Decision support system in an international-voice-services business company

R. Hadianti[1], S. Uttunggadewa[2], M. Syamsuddin[3] and E. Soewono[4]

[1,2,3,4]Research Consortium of Financial Modeling, Optimization and Simulation, Center for Mathematical Modeling and Simulation. Gedung Labtek III Lt. 1 Jalan Ganesha 10 Bandung 40132, INDONESIA.

E-mail: hadianti@math.itb.ac.id, s_uttunggadewa@math.itb.ac.id,

msyamsuddin8@gmail.com, esoewono@bdg.centrin.net.id

Abstract. We consider a problem facing by an international telecommunication services company in maximizing its profit. From voice services by controlling cost and business partnership. The competitiveness in this industry is very high, so that any efficiency from controlling cost and business partnership can help the company to survive in the very high competitiveness situation. The company trades voice traffic with a large number of business partners. There are four trading schemes that can be chosen by this company, namely, flat rate, class tiering, volume commitment, and revenue capped. Each scheme has a specific characteristic on the rate and volume deal, where the last three schemes are regarded as strategic schemes to be offered to business partner to ensure incoming traffic volume for both parties. This company and each business partner need to choose an optimal agreement in a certain period of time that can maximize the company's profit. In this agreement, both parties agree to use a certain trading scheme, rate and rate/volume/revenue deal. A decision support system is then needed in order to give a comprehensive information to the sales officers to deal with the business partners. This paper discusses the mathematical model of the optimal decision for incoming traffic volume control, which is a part of the analysis needed to build the decision support system. The mathematical model is built by first performing data analysis to see how elastic the incoming traffic volume is. As the level of elasticity is obtained, we then derive a mathematical modelling that can simulate the impact of any decision on trading to the revenue of the company. The optimal decision can be obtained from these simulations results. To evaluate the performance of the proposed method we implement our decision model to the historical data. A software tool incorporating our methodology is currently in construction.

Keywords: decision support, international telecommunication, revenue maximization

1. Introduction

Telecommunication industry is continuously and simultaneously growing as the result of the various innovations of today's telecommunication technology. Nowadays, customers of this industry get some benefits from the growth of over-the-top (OTT) players in this industry that continuously expanding the scope of their offerings, the competitiveness in this industry is very high which leads to lower and lower customer cost of communication. Without any investment in faster network capabilities, cost control, business efficiencies and partnerships, any telecommunication company cannot be survive in the current situation.

We consider a problem facing by an international telecommunication services company which provides voice services, data services, and network provider, in the very high competitive

situation. The voice services of this company are classified as wholesale services, international hubbing, extension voice service, and international direct dial. We focus on profit maximization from wholesale services, in which this company trades voice traffic with more than seventy business partners. There are four trading schemes that can be chosen by this company, namely, flat rate, class tiering, volume commitment, and revenue capped. Each scheme has a specific characteristic on company revenue assurance, company potential loss, and attractive or not for business partners to transfer significant traffic volume. Each scheme has a number of scheme parameters, such as rate, volume deal or revenue deal, where its values are determined by both parties. In section 2 we will describe more about the schemes and we also discuss that the last three schemes are regarded as strategic schemes to be offered to business partner to ensure incoming traffic volume for both parties. This company and each business partner need to choose an optimal agreement in a certain period of time that can maximize the company's profit. In this agreement, both parties agree to use a certain trading scheme, rate and volume/revenue deal. In the past, the agreements were usually decided by the sales officers without any decision support system. Therefore, not all agreements yield optimal profits. A decision support system is then needed in order to give a comprehensive information to the marketing officers to deal with the business partners.

The need of the decision support system is triggered by the fact that the company's revenue has a decreasing trend, contrasts to the traffic volume that has an increasing trend. Figure 1 below shows this phenomenon. The factor that causes this phenomenon is shown in Figure 2, which tells us the average rates to the six classes of destinations. The average rates have decreasing trends, and these cause the company's revenue is decreasing.
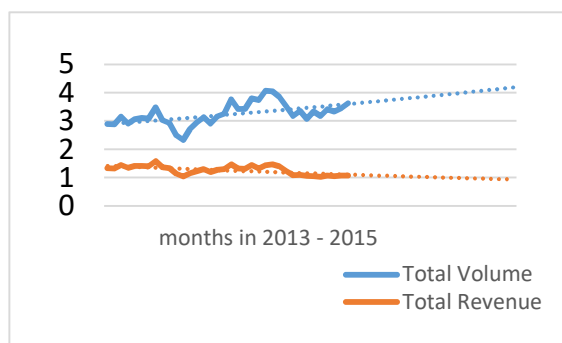

Figure 1. The incoming traffic volume (in 1000 million minutes) and the revenue (in US $ 10 million)
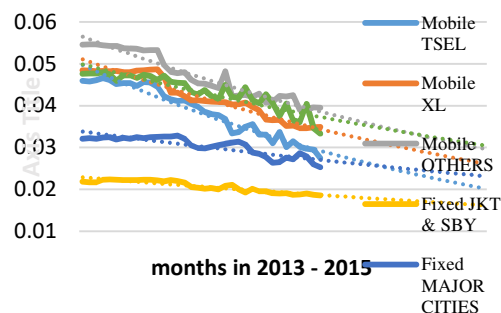
Figure 2. The average rates (US$/min and its extrapolations

If the rates are decreasing monotonically, then nothing can be done to control or to maximize revenue. But we can see from Figure 2 that the rates are not monotonically decreasing, which tells us that we need to explore what factors that influence the rates. Our elaboration on the company business process gave a conclusion that the rate is determined by negotiation between the company sales and business partners sales, and we may find some careless negotiations which leads to very low effective rates or unexpected business partner responds that cause un-optimal revenues. The decision support system is expected to give a guidance to sales officers in order to obtain win-win agreements to both the company and its business partners.

This paper studies a mathematical modeling that can simulate the impact of any decision on trading to the revenue of the company. In this paper, the study is focused on the incoming traffic analysis, so in the remaining of this paper we just consider the company's revenue since the company's profit can be studied by analyzing both incoming and outgoing traffic. The mathematical model is derived by performing following steps.

1. Analyzing the potential loss that can be imposed by a trading scheme.
2. Historical data analysis.
3. Modeling the expected revenue as a function of volume realization, rate, and others trading scheme parameters,
4. Modeling the optimal decision.

To evaluate the performance of the proposed method we implement our decision model to the historical data. We obtained that by performing our decision strategy, some unexpected phenomenon can be avoided so that the company's revenue can be optimized. The decision strategy is implemented into a software that can be used by sales officers. This software is on the trial stage, and is expected to be operated soon.

This paper is organized as follows. After this introduction, in section 2 we describes more the four trading schemes that can be chosen by sales officers. We also discuss the potential losses that can be imposed by the trading schemes. In Section 3, we present the results of our historical data analysis concerning on the price elasticity. By the analysis data we want to know at what level of rate reduction that will yield an increasing traffic volume. Besides that, we also want to know what the impact is if we increase the rate. After that, in Section 4 we derive a mathematical model for the expected revenue due to a decision. The results in Sections 2, 3 and 4 then is combined to derive an optimal decision model, which we present in Section 5. In Section 6 we give some examples on the decision model implementation. We end this paper by presenting some discussions in Section 7.

2. Trading schemes and the potential of loss

In each negotiation process, any sales officer and the business partner will choose one of four trading schemes, namely flat rate, class tiering, volume commitment, and revenue capped, for the next bilateral agreement. The description of all trading schemes are given in the following table.

Table 1. The description of the trading schemes

Trading scheme	Description
Flat rate	This trading scheme is a normal scheme, where both parties agree to deliver their traffic volumes at the specific rates, regardless how much volume of the traffic they deliver.
Class Tiering	By this trading scheme, both parties agree to set tier classes of volume in which each class is associated to a specific rate. In general, the rate for the lowest tier class is higher than the rate for the second tier class, and the rate for the second tier class is higher than the rate for the third tier class (if any). This setting is aimed to create an attracting scheme, so that the company and the business partner are eager to deliver more significant traffic volume.
Volume Commitment	By this trading scheme, the company commits to deliver a minimum traffic volume (which is called the first volume deal) during the period of the agreement at a certain rate (which is called the first rate deal). If the total volume exceeds the first volume deal, then the rate for the volume after the first volume deal follows the second rate deal. If during the period of the agreement the company could not fulfill the commitment, then the volume shortfall cost have to be paid in the grace period. On the other hand, the business partner has the same obligation in delivering its traffic volume, with respect to its volume deals and rate deals.
Revenue Capped	By this trading scheme, the company commit to pay a certain amount (which is called the revenue deal) to the business partner as the cost for terminating traffic volume delivered to the business partner to the end users, regardless how much volume of the traffic the company deliver.

Table 2 below shows examples of the trading schemes and its parameters involved.

Table 2. Examples of trading schemes.

Trading	Volume deal	Rate (US	Revenue deal
Flat rate	-	0.0273	
Class Tiering	100,000	0.0390	
	> 100,000	0.0360	
Volume Commitment	100,000	0.0400	
	> 100,000	0.0290	
Revenue Capped	-	-	1,415,000.00

It is clear that if we have a significant volume of traffic, the class tiering and the volume commitment trading schemes are preferable than the flat rate trading scheme since with an appropriate the first volume deal it can generate a lower effective rate, which can be obtained from the application of the second rate deal (and the third rate deal, if any). It should be noted that if the first volume deal is not appropriate, in the sense it is to high compare to our volume of traffic realization, by the volume commitment trading scheme will impose the shortfall loss that is the cost that has to be paid for unfulfillment of volume commitment. But this kind of loss will not be imposed by the class tiering trading scheme. The revenue capped trading scheme also can generate a lower effective rate if the traffic volume is very high (the effective rate is equal to the revenue deal divided by the traffic volume).

From the company point of view, the business partner revenue deal in the revenue capped trading scheme or the business partner first volume deal in the volume commitment trading scheme assure the company revenue. The opportunity for the business partner to gain a lower rate can be regarded as probability for the company to gain loss. But we note that the probability the company to gain loss in the revenue capped trading scheme is higher that the probability in the class tiering or the volume commitment trading schemes since in the last two trading schemes the minimum effective rate is bounded below by the minimum rate deal, meanwhile in the revenue capped trading scheme the higher traffic volume delivered the lower effective rate obtained. We summarize our analysis in the following table.

Table 3. Characteristics of trading schemes.

Trading scheme	Revenue assurance for the company	Opportunity for business partner to gain a lower	Probability of the company loss
Flat Rate	×	×	none
Class Tiering	×	√	low
Revenue Capped	√	√	high
Volume Commitment	√	√	low

3.   Historical data analysis

We perform data analysis in order to validate the assumption we got that the voice product is price sensitive, in the sense that business partner will send more incoming traffic volume if the price is decreased. Contrary, business partner will not interested to send a significant incoming traffic volume if the rate is considered too high. This assumption is a well-known assumption, as written also in Meisner and Stefan [3] and Scott, *et al.* [7]. The assumption can easily understood by following figures 3 – 5 below. Figure 3 shows the historical data of the incoming traffic volume, the effective rate, and the average rate (obtained by averaging all rates applied to the others business partners to the same destinationtion). We can see that during two years the rate was never changed, and was always higher than the average rate. The higher rate made the business partner not very eager to deliver more and more traffic volume, causes a deacreasing trend in the traffic volume which leads to a deacresing trend of revenue.
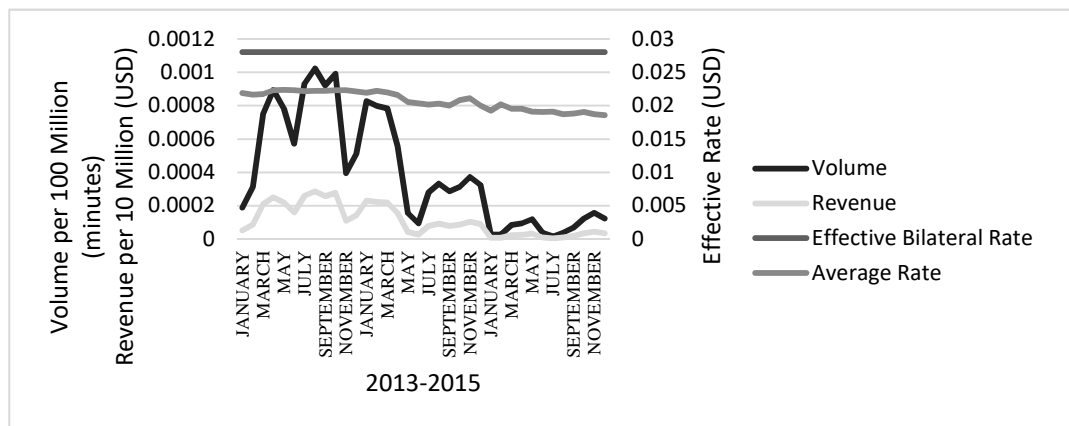

Figure 3. Analysis of Incoming Traffic Volume
Destination: Indonesia Fixed Jakarta & Surabaya - From Partner X

Figure 4 shows a very interesting phenomenon where the business partner seems do not want to deliver traffic anymore when the rate is increased.
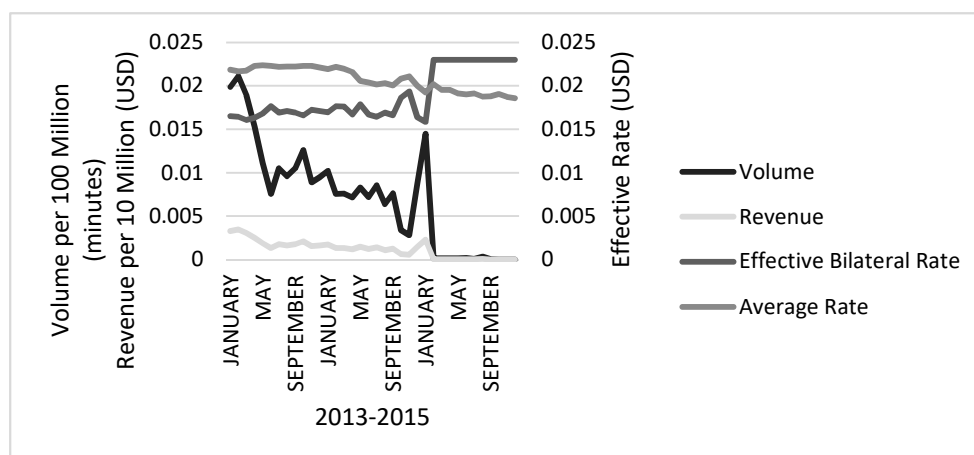

Figure 4. Analysis of Incoming Traffic Volume
Indonesia Fixed Jakarta & Surabaya – from partner Y

Figure 5 shows another interesting phenomenon where the business partner eagers to deliver a significant traffic volume when the rate is decreased quite significantly, and the business partner does not eager to deliver a significant traffic volume when the rate reduction is not significant.
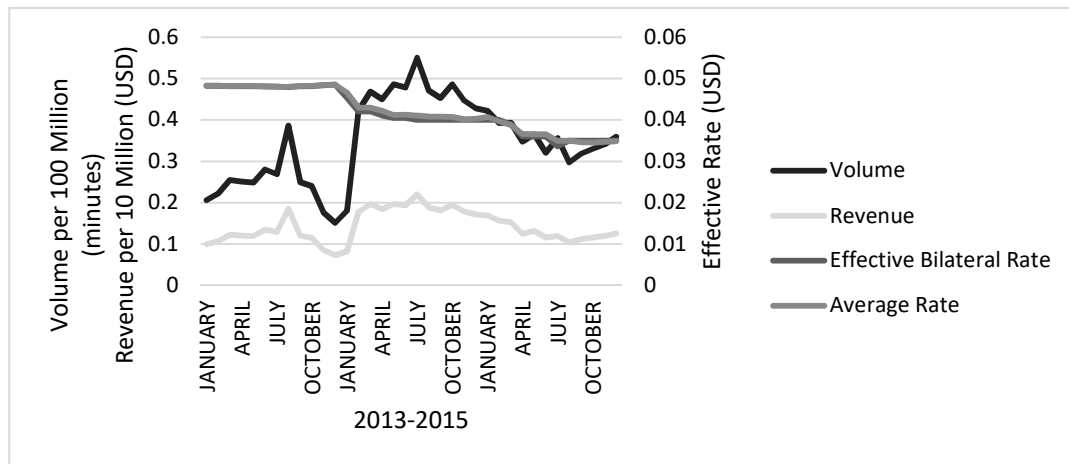

Figure 5. Analysis of Incoming Traffic Volume
Indonesia Mobile XL – from partner Z

We perform data analysis to obtain the statistics of these phenomena, and the results are written in the following table.

Table 4. Actions on rate change and its impacts

Action	Impact
Increasing the rate	Incoming traffic volume will be deacreased
Decreasing the rate $<$ 7.5% the last rate	The trend of incoming traffic volume will be preserved
Decreasing the rate $\geq$ 7.5% the last rate	With probability 0.83 the incoming traffic volume will be positively shock with a certain increment

The results bring us to an assumption we make in our mathematical model that with probability 0.83 business partner will deliver more traffic volume if we decrease the rate at least 7.5% from the last rate, and business partner will deliver less traffic volume if we increase the rate. But we cannot decrease the rate freely since the rate have to greater or equal to so called $critical_{rate}$ the rate which reflects the operational cost.

4. Modeling the expected revenue

The decision support system is created to control the company revenue. We can control the company revenue by controlling the rate. Our discussion in the previous section tells that we just can keep the last rate or decrease the rate at least 0.75% of the last rate. There are two possible behavior:

- **Behavior 1**. If we keep the last rate or if we decrease the rate 0.75% of the last rate, then in the future the traffic volume will continue to behave as before.
- **Behavior 2**. If we decrease the rate by 0.75% of the last rate then in a certain period of time (of average three months) the traffic volume will increase with a certain slope that depends on the business partner, after that the traffic volume will back to its behavior before the rate is decreased. We formulate these two types of future traffic volume behaviors in the following, where we model the traffic volume for six following months.

Let:

V_0 be the traffic volume at the last month,

t be the months, $1 \leq t \leq 6$,

d_1 be the average increasing slopes experienced by the historical traffic volume,

d_2 be a slope parameter of the last six months traffic volume model (which leads to **Behavior 1**)

$$v(t) = Ae^{d_2 t}, t = 1, 2, \ldots, 6 \tag{1}$$

ER_1 be the expected revenue in the following six months if the last rate is preserved, where the traffic volume follows model (1),

ER_{opt} be the expected revenue in the following six months if the rate is decreased by 7.5% of the last rate, under the condition that the volume follows **Behavior 2**,

$$V(t) = \begin{cases} -\dfrac{d_1}{3}t^2 + 2d_1 t + V_0, & 1 \leq t \leq 3 \\ (V_0 + 3d_1)e^{-d_2(t-3)}, & 4 \leq t \leq 6. \end{cases} \tag{2}$$

ER_2 be be the expected revenue in the following six months if the rate is decreased by 7.5% of the last rate.

$rate_{end}$ be the rate in the last month.

Then,

$$ER_1 = rate_{end} * \sum_{t=1}^{6} Ae^{d_2 t} \tag{3}$$

$$ER_{opt} = (rate_{end} - 7.5\% \, rate_{end}) \left(\sum_{i=1}^{3} \left(-\dfrac{d_1}{3}i^2 \right) + 2d_1 i + V_0 + \sum_{i=1}^{3}(V_0 + 3d_1)e^{-d_2 i} \right) \tag{4}$$

$$ER_2 = 0.83 ER_{opt} + 0.17 ER_1 \tag{5}$$

From (1) we obtain the expected traffic volume in the month is $EV = V_0 e^{d_2}$. These models are used in **Simulation 1**, which is used to know the impact of decresing the rate to the expected revenue. This simulation will be used as a subroutine in **Algorithm 1** that will be discussed in the next section.

Simulation 1

Input

- the last trading scheme and its parameters (rate deal/volume deal/revenue deal)
- the traffic volume in the last six months

Steps

1. Evaluate A, d_2 by using model (1).
2. Evaluate er (the effective rate in the last month).
3. Evaluate ER_1, ER_{opt}, ER_2 from (1), (2) and (3).
4. If $ER_1 \leq ER_2$, decreasing the rate, the new rate deal $= 0.925 * er$, the expected revenue $= ER_2$,

   else, preserve the rate, the expected revenue $= ER_1$

Output

decission on the new rate and the new trading scheme parameters

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5. Modeling of optimal decision

The decision support system can be used by sales officers to monitor the performance, and if the last agreement is considered by the company or by the business partner to be a non-optimal agreement the decision support system can give some options to be chosen so that the next agreement is hoped to be an optimal one.

We assume that the performance of the last argument can be reviewed if it has been elapsed at least 80% of its duration, The performance indicator we use depends on the trading scheme of the last agreement, which we describe in the following table.

Table 5. The first performance indicators of the trading schemes

Trading scheme	The first performance indicator	The performance classes	The conditions
Flat Rate	the effecive rate	good	if the effective rate is higher than the critical rate
		bad	if the effective rate is less than or equal to the critical rate
Class Tiering	C=(the total first volume deal-the aggregate volume) / the total first volume deal	good	if $C > 0.5$
		bad	if $C \leq 0.5$
Revenue Capped	the effecive rate	good	if the effective rate is higher than the critical rate
		bad	if the effective rate is less than or equal to the critical rate
Volume Commitment	the expected aggregate volume at the end of the agreement period	good	if the expected aggregate volume exceeds the first volume deal
		bad	if the expected aggregate volume does not exceed the first volume deal

We also use another performance indicator, i.e. the trend of the traffic volume in last six months, which we denote by d_2.

The decision for the next agreement is obtained by following the algorithm below.

<div style="border:1px solid black; padding:10px;">

Algorithm 1

Input

- the last trading scheme and its parameters (rate deal/volume deal/revenue deal)
- the traffic volume in the last six months

Steps

1. Evaluate A, d_2 by using model (1).
2. Evaluate er (the effective rate in the last month).
3. Evaluate the first performance indicator.
4. If the first performance indicator is good, the last agreement can be preserved, go to , otherwise go to 5.
5. We have four cases:

Case 1 (if the last trading scheme is Flat Rate)	If $d_2 > 0$ preserve the last trading scheme parameters, else if $critical_{rate} < 0.925 * er$ then call **Simulation 1,** else convert to Volume Commitment trading scheme with: • the first volume deal $= EV$ • the first rate deal $= er.$
Case 2 (if the last trading scheme is Volume Commitment)	Try to preserve the last trading scheme parameters. If the business partner wants to change the parameters, the minimum first volume deal for a month is EV.
Case 3 (if the last trading scheme is Class Tiering)	If $d_2 > 0$ preserve the last trading scheme parameters, else if $critical_{rate} < 0.925 * er$ then call **Simulation 1,** else change the trading scheme parameters to: • the first volume deal $= EV$ • the first rate deal $= er.$
Case 4 (if the last trading scheme is Revenue Capped)	Convert to Volume Commitment trading scheme with the minimum first volume deal for a month $= EV$ and the first rate deal $= critical_{rate}$.

then go to 6.

6. end

Output

chosen trading scheme and its (new) parameters.

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6. Modeling of optimal decision

In this section we give some examples of the implementation of the Algorithm 1. If the last agreement has come to be review, we give the trading scheme parameters for all trading schemes that can be chosen.

The first example is the agreement between the company and business partner P_1 to destination ROC[1], where the last trading scheme is Volume Commitment. From Figure 6 we can see that the first volume deal is too high and can impose a loss to the business partner due to volume shortfall at the end of the agreement period. If the business partner realize it, and want to change the agreement, our decision is to preserve the trading scheme but the trading scheme parameter can be changed as

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[1] one of six destinations.

can be seen in Figure 7. If the optimal decision above is followed, then in the next six month the traffic volume will follow the combination of the red trend and the yellow trend shown in figure 8.
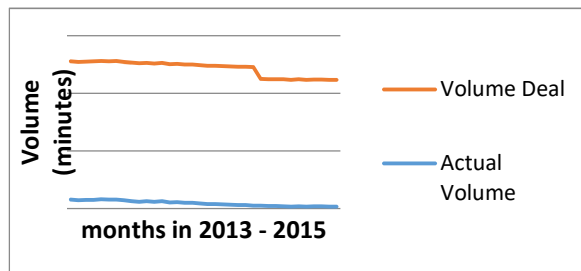

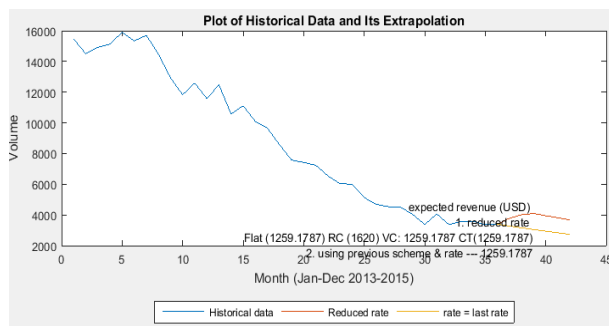**Figure 6.** The chart of the first volume deal and the actual volume of the company and business partner P_1

Figure 8. The expected revenue at the next agreement between the company and business partner P_1, if the optimal decision is followed.
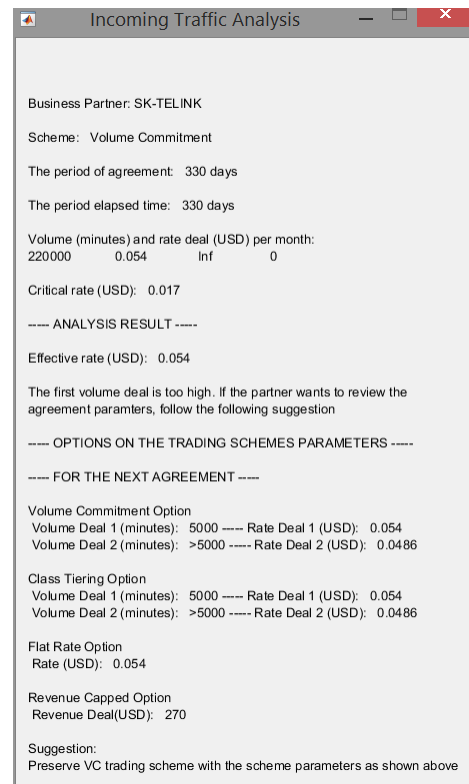

Figure 7. The optimal decision for the next agreement between the company and business partner P_1

The second example is the agreement between the company and business partner P_2 to the same destination and the same trading scheme as the first example. Unlike the first example, the first volume deal is not too high (see Figure 9) so that the business partner get benefit from the second rate deal application due to the actual volume which exceed the first volume deal. This reasonable volume deal in fact yields an increasing trend in the volume, and this condition is what we try to achieve by our optimal decission. The trading scheme parameters for the next agreement can be seen in Figure 10, and the expected volume and the expected revenue due to the optimal decision can be seen in Figure 11.

Actually, we still have many interesting examples of decisions for various trading schemes. But due to space limitation, we just present the two examples here.
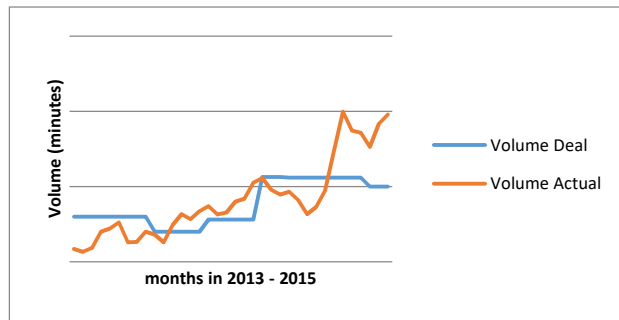
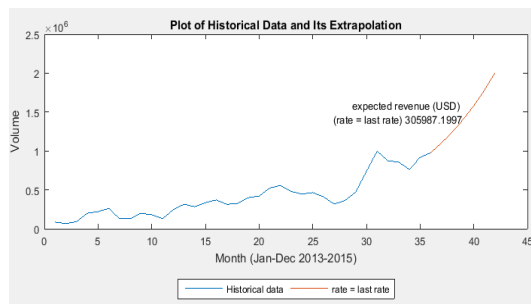**Figure 9.** The chart of the first volume deal and the actual volume of the company and business partner

Figure 11. The expected revenue at the next agreement between the company and business partner P_2, if the optimal decision is followed.
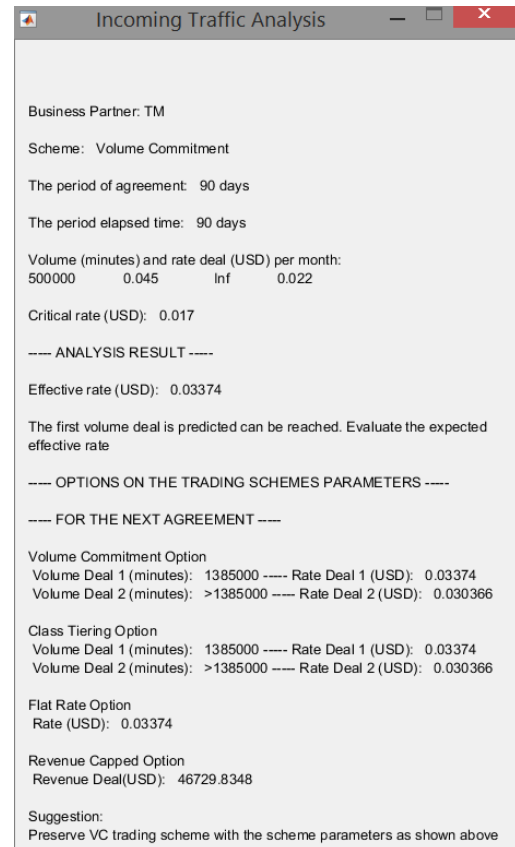

Figure 10. The optimal decision for the next agreement between the company and business partner P_2

7. Conclusion

In this paper we derive an algorithm for obtaining an optimal decision for the next agreement between the company and a business partner. The algorithm is derived through a mathematical modeling process which consists of trading scheme analysis, historical data analysis, modeling the future traffic volume and the expected future revenue. The decision we provide are the trading scheme that can be chosen and its trading scheme parameters. If the optimal decision is followed, we can calculate the expected future revenue. A software tool incorporating our methodology is currently in in the trial stage, where this software also has a feature where any user can simulate the future traffic volume and the expected future revenue if trading scheme and the trading scheme parameters chosen by the user are different from the optimal ones. Another feature that can be found in the software is the optimal decision for outgoing analysis, where the mathematical model for the derivation of this optimal decision can be found in other article we has been composing (see Hadianti and Uttunggadewa [2]).

Acknowledgment

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