Maputo Bay Wireless Network Cost Analysis

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***Abstract*—The objective of this paper is to analyze the cost of building wireless networks in the context of Network Engineering (NE). Cost analysis is important in planning and design phases in network lifecycles, especially for developing countries. The Techno-Economic Analysis presented in this paper is based on the project for planning and designing new wireless network around Maputo Bay. Based on techno-economic evaluation measures, such as Net Present Value (NPV) and Internal Rate of Return (IRR), in Maputo Bay Wireless Network (MBWNet) is projected financial assumption and two categories of Total Cost of Ownership (TCO), Capital Expenditure *(*CAPEX) and Operating Expenditure *(*OPEX) of economic model are wide discussed.**

***Index Terms*—CAPEX, internal rate of return, OPEX, net present value.**

I. Introduction

The big challenge to spread ICT infrastructures to Maputo Bay and Islands is highest cost effective. The existing infrastructures are not covering all region and the services are unsatisfied of demand. The technical chose is unfavorable, high deployment and maintenance cost. In this study our approach is to identify better and low cost technologies for Maputo Bay wireless design. The financial assessment of the overall technology deployment is done based on techno-economic evaluation measures such as Net Present Value (NPV) and Internal Rate of Return (IRR) [1].

The paper is organized into six sections. In the section II, description of region; Section III network scenario; Section IV techno-economic analysis; Section V results and discussion. Finally, section VI conclusion and future work.

II. Description of Study 'S Region

Maputo Bay is an inlet of the Indian Ocean on the coast of Mozambique, between 25 ° 40' and 26 ° 20' S, with a length from north to south of over 55 miles (90 km) long and 20 miles (32 km) wide. The southern part of the bay forms the Machangulo peninsula, north of the peninsula is Inhaca Island, and beyond it is a smaller island known as Elephants Island; the island of Inhaca has a height of 240 ft., and is used as a sanatorium. The Komati from the northern, Matola from the north, the Umbeluzi from the west, and the Tembe and Maputo rivers in the south. From the Lebombo Mountains, meet towards the middle of the bay in the estuary known as the English river [2]. The network will cover approximately 2.880 km^2.

According to the topology map, it is a region with complicated landforms such as ridges, hills, lakes, ocean, forests, and islands, densely yet unevenly distributed population, tropical and humid climate and high traffic during tourist seasons together have posed serious challenges for the construction of the wireless network. In order to make a good plan, it is necessary to collect data on population distribution, economic status, geographic terrain, the traffic distribution of the existing network and predicted the traffic, the coverage in each scenario. The study of the area shows us 1020 users and the traffic between nodes to backbone is estimated from 4 up to 250 Mbps; the peak rate to users is approximately 300 MB.

For areas with high density of population and large traffic and areas requiring broad coverage, macro cellular base stations will be used. For indoor and partial traffic hot spot areas, the micro cellular base stations will be used to enhance the indoor coverage and to the increase capability for traffic. For areas with high traffic, the frequency multiplexing mode will used to improve the network spectrum efficiency and enlarge the network capacity.

In Maputo Bay area the MBWNet is connected with nationwide backbone, SAT-3 from Southern African Project and the region exist others wireless infrastructure such as MorNET, network which connect high education institution in the country and abroad; GovNET; SchoolNET [3], these projects not cover or have not satisfy the needs of users from islands around Maputo. As depicted in Fig. 1.

Fig. 1. Maputo bay region

III. Network Scenario

In a preliminary design, 4 large macro-cells with a radius of 10 km and 25 medium micro-cells with a radius of 2 km are planned. The 4 macro-cells cover 1256 km2 around Maputo and their base stations are installed at Matola, Catembe, Xefina and Inhaca Archipelago respectively (see

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Fig. 2). The network provides 10 channels and has 600 MB total of capacity; each user is allocated 8 MB minimum. The demand is very high; around 1150 potential users remain without communications. For connecting the backhaul network with the Maputo Network Access Points, (point to multi-point links) are used technology Tsunami from Proxim Wireless and Motorola [4]. Each Access Point or Base Station serves 6 centers using sectored or omni antenna.

In the planning process 4 macro-cells not cover the region. There must be used relaying technique associated with WiDL technology to enhance coverage and capacity. The solution is to buy three more macro-cells base stations reducing abusive use of relaying system for low OPEX. That scenario needs realistic evaluation of budget on acquisition of equipment and technologies to cover the region. See Fig. 2.

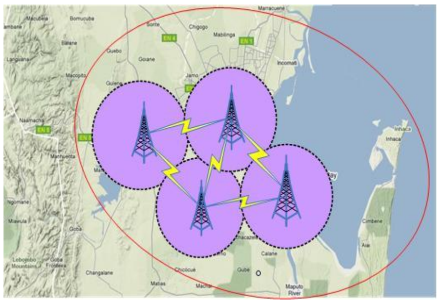

Fig. 2. Maputo bay wireless links design

IV. Techno-Economic Analysis

Techno-Economic Analysis is evaluation of technical and economic aspects (in acquisition, system design and services). Techno-Economic Analysis in our approach is the analysis of selected network technologies and services in Maputo Bay Wireless Communications Network, to evaluate the cost-effective of acquisition of equipment, installation, maintenance and fees of services.

According to EURESCOM P816 Project studies [5], the link between market data and provisioning costs and the corresponding techno-economic evaluation is a task of the strategic marketing. This task has to be prepared by several steps:

1) Description of new technologies and scenarios, see Table I.
2) Analysis of technical opportunities and constraints of new systems and network concepts
3) Recommendations of new network concepts from a technical point of view
4) Evaluation of network concepts from a techno-economic point of view – calculation of the global costs of new network concepts
5) Introduction of service related aspects - Business case calculations.

The options of technologies depends on various parameters, demography and geography, number of users their localization and type of services with associated bit rate; geographic characteristics; Infrastructure costs; Labor cost; Operation costs; and Access costs.

TABLE I: Emerging Technologies And Characteristics

Features	WiMAX	LTE	WiFi	UWB	Zigbee	WLL	WiLD
Transmission Techniques	OFDMA/MIMO	OFDMA/SC-FDMA&MIMO	OFDM/MIMO	OFDM or DS-UWB	DSSS or OFDM	OFDM	OFDM
Bandwidth	20, 40 up to 100 MHz	20 Up to 100 MHz	20 up to 40 MHz	20 MHz	20 MHz	Up to 40 MHz	Up to 40 MHz
Date rate	Up to 1 Gbps	Up to 1 Gbps	Up to 600 Mbps	53, 480 Mbps	20-250 kbps	Up to 1 Gbps	54 Mbps
Frequency	2.4 GHz up to 5.8 GHz	2.4 GHz up to 5.8 GHz	2.4 GHz or 5 GHz Unlic.	3.1 GHz to 10.6 GHz Unlic.	868-915 MHz or 2.4 GHz	2.4 GHz or 5 GHz Unlic.	5.4~5.8 GHz
Range	10 Km, 30 Km, 50 Km to 100 Km	10 Km, 30 Km, 50 Km to 100 Km	More than 1Km	10-30 m	70-300 m	5-10 km	50-100 Km
Mobility	250 km/h	300 km/h	Fixed	Fixed	Fixed	Fixed	Fixed/Nomadic

TABLE II: Cost of Equip, INSAL. Fees and Maintenance

Equipment	Cost	Installation	Fee (month)	Maintenance (annual)
WiMAX BS	$32000.00	$7000.00	$900.00	$1000.00
WiFi	$1000.00x6	$360.00	$800.00	$400.00
WLL	$500.00x6	$600.00	$550.00	$200.00
WiLD	$500.00x4	$480.00	$700.00	$250.00
SDL	$800.00x2	$600.00	$800.00	$800.00
Relay	$600.00x12	$500.00	$200.00	$900.00
CPE for users	$900.00x10	$200.00	$150.00	$300.00

In this paper to evaluate the needs for building the robust MBWNet are considerate two categories of Total Cost of Ownership (TCO), CAPEX and OPEX are defined and discussed.

CAPEX costs would include the fixed initial costs necessary for the BS deployments, including the tower, antenna, ASN-GW, installation and civil works, site acquisition, P2P equipment (peripheral), as well as the costs of the CPE for each customer/user, Table II. These costs will be distributed throughout the five years as the capacity demand increases. Note that the network equipment price discount in each year is assumed to be 10%.

OPEX include the BS site lease, maintenance and power supply, core lease, spectrum lease, and equipment maintenance. There is also the equipment depreciation in each year to be considered [6].

Equipment cost is a summation of equipments at end user premises and equipments at the service provider's side [1]. Connectivity costs for a particular user during 5 years can be calculated by using the following general formula:

$$C = (CAPEX) + (OPEX) \quad (1)$$

In this study we use two standard economic measures: Net Present Value (NPV) and Internal Rate return (IRR).

NPV is the future stream of benefits and costs converted into equivalent values today. It is the indicator of how much value the investment can add to our organization.

NPV (Net Present Value) is calculated according to the dynamic investment evaluation method that considers the life cycle of the investment (I), the positive cash flow in particular year, the interest rate and the initial investment [7].

$$NPV = \left(\sum_{t=1}^{n} \frac{D_t}{(1+r)^t}\right) - \left(\sum_{t=0}^{n} \frac{I_t}{(1+r)^t}\right) \quad (2)$$

Here r is the interest rate and I is the investment and D is the positive cash flow in particular year. The calculation method clearly shows the dependence of the NPV from the value of the capital used for the investment in course of the time (1 to t) and the interest rate associated with it.

When

$$I_0 = \frac{\sum_{t=1}^{n} D_t (1+r)^{n-1}}{(1+MISD)^n}, \quad (3)$$

where the MISD is the modified IRR.

In this case, the modified IRR is used the re-investment of the cash flow with a lower interest rate (Brigham, 1977).

In following steps are described the meaning of calculated value of NPV:

1) If NPV > 0 the investment would add value to the organization: project may be accepted.
2) If NPV < 0 the investment would subtract value from the organization: project should be rejected.
3) If NPV = 0 the investment would neither gain nor lose value for the organization: Would be indifferent in the decision.

The IRR is more sub alternate to NPV.

V. Results and Discussion

In simulated results, Fig. 3 shows the CAPEX (The cost of long-term improvements), where are incorporated equipment and installation costs of technologies in different Access Points and the main Base Station. Fig. 3 represents financial investment of establishing connectivity in the region using different technologies. The results show that WiLD, WLL and WiFi connectivity are cheaper options than other after 5 years of implementation.

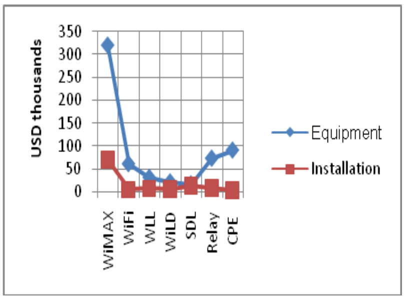

Fig. 3. Comparison of capital investment (CAPEX)

The Fig. 4 shows SDL has a lowest CAPEX but its cost for maintenance is high, short distance, great problem for installation in worst place and not easy its maintenance. WLL has low investments, but it is not option because WLL has limited coverage. The best choice after 5 years should be WiLD and WiFi convergence with WiMAX. Relaying technique must be considerate negligible, it is not good option because increase OPEX after 5 years. There needs to look other technique to improve coverage and capacity of technologies such as adaptive modulations techniques.

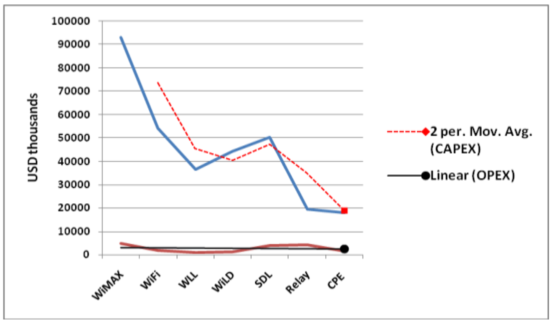

Fig. 4. (CAPEX + OPEX) comparison after five years by different technologies

In the Wireless Maputo Bay project NPV must be great then zero to be accepted. The cash flow should be positive highest with reduced investment. However there need almost big investment to guarantee quality of network. Our intention is to invest with modern technologies reducing maintenance and new acquisition during five years. We need to keep CapEx and OpEx at reasonably low level to be able to offer economical solutions [8].

V. Conclusion and Future Work

The techno-economic Analysis is crucial when we are planning and designing any IT infrastructure. In this paper was widely discussed the total cost of Ownership for Maputo wireless network. The figures show that WiLD, WLL and WiFi should be good choice technologies after 5 years of implementation. However, we conclude that the best option after 5 years will be WiLD and WiFi convergence with WiMAX; WiLD can cover long distance, provides clusters connectivity and WiFi provides connectivity over hundred users with low costs of connectivity and maintenance. For future work will be discussed widely the economic measures: Net Present Value (NPV) and Internal Rate return (IRR).

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