lost of control of heavy machinery and so forth. For instance Davanzo et al., (2007) reported that between 2004 to 2006 alone, 497 cases of accidents with instruments contaminated with biological fluids were reported among a university healthcare staff. Some of the cases were as serious as hepatitis B, HIV and HCV (hepatitis C virus). Some of the accidents in academic institutions are so severe that some experts advocate the inclusion of safety studies in business schools curricula (Stewart, Ledgerwood, & May, 1996).

Given that an accident and the resulting incident report have the capacity to immediately call attention of stakeholders, including regulating agencies to safety issues, the significance of the report can not be overstressed. However, there is scant research attention focusing on the nature of the knowledge extracted from such reports and how it is transferred within universities and among the stakeholders.

Further, knowledge is the most important asset in organizations and nations, not only because it is the prime source of wealth (Parent, Roy, & St-Jacques, 2007) but also because it saves lives. To increase research output, graduate students and professors are required to work with increasingly complex machines and within the confines of equally complex structures. In such environments, accidents happen; and because human lives are involved in such incidents, their occurrence is taken seriously by the schools, supervising agencies, manufacturers and professional associations. To underscore such importance, legislations exist in many countries requiring organizations to record and report incidents. The mechanism by which that requirement is fulfilled is by filing incident reports (Tyler, 2007).

Incident here means an accident or a near-miss.

Every incidents associated with any kind of personal injury is required to be documented. Based on the kind of injury, its seriousness as well as implications, accidents may also be required to be reported to the associated regulating agencies. However, some accidents which do not cause any specific personal injury will likewise have to be reported. Due to the importance of such reports, organizations are usually careful in ensuring that various requirements of reporting are fully understood and complied with. It can also be crucial to preserve significant evidence on many grounds. As it will be probably needed for an organisation’s investigation of an incident in a bid to avoid its reoccurrence (Tyler, 2007). Incident reports are used to fulfill many purposes such as feedback for safety programmes in organizations, data for insurance claims, yardstick to assess old safety rules by government agencies, and grounds for creating new ones.

The extant literature tends to focus on research findings as transferable safety knowledge. Even experts that are affiliated with safety research institutes operationalize safety knowledge as research findings. For example, among the objectives of the Robert Sauvé Research Institute on Workplace Health & Safety (IRSST) based in Canada, are to:

“To add new, interdisciplinary research and KT [Knowledge Transfer] capacity related to workplace injury and permanent structures for ongoing capacity enhancement linking the participating
organisations and to build a network of research and community WHS collaborators in Atlantic Canada linked to the three Québec research organisations with their established social capital of community and institutional connections, thus creating a truly Eastern Canadian regional organisation (Roy, Parent, & Desmarais, 2003). But they define “knowledge [as] research findings” (p. 159).

Based on this conceptualization, for knowledge to transfer there must be research preceding it. Therefore, safety knowledge is a commodity created by researchers for onward transmission to end-users. Even researchers who argue for the social contextual importance of knowledge transformation and translation do so with the belief that the social exchange has to be set off by researchers.

Baines (2007) drawing on data collected as part of a larger qualitative study of health and safety issues in the Canadian social services sector, explains that such efforts of knowledge translation, as currently conceptualised as well as organized, is limited and also constraining by means of its very own discourse associated with research neutrality, and through the political economy regarding research institutes and also organizations which grant research funds. These entities are inclined to encourage people generating journal articles and discourage people spending time getting the research accessible to those who need it.

Still Knowledge translation is actually an increasing requirement in an increasing number of studies. Since prevention as well as intervention tend to be the specific and also preferred final results, knowledge translation has special prominence in safety studies. Baines argues that utilizing knowledge to enhance health and safety practice would be greater if perhaps knowledge translation was incorporated into the research methodology, specifically as an appraisal of research validity. As Baines argues, transfer of knowledge from research institutions to practice remains a problem and the effectiveness of introducing knowledge translation as a form of validity remains to be seen.

However, researchers are increasingly championing other sources of knowledge other than scientific studies e.g. the significant role of social systems in knowledge acquisitions creation, utilization and sharing.

In arguing for the inclusion of social systems in the generation and dissemination of knowledge, Parent and his colleagues (Parent et al., 2007) introduced the Dynamic Knowledge Transfer Capacity (DKTC) model which promotes a new systemic as well as generic framework to describe the parts required for social systems to generate, disseminate and utilize new knowledge to address their needs.
Before Parent and his colleagues’ work, knowledge transfer models concentrated on KT as a process; a paradigm which viewed organizations as the place where the KT process takes place and researchers were more interested in how KT occurs. Parent et al. (2007) explored the capacities for KT inherent in the organizations. These capacities or assets, they say, must be present in the organization before KT can take place. They also conceptualized knowledge as a by-product of social interactions among individuals in the social system, not as an object.

The four capacities identified by the authors are: generative, disseminative, absorptive and adaptive capacities; accordingly, without these capacities, knowledge transfer cannot take place even in presence of the two pre-existing conditions they identified – need and prior knowledge.

Parent et al's (2007) work is quite significant; since, by employing a functional relation of parts to the whole as inherent in systems-thinking to knowledge transfer, it becomes clear that knowledge transfer is connected with the relationship between and within systems. However, their model is built on the three pillars of needs, goals and processes with needs being the most fundamental; believing that when there is need for knowledge in social systems, such knowledge will be generated. This notion ignores the fact that useful knowledge can be created even before the need is discovered. For example, an accident in a laboratory can provide useful information to employees on how to tackle similar tasks or machine that caused the accident in the future; such knowledge will be generated prior to any demands occasioned by a need.

One of the most important works on safety knowledge translation and circulation is Gherardi and Nicolini’s (2000) work. They posit that organizational knowledge is essentially a practice engaged by individuals acting together. This endeavour brings together a motley of elements and agencies, including concepts, principles, artefacts, rules, individuals, standards, as well as customs and tends to be marshalled, revised, converted, altered, revealed, utilized, disregarded or even concealed because of certain pragmatic outcomes, like safety within a building location.
Safety as a type of organizational know-how thus remains located within the process of continuous routines (Gherardi & Nicolini, 2000). Further, it possesses both express as well as implicit aspects. Additionally, it is connected to and intermediated through artefacts, which means, it is material in addition to being a mental representation. Using examples derived from the observation data, the authors discuss how safety-linked knowledge is formed, transferred, as well as constantly expanded in addition to being revised inside the organizing system via the interaction involving action as well as some sort of logical relation. As significant as Gherardi and Nicolini’s (2000) work is, incident report is presumably subsumed under the generic classes of artefacts and rules and therefore we are yet to know how safety knowledge is specifically extracted from incident reports.

**Materiality of Knowledge**

Advocates of the materiability of knowledge view knowledge as performative, not representational (Orlikowski, 2006). Thus, knowledge is not only a long-lasting, or important element — but also, an active and continuous communal outcome. This is a perspective of knowing in practice that is getting significant research interest by many experts such as (Blackler 1995; Lave, 1988; Nicolini, Gherardi, and Yanow, 2003; Tsoukas, 2005). This points us to pay attention to knowledge that is not only static or simply constant, but like an ability created and also recreated within continual communal behaviours.

The practice perspective of knowledge drives us to recognize knowing as emergent (as a result of daily actions and therefore usually “in the making”), embodied (as apparent in this kind of ideas such as tacit knowing as well as experiential learning), and embedded (based within the socio-historic setting of people’s lives in addition to work) (Orlikowski, 2002). To this specific notion (Orlikowski, 2006) contributes an additional crucial element, which is, that knowing is often material.

Daily routines along with the knowledge produced as a consequence of such interactions can be profoundly locked up within what Orlikowski called the "stuff" (forms, artifacts, settings, as well as infrastructures) around, with and within which people operate. Think of any kind of human activity, then consider the accompanying materiality. It is clear that a lot of an individual's actions are quite influenced by “stuff” like research structures, equipment, vehicles, laboratory garments, spaces, furniture, electronic gadgets, stationery, and so forth. Some "stuff" are less conspicuous like water, air, electrical energy, information as well as voice systems. Although sometimes, we realize realize this materiality of knowledge in our actions. Yet "on another level, the level of conceptualizing and theorizing, we tend to disregard this knowing, and render our accounts of knowledge in organizations without attention to material matters" (Orlikowski 2006, p. 2).

Orlikowski (2006) asserts that an individual’s action is not only dependent on artefacts, but that it is also formed by them. Absent the material stuff of daily existence, our actions would not be feasible. Therefore, action inevitably necessitates materiality. Further, just as materiality is inherent in action,
so is it also inherent in the knowledge constructed in practice. On the whole, as the foregoing has shown, knowing is material.

Additionally, it is recommended that this rich blending of knowing, practice, and materiality merits a broader probe in our investigations of safety knowledge in organizations. Despite the fact that material objects along with spaces are already a section of the organizational knowing in extant literature, they have been somewhat in the background rather than the foreground. The only difference being the crucial research regarding boundary objects (e.g., Bechky, 2003a, 2003b; Carlile 2002, 2004; Star and Griesemer, 1989); other than these and prior to Orlikowski’s (2006) work, there is scant theorizing in regards to the role of materiality within knowing. Establishing this kind of material perspective on safety knowing could generate useful ideas for the understanding of safety knowledge transfer in academic institutions.

**Systems Thinking**

Systems thinking serves as a conceptual perspective for thought process that searches to assimilate diverse views in scientific disciplines. This can be different from the actual conventional methodical approach to thought process, which attempts to fragment or take apart the system into categories so as to analyze the way the several components operate. Von Bertalanffy (1968), commonly acknowledged as the father of the General Systems Theory, described it thus:

“It is necessary to study not only part and processes in isolation, but also to solve the decisive problems found in the organization and order unifying them, resulting from dynamic interaction of parts, and making the behavior of parts different when studied in isolation or within the whole” (Von Bertalanffy, 1968, p. 31).

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![Figure 2. A safety system within a larger KT system](image)

The schema shown in Figure 2 shows that researchers/employees error is recognized as a constant condition that will be demonstrated to some degree by all researchers. That is, the schema accepts that laboratory researchers will make mistakes and will have to encounter accidents or near-misses. Thus,
the Health, Safety and Environment (HSE) officer/manager who may have more knowledge on safety issues among the stakeholders and who is the first person to be notified when and incident occurs, must be ready to use the safety system to handle the error.

Note that the safety system contains two smaller boxes. They represent the stages incident reports pass through; the relationship between the stages are indicated by the arrows. The initial interaction among the incident reports and stakeholders (among who are, HSE officer, medical personnel, regulating agencies and the victim) take place within Stage I as each make an input input into the system. In the event that investigations progresses beyond the first stage, interactions of a different kind are invoked in Stage II. In the event that an error is recognized in Stage II, the HSE officer can recycle to Stage I and correct the error. The arrows from Stage II back to stage I symbolize this concept. For instance if the HSE officer noticed that an injury was not properly reflected in the incident report when it reached Stage I, it will be necessary to recycle back to Stage I to correct the mistakes.

In recent decades, the concept "systems" continues to be used by practically all scientific disciplines and system thinking seems to have appeared and referred to the excogitation of problems in their entirety. A system can be described as a mental model or even a combination of pieces that work together along with one another inside the system's limits (form, framework, organization) to operate. People view their environment more or less as structured into or by systems. The devices that are around us, the agencies that create them, the vegetation that sprouts inside the backyard, the trees and shrubs in the woods, political elections, the households, the communities as well as ourselves all could be perceived as systems and sub-systems. In systems thinking, the term system is employed to describe an element as well as the relationships between and amongst its components and also the whole. The system perspective of the universe holds that the world is all about a system in a hierarchy of integrated sophistication—a sequence of wholes inside wholes, just about all of which are interconnected as well as interdependent. From this standpoint, a specific system can not be correctly grasped without having also understand its connection to the world of which it is a component. Systems thinking is a subjective approach of engaging with the world through comprehending the interactions between the numerous systems in the environment. In the manner a mechanistic perspective breaks components down to know the operation of a device, the systems thinking perspective endeavors to know the environment by way of regrouping the interactions which can be found between systems. Most people venture onto the world with our individual models for arranging knowledge, and we present these styles to the people around us. When we study these models attentively we may observe that, similar to every language, these are made of components, processes, principles as well as boundaries. The technology of these relationships is systems thinking. According to Rubenstein-Montano et al. (2001, p. 6), "problem-
solving in this way involves pattern finding to enhance understanding of, and responsiveness to, the problem”.

In 1972, Ackoff and Emery, two renowned systems thinkers, suggested the idea of purposeful systems to strengthen the conceptualization that systems arise within the context of particular goals. Holland (1962) had formalized the notion of adaptive systems which represent the basic need for systems to adjust as well as conform to alterations in the system’s context to better attain their goals. Shakun (1981) after that suggested the concept of responsive systems to permit the manner systems learn from previous operations to enhance functioning and proficiency.

Lastly, Rubenstein-Montano et al. (2001, p. 6), indicated that: Results from systems thinking rely greatly on precisely how a system is defined due to the fact that systems thinking looks at associations between the several components associated with the system. Limitations ought to be established to differentiate what parts of the world are actually covered within the system and also what components are regarded as the environment of the system. The actual environment of the system may impact problem solving due to the fact that it influences the system, however it is not part of the system. Consequently, knowledge transfer inside as well as in between systems should start with a solid definition of the system being referenced, together with its limitations (Parent et al., 2007); moreover, it will be beneficial to view academic institutions with a potpourri of sub systems usually housed at one location, using the systems approach. Utilizing this perspective will also make it easier to appreciate the flow of safety knowledge translation from incident reports.

The Incident Report-Based Safety Knowledge Transfer (IRSKT) model

The Incident Report-Based Safety Knowledge Transfer (IRSKT) model proffers a unique systemic as well as universal theoretical account for specifying the parts and steps necessary to get social systems to create, share as well as utilize new knowledge from incident reports in academia. By employing the all encompassing systems theory perspective to knowledge exchange, we can understand knowledge transfer as connected to the actual interactions among, as well as within systems; for example, one can see how the systems are associated with specific goals as well as processes. The systemic viewpoint permits observing knowledge transfer through the way in which knowledge is transferred (the process), as well as what components enable knowledge exchange to achieve success. Since all systems contain limits, the model considers the area inside which knowledge transfer generally occurs. The IRSKT model is not opposed to the classic knowledge transfer models which refer to knowledge transfer as being a process, but it also concentrates on the parts and the steps an incident report must take in a social system before knowledge transfer can take place. Figure 2 shows that the model contains an accident or a near-miss as the precursor of knowledge
translation. The specific components of incident report based knowledge transfer are explained in the next pages.

Figure 2. The Incident Report-Based Safety Knowledge Transfer (IRSKT) model

Basic Components of the incident report knowledge transfer process

The transfer process has four basic components. They consist of:

1. The incident report
2. The stakeholders (researchers, safety inspectors, machine manufacturers, government agencies, professional bodies, and so forth.)
3. The safety knowledge transfer system
4. The outcomes of the safety transfer system

1. Incident report input

The incident report inputs brings into the system not only the nature of the accident or near-miss but also problems and concerns about machines, structures and operations; including how prone some locations, certain researchers and materials are to incidents. These provide a lot of background and direction towards safety culture in the organization. The particular way these materials and persons are integrated gives the incident or set of incidents a pattern. Thus, the stakeholders must be prepared to respond to the patterns of the incidents.

2. Stakeholders’ input
Besides the incident reports, the stakeholders too, input certain skills, knowledge, and attitudes into the system. For example, the Health Safety and Environment (HSE) manager must institute an effective procedure on passing the information about the incident to other stakeholders and to develop a sound human relationship with the victim that is based on trust, understanding, and respect. A professional relationship must be established with the victim regardless of the victim’s behaviour, attitudes, creeds, race, sex, or socioeconomic status so that further details about the incident could come to light. Further, safety inspectors must monitor the trend of incidents in organizations and classify type, nature, severity and other information into categories to help them modify or enforce the existing rules. Researchers in the institution have the responsibility for being competent in the use of those tools, techniques, and strategies demanded by the safety culture. These include such skills as observation, testing, operation and the use of a variety of other safety techniques.

3. The Safety System

The inputs made by the stakeholders and incident reports interact within the safety system. The type of interaction that takes place depends upon the nature of the safety system used by the institution and the calibre of inputs made into this system by the stakeholders and incident reports.

For example, a particular safety system may not be appropriate for an incident of a certain department or from a particular service. For other incidents, the system may be adequate but the stakeholders may not be able to control or efficiently input their own input sufficiently to enable safety knowledge move from one stage of the transfer to another. The stakeholders may be “turned off” by the frequency or natures of the incidents experienced by an individual or department and thus lose sight of professional responsibilities. A stakeholder may fail to make the type of inputs into the system that would make safety knowledge transfer a facilitative process.

The type of interaction that takes place within a safety knowledge transfer system also depends upon the input into the system made by the incident reports. The report may not be sufficiently detailed enough to facilitate the extraction of safety knowledge into the system. Or, the victim may be deceptive or dishonest in communications with an HSE department. Inputs can be used to the advantage of the organization if the stakeholders utilize a safety knowledge transfer system that has the capability of providing guidelines for working with a wide range of materials and persons, and if the HSE department has the appropriate skills, knowledge, and attitudes to input into the safety knowledge transfer system. It is the primary responsibility of the HSE and not the victim to provide the necessary conditions for effective human interaction.
4. Safety knowledge outcomes

The last basic component of the safety knowledge transfer from incident report is the output or outcomes of the interaction between the stakeholders and incidents that have taken place within the safety knowledge transfer system used by the organization. Any time incidents happen and the HSE and incident reports engage in the knowledge transfer process there is some kind of outcome as a product of their interaction. This is the “payoff” of the safety process and the HSE “moment of truth”.

The outcomes of safety system can be positive or negative for the research institution. For the institution which attains the goals established in the system design, the outcomes represent a rewarding experience. Perhaps the organization has made a decision that will change some machines or structures in the organization. The organization may have obtained information that will help in getting a certain job done safely. Or, perhaps the organization has learned how employees can handle certain procedural situations. Whatever outcome emanates from the safety system, the stakeholders receive it as a feedback; this is shown by the letter F in figure 2. The feedback informs the stakeholders whether to modify the system, leave it as it is or change the system. The stakeholders also use the feedback to fashion products and services towards an optimum safety system.

Case Study

To test the applicability of our model, we used academic intuition as a case study. HSE department agreed to use one our model to report a certain incident that occurred in the laboratory. First, the case was a test tube explosion of by undergraduate student, which was started by incident reports are used to fulfill many purposes such as feedback for safety programmes in organizations, data for insurance claims, yardstick to assess old safety rules by government agencies, and grounds for creating new ones. Given that an accident and the resulting incident report have the capacity to immediately call attention of stakeholders, including regulating agencies to safety issues, the significance of the report can not be overemphasized. However, there is little research attention focusing on the nature of the knowledge extracted from such reports and how it is transferred within the organization and among the stakeholders.

Therefore, this paper argues for the fusion of systems thinking and materiality of knowledge in understanding safety knowledge transfer (SKT); and to propose a new systems-based safety knowledge transfer model founded on incident reports. As a review of the literature on safety knowledge transfer, materiality of knowledge and systems thinking; it leads to the proposal of a new SKT paradigm. The Incident Report-Based Safety Knowledge Transfer (IRSKT) model identifies the elements necessary for social systems in workplaces to extract, disseminate and use new knowledge emanating from incident reports.
The Incident Report-Based Safety Knowledge Transfer (IRSKT) model proffers a unique systemic as well as universal theoretical account for specifying the parts and steps necessary to get social systems to create, share as well as utilize new knowledge from incident reports. By employing the all encompassing systems theory perspective to knowledge exchange, we can understand knowledge transfer as connected to the actual interactions among, as well as within systems; for example, one can see how the systems are associated with specific goals as well as processes. The systemic viewpoint permits observing knowledge transfer through the way in which knowledge is transferred (the process), as well as what components enable knowledge exchange to achieve success. The IRSKT model is not opposed to the classic knowledge transfer models which refer to knowledge transfer as being a process, but it also concentrates on the parts and the steps an incident report must take in a social system before knowledge transfer can take place. In sum, we offer a new safety knowledge transfer paradigm that views safety knowledge as a systemic, emergent, embedded and materially entangled representation of reality. The proposed knowledge transfer model is different from earlier attempts, concentrating movement of safety information in
incident reports and the significance stakeholders must attach to them to minimize both human and machine error.

Conclusion

This study shows that the IRSKT model is well suited to analyzing safety knowledge transfer in both complex and small-scale systems. Empirical studies in various systems (of complexity) environments will help affirm and enrich the model. The paper sees that in academia where safety of researchers and students is important, the ability to extract knowledge from incidents reports – which is an asssible and ready estimate of safety situations in academic institutions - is vital for establishing safe laboratories. The capacity for effective exchange and utilization of safety information inherent in incident reports by employees, equipment manufacturers, professional bodies and government agencies as reflected in IRSKT will inform the decisions to build in safety in machinery, better safety rules, effective safety campaigns and enhance safety conscious behaviours in institutions.

References


