Economic Analysis of SON-Enabled Mobile WiMAX

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Abstract. Even though mobile communication traffic continues to grow fast, its revenue does not increase sufficiently. Hence, mobile communication network operators are seeking technologies and strategies to maintain qualitative network services and reduce the Operational Expenditure (OpEx). Self Organization Network (SON) technology is one of the effective solutions to reduce OpEx. This paper presents the economic analysis of SON-enabled Mobile WiMAX. We define Network Propagation Models (NPM), introduce feasible SON use cases that can reduce the OpEx efficiently, select OpEx factors that can be reduced by deploying SON use cases, and propose mathematical expressions for revenue, CapEx, OpEx, CF, DCF and NPV. For the analysis, we consider a sample site and perform its cost and financial analysis through comparisons before and after SON deployment. As a result, 69% and 89% of total OpEx are decreased at newly added sites and traditional sites, respectively. Moreover, profits are increased earlier. Finally, SON technology can be achieved substantial OpEx reductions in network operational tasks.

Keywords: Mobile WiMAX, Capital Expenditure (CapEx), Operational Expenditure (OpEx), Net Present Value (NPV), Self Organization Network (SON).

1 Introduction

The volume of mobile data traffic is increasing rapidly. Not only because the consumption of mobile devices more specialized and specified towards the operators' richer mobile-service offerings, such as mobile entertainment, multimedia services and enterprise services, is increasing rapidly but mobile communication networks are deployed widely. Figure 1 shows the relation of growth of data traffic and revenue that does not increase as much as growth of data traffic and the mobile communication trend are changing from voice to data dominant. That indicates mobile communication

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network service providers need more and more expenses of Capital Expenditure (CapEx) and Operational Expenditure (OpEx) to guarantee compelling QoS and operators' richer requirements. In mobile communication networks, revenue highly depends on its operational efficiency, for OpEx accounts to generally 24% of a typical wireless operator's revenue [1].

Mobile communication network service providers are seeking technologies and strategies to increase their revenue by reducing OpEx substantially. Self Organization Network (SON) technology is introduced not only for OpEx reduction by diminishing human involvement in network operational tasks but for optimizing network efficiency and service quality [2].

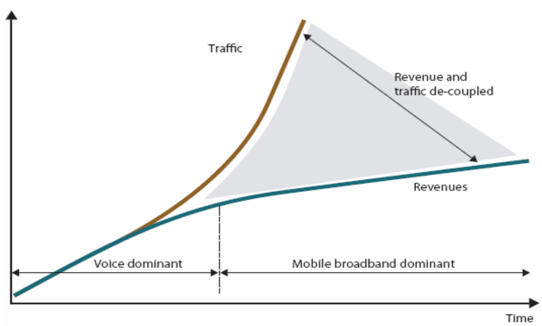


Fig. 1. Mobile traffic volume and revenue (Lighting Reading, 2010)

This paper describes a cost and financial analysis for the SON-enabled Mobile WiMAX using Network Propagation Model (NPM) defined in chapter 3. Cost analysis includes revenue, CapEx and OpEx. Financial analysis includes cash flow (CF), Discount Cash Flow (DCF) and Net Present Value (NPV).

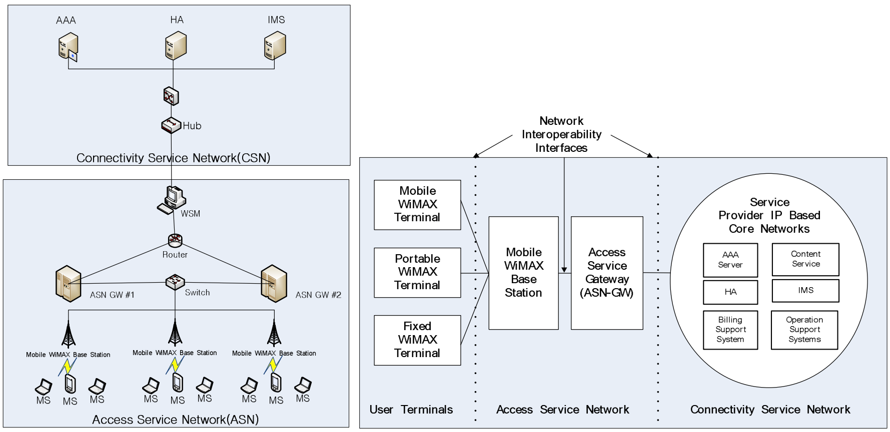
2 Relation Works

2.1 End to End Mobile WiMAX Network Architecture

Mobile WiMAX services are required the installation of Access Service Network (ASN) and Connectivity Service Network (CSN) facilities to cover the cell sites. Figure 2 a) illustrates the physical topology of Mobile WiMAX. This topology mainly includes the following parts; User Terminals (MS), ASN and CSN.

ASN provides means to connect mobile subscribers using OFDMA air link to IP backbone with session continuity [3]. The CSN represents a set of network functions providing IP connectivity services to WiMAX subscribers.

Figure 2 b) illustrates the IP-based Mobile WiMAX architecture [4]. If CSN is installed on, that will nearly changed for a period time and needs some core network devices for connectivity services. But if ASN, it will need a large number of network access devices which are movable and much changeable than CSN to guarantee outdoor coverage. So ASN expends operational cost more than CSN. If SON technologies are deployed in ASN, sizable OpEx can be reduced. Therefore, we will include the ASN and MS parts for financial analysis of the SON enabled Mobile WiMAX.



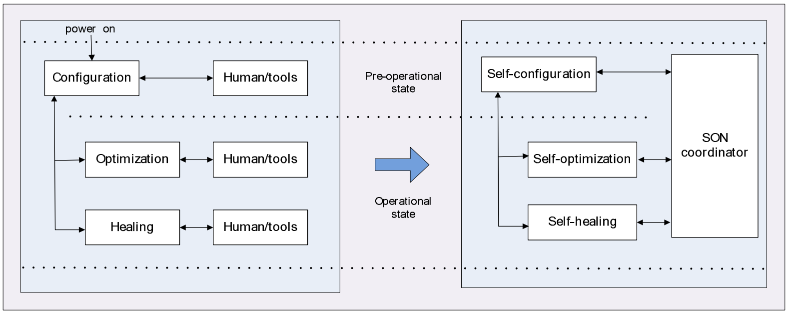
(a) Physical topology (b) IP–based architecture

Fig. 2. Mobile WiMAX architecture

2.2 Introduction to SON

The main objective of SON is to achieve substantial OpEx reductions by diminishing human involvement in network operational tasks and to optimize network capacity, coverage and service quality. According to the SOCRATES (Self-Optimisation and self-ConfiguRATion in wirelEss networkS) project, SON is introduced self-organization, self-optimization (SO), self-configuration (SC) and self-healing (SH). The general idea is to integrate network planning, configuration, and optimization into a single, mostly automated process requiring minimal manual intervention as shown in Fig.3 [5]. Detailed issues of SON are SC, SO and SH. First, SC function enables fast installation and deployment of mobile WiMAX system, and makes to reduce human involvement and deployment time e.g. SC mechanism without dedicated backhaul interfaces. [5] Second, SO function is crucial for the operational state of mobile networks. SO function is to optimize their operational algorithms e.g. MLB algorithm [5] and parameters of antenna, resource management, power setting etc. And scenarios of SO are introduced in response to changes in network, traffic and environmental condition [6]. Third, SH function assists network operators in recovering a network when it collapses and sudden failures due to some unexpected reason. It will reduce OpEx and make Mobile WiMAX system stable.

But mobile communication networks have complex systems with a multitude of vendor control mechanisms and time varying parameters. These are intricate for interdependencies among these control mechanisms and parameters. So design of effective and dependable SON function has main challenges for these complexities.



(a) Without SON (b) With SON

Fig. 3. Network operations

This paper analyses the Mobile WiMAX network using SON, financially and costly.

2.3 Cost Analysis

Cost analysis contains Revenue, CapEx and OpEx. These factors are well-known in accounting and economics. We describe that factors included to calculate or analysis, as follows [12].

Revenue is income that a company receives from its network business activities during a period t. Revenue includes call termination charges, the number of users etc.

CapEx is the most closely-watched metric for determining the direction and level of investment that telecommunications carriers are making in network equipment and services. The CapEx includes costs for towers, network equipment, spectrum licensing etc.

OpEx is operational expense of maintaining cost in time period t and includes salaries of employee, cost of power etc.

2.4 Financial Analysis

CF is a basic financial measure of a company's financial health that equals cash receipts minus cash payments over a given period of time. In this paper, it is measured during a specified, finite period of time using for calculating CapEx, OpEx and revenue.

NPV is well used in capital budgeting to analyze the profitability of an investment or project. NPV analysis compares the value of money today to the value of money in the future. If the NPV of a perspective project is positive, it should be accepted. However, if the NPV is negative the project should be rejected because cash flows will also be negative i.e. the project will lose money. A NPV equal to zero indicates that the project would provide no overall profit and no loss.

3 Financial Analysis of Mobile WiMAX

3.1 Definition of NPM

To obtain realistic figures, we define a scenario model, NPM for Mobile WiMAX. NPM has three types; first is Fixed Expansion Network Operation Type (FENOT) that means operation of Mobile WiMAX in specific geographic area which has no increase, during a period of time. Second is Linear Expansion Network Operation Type (LENOT) that means operation of Mobile WiMAX in geographic area which has linear rate of increase, during a period of time. Third is Exponential Expansion Network Operation Type (EENOT) that means operation of Mobile WiMAX in geographic area that has exponential rate of increase, during a period of time. Figure 4 illustrates the LENOT, at initial year; network provider will make an operation of Mobile WiMAX service in an Operational Model, which means a single geographical area. After second year, Mobile WiMAX services will produce in geographic areas with a linear rate of increase.

Table 1 defines the symbols of NPM types. 'OM' means a unit network type that means a single geographic service area. Table 2 defines propagation types of NPM, describes the characteristics of geographic service area of NPM, during a period of time, n.

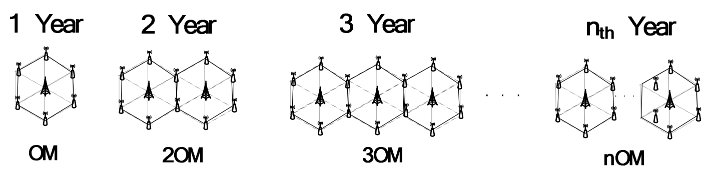


Fig. 4. Linear expansion network operational type model

Table 1. Symbol definition of network expansion type

Symbols	Description
OM	Operational Model
FENOT	Fix Expansion Network Operation Type
LENOT	Linear Expansion Network Operation Type
EENOT	Exponential Expansion Network Operation Type

Table 2. Definition of network expansion types

FENOT	LENOT	EENOT
FENOT = OM	LENOT = n·OM	EENOT = 2^n ·OM

3.2 Selection of SON Use Cases

SON Use Cases and Standardization

We need to know SON use cases and processes to evaluate the effectiveness of OpEx reduction. According to Network Working Group (NWG) in WiMAX forum release 1.6 and 802.16m, the SON technology of Mobile WiMAX is defined only for Femto cell [7]. And we can expect that the SON technologies of Mobile WiMAX will follow the LTE SON standardization. In this paper, we analyze the SON technology of 3GPP standardization. And documents of 3GPP TR 36.902 show the SON concepts and TS 32.500 show the SON use cases [8].

Introduction to SON Use Cases

In 3GPP TR 36.902, SON use cases are introduced as (1) coverage and capacity, (2) Energy saving, (3) Interference reduction, (4) Automated configuration of physical cell Identity, (5) Mobility robustness optimization, (6) Mobility load balancing optimization, (7) RACH load optimization, (8) Automatic neighbor relation function, (9) Inter-cell interference coordination [9].

Because detail SON usages are not fully defined in 3GPP and there are few deployment of SON technology in commercial network products. Therefore we choose SON use cases that are expected to reduce OpEx efficiently as (1) Coverage and capacity optimization, (2) Energy saving, (3) Mobility load balancing optimization, (4) Inter-cell interference coordination. Because these use cases are efficient to reduce management services that has almost 50% more portion of OpEx. And to obtain realistic figures, we have defined a business case for a Mobile WiMAX rollout in Iran.

We choose a sample site in Iran, and analyze the OpEx major components which consisted (1) Managed Service with filed operation and maintenance and radio network management, (2) Optimization Service during Service period, (3) Site survey and Design for ACR, (4) Network Optimization Service for RAS, (5) RF Planning Service.

3.3 Analysis Methods

Revenue

We define the revenue, R(t) during a period of time. In this paper, we calculate the revenue with NPM. For FENOT, we assume initial revenue and Revenue Growth Rate (RGR). And we calculate the revenue using multiplying revenue and RGR as follows.

$$R(0) = InitialRevenue \quad (1)$$

$$R(t) = Revenue(t-1) \times RGR(t) \quad (2)$$

For LENOT, revenue is separated into two cases; the revenue of a geographic site which already produced Mobile WiMAX services and the revenue of newly added sites. First, a site of LENOT is calculated by multiplying the RGR and revenue at each year. Second newly added sites can be calculated by multiplying the initial revenue, RGR and number of sites which are growing linearly.

$$R(0) = InitialRevenue \tag{3}$$

$$R(t) = Revenue(t-1) \times RGR(t) + R(0) \times LinearExpendedSites \tag{4}$$

For EENOT, revenue also is separated into two cases: Operated sites using LENOT calculation method and newly added sites using calculation method as follows.

$$R(0) = InitialRevenue \tag{5}$$

$$R(t) = Revenue(t-1) \times RGR(t) + R(0) \times ExponentialExpendedSites \tag{6}$$

CapEx is under consideration of installation fees, number of users and cost of ASN G/W, BTS, Installation Materials, M/W & Transmission System, Power Supply Unit, CPE, Engineering Services and Civil Work. Then we calculate as follows [9].

$$CapEx = CapEx_{Equipment} + CapEx_{CPE} + CapEx_{CivilWork} \tag{7}$$

$$CapEx_{Equipment} = \sum CapEx(ACR + BTS + PowerSupply + Microwave + Trasmission) \tag{8}$$

$$CapEx_{CPE} = \sum CapEx(Outdoor + Indoor + MultiIndoor + USBDongle) \tag{9}$$

$$CapEx_{CivilWork} = \sum CapEx(Rooftop + Greenfield + Shelter + Installation) \tag{10}$$

OpEx is under consideration cost of Project Management Service, Training Service, Managed Service and Technical Support, ASN G/W, NMS, Engineering Services. Then we calculate as follows.

$$OpEx = OpEx_{Management} + OpEx_{Training} + OpEx_{Engineering} \tag{11}$$

$$OpEx_{Management} = \sum OpEx(project + NMS + Shelter) \tag{12}$$

$$OpEx_{Engineering} = \sum OpEx(TestCost + SiteSurvey + NetOptimize + RFPanning) \tag{13}$$

CF equals cash receipts minus cash payments over a given period of time. In this paper, CF are calculated to three cases; FENOT, LENOT, EENOT. In FENOT case, OpEx is unchangeable for just keeping the operating sites. And we assume that CapEx is fixed for the initial cost and also assume the calculation method as follows [10].

$$CF(t) = Revenue(t) - CapEx(1) - OpEx(t) \tag{14}$$

In LENOT and EENOT cases, CapEx and OpEx will increase for newly added sites. So we assume the calculation method as follows.

$$CF(t) = Revenue(t) - CapEx(t) - OpEx(t) \tag{15}$$

DCF is the major factor for calculating the NPV. After calculating the NPV value with growing discount rate 3%, 6%, 9%, 12%. We find out that there is nearly effect to NPV value. So we assume the DCF to 10% and assume the calculation method as follows [11].

$$DCF(t) = \frac{P(t,p)}{(1+r)^t} \tag{16}$$

NPV is the future stream of benefits and costs converted into equivalent values today. Economic measures based on the NPV are defined to assess the financial viability of potential network designs [13]. The NPV is used within the mathematical optimization framework to produce cost-effective deployments that maximize economic performance while maintaining technical constraints on the network. We assume the NPV calculation method as follows [11].

$$NPV = \sum_{t=1}^{NetworkPeriods} DCF(t) \tag{17}$$

4 Financial Analysis Results of Mobile WiMAX

We choose a sample site in Iran to deploy at the NPM and to analyze the financial factors; Revenue, CapEx, OpEx, NPV etc. and we will deploy the SON algorithm to the same sample site and will compare the result of before and after SON.

4.1 Cost Analysis

The result of cost analysis. We assume the cost analysis factors with revenue, CapEx, OpEx. The cost factors are defined as follows.

The Analysis of Total CapEx Result
After analysis of the total CapEx result, equipment cost and installation fees account for 70% for the total CapEx.

In this paper, we assume the CapEx to initial cost, because we just are interesting the OpEx reduction.

The Analysis of Total OpEx Result
After analysis of the OpEx calculation result, the 51.67% OpEx is spent on 'Managed Service' and 'Technical Service' of the total OpEx as shown in Fig 5. And 'Managed Service' includes 'Field Operation and Maintenance', 'Project Management', 'Radio Network Management' and 'Optimization Management'. We find out that network service providers spent most expense for the network management and optimization.

In this paper, we assume that ACE S/W, WSM S/W costs are included in initial OpEx. And others are included in maintenance expense.

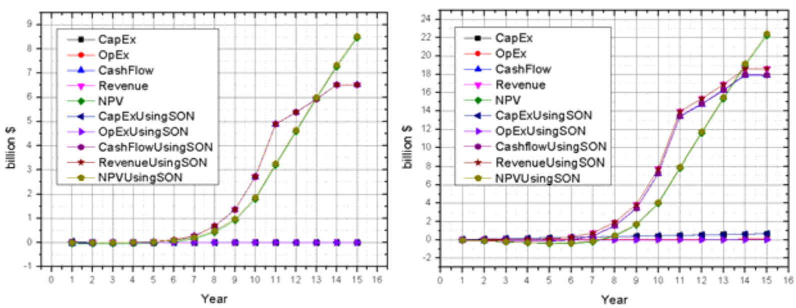
RGR; we assume RGR following Gaussian distribution, with a standard deviation of 64% as follows to calculate the revenue. The revenue is steadily declining during first five years, increasing rapidly from 5 to 10 years and decreasing from 10 to 15 years.

4.2 Cost Analysis of SON-Enabled Algorithms

After analysis, we find that initial OpEx of new site is decreased about 69% of the total OpEx after deploying and traditional network OpEx is decreased about 84%.

4.3 The Financial Analysis of SON-Enabled Algorithms

We find that CF and revenue curves, Fig. 5 of both FENOT and LENOT are following the Gompertz model. FENOT provides positive NPV and payback in less than 5 years. And LENOT provides positive NPV and payback in fewer 8 years. In other words, when network service provider can have profit after 5 year using FENOT and after 8 year using LENOT. But if they use EENOT, it will be not profitable over the time-period 15 years. Because they spend excessive expenses CapEx and OpEx more than revenue at initial time-period. And these will be accumulated during the total time-period.



FENOT LENOT

Fig. 5. Comparison of Financial Analysis SON enabled and disabled

5 Conclusion

Network operators have managed multi vendor equipments for flexible network services and spent much OpEx for various vendors, heterogeneous network and plenty of network elements. SON is announced to reduce OpEx reduction by diminishing human involvement in network operational tasks. In this paper, we choose the factors to reduce OpEx by using SON algorithms and choose the SON use cases feasible. We analyze cost and financial benefits. As a result, 69% and 89% of total OpEx are decreased at newly added sites and traditional sites, respectively. Moreover, profits are increased earlier. That is, network service providers can have network profits 3 years earlier when using FENOT than other network expansion types.

If network service providers use SON technologies, it must be beneficial to deploy Mobile WiMAX services. But there are few cases deployed SON-enabled commercial network, so we need to do research more about the realistic deployment of SON.

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