Real Options Analysis for GPRS Network with Wi-Fi Integration

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ABSTRACT
Currently, cellular operators are not able to provide high data rate connections to their subscribers. Researchers have proposed integration of WLANs with GPRS networks to offer higher data rates. WLANs are proliferating at a high rate in both household and enterprise arena. In this paper we value the integration of GPRS network with WLANs, as an option to expand. We also study the effect of key parameters such as investment cost, number of subscribers and risk, in the decision process.

Keywords
2.5G, GPRS, WLANs, Real Options Theory, Valuation.

1 INTRODUCTION

The 3G technology has promised to provide data rates of 384Kbps with a maximum user speed of 120Km/hr. However, with the spectrum auctions for 3G networks not having taken place in the US yet, there is a delay in the introduction of 3G technology. In order to meet the requirements of higher data rates, 2.5G operators could integrate with Wireless LANs.

Wireless LAN (WLAN) technology is simpler, cheaper, and easier to deploy. WLANs offer high speed data connection in the range of 11Mbps to 54Mbps, compared to 171kbps of 2.5G services, such as General Packet Radio Services (GPRS). In reality GPRS offers far less than the theoretical data rate of 171kbps. Due to lack of spectrum, GPRS operators have not been able to satisfy the needs of their subscribers.

2.5G technology when integrated with Wi-Fi can offer 3G like services [1]. Integration can be a valuable option for 2.5G operators because they have an already established subscriber base to whom they can cater the integrated network, and offer them high speed data connections. Secondly, they can attract new subscribers to the network, holding-on to their subscriber base. By integrating their network, they can gain additional revenue from Wi-Fi subscribers.

The paper deals with the application of real options theory in wireless networks. The objective of this paper is to analyze the deployment of Wireless LANs as a complement to 2.5G networks. We highlight the strength of applying the real options valuation approach as a decision making tool in expanding the 2.5G network to provide higher data rates services when integrated with WLANs.

The structure of the paper is as follows: In Section 2, we present the problem, outline our approach, formulating it as a real option. In Section 3, we discuss our assumptions and the parameters we are using to perform our analysis. In Section 4, we calculate and compare numerical results, using both the traditional and real options approaches. In Section 5, we study the effect of key parameters in the decision to expand, and in Section 6 we draw our conclusions.

2 PROBLEM FORMULATION

Our hypothetical company covers downtown Manhattan, offering voice and data services e.g., GSM/GPRS services, to its subscribers, through a 2.5G network. Currently GSM/GPRS operators cannot upgrade to 3G, as the required spectrum is not available to them.

The United States is experiencing a delay in launching 3G, due to lack of spectrum, and delay in the 3G spectrum auctions. Even if the operators start deploying the 3G networks, it will take a considerable amount of time for 3G to become operational. This delay in the introduction of 3G technology increases the uncertainty. But the delay in the introduction of 3G technology is not necessarily a bad sign for the operators. In fact, operators can re-consider their strategies. For example, instead of waiting, the operators can integrate Wireless LANs with their existing 2.5G networks and provide 3G like services [1].

Capital budgeting is important in our analysis. The capital expenditure is comprised of the WLAN access point construction cost. The amount of capital required to upgrade the network is based on the number of access points the company has to install. The operational expenditure consists of access point maintenance cost and cost of business DSL line. We next calculate the additional revenue from subscribers. In this paper, we consider the pricing model proposed by Harmantzis et. al., for the integrated network [5]. The model calculates the additional revenue that can be made due to integration, making certain assumptions. Finally, the valuation phase takes place: we calculate the net present value of the integration project first. Then we use the derivatives theory to value the option that the operator has, to elaborate on the decision making process.

The proposed methodology in this paper is based on an option to expand. It focuses on the option that a network operator has, considering integrating the existing 2.5G network with Wireless LANs, in order to offer 3G like services [1]. There are two types of integration: tightly coupled architecture and loosely coupled architecture [1].

Option to Expand

An option to expand provides the management, the ability and right to expand into different markets and products. In our case, the company has the option to expand its network from 2.5G to an integrated network. This allows the company to be competitive, hold-on to its existing subscriber base, and attract new subscribers. The project can be modeled as an American call option, since the expansion can take place at any time until the expiration date, i.e., life of the option [2]. The value of the option to expand can be estimated using the Black-Scholes option pricing model [8]:

$$c = S_0 N(d_1) - K e^{-r_f T} N(d_2) \quad (1)$$

$$d_1 = \frac{\ln(S_0 / K) + (r + \sigma^2 / 2) T}{\sigma \sqrt{T}} \quad (2)$$

$$d_2 = d_1 - \sigma \sqrt{T} \quad (3)$$

where S_0 is the current price of the asset, K is the strike price, r_f is the risk free interest, T is the maturity of the option, and $N(d)$ is the cumulative normal density function. The value of the option, once calculated, is incorporated in the net present value from the traditional approach. The combined value is used in the decision making process.

3 PARAMETERS AND ASSUMPTIONS

We have made certain assumptions in our paper to perform the analysis. To perform our analysis, we consider Downtown Manhattan, an area of 23 square miles. We consider two scenarios for the revenue stream in the integrated services setting: In the first one, the company experiences revenues coming from its existing customer base, i.e., a percentage of existing data subscribers. In the second scenario, the company considers revenues coming from both integrated network subscribers and Wi-Fi (new) subscribers.

As far as the option parameters are concerned, our assumptions are as follows: we have considered the present value of future cash flows as the underlying asset; S_0 is its current price. The maturity of the option T is three years; the strike price K , i.e., the present value of investment cost of the project, is the sum of both capital and operational expenditures. For the volatility σ of the underlying, we looked at the historical price movements of the US Telecom Index for the past 3 years, and estimated it at 31.225% (annually). We consider a risk-free rate r_f of 2.62%, after we looked at the current US Treasury Bonds Rates corresponding to the life of our option [12]. We discounted the cash flows in the traditional approach, using the weighted average cost of capital (WACC). For our analysis we assume a WACC of 10.8% (wireless aggregate) for the time of project [10].

Investment Cost Break Down and Estimates

Table 1 shows the investment cost break down to Capital Expenditure (CapEx) and Operational Expenditure (OpEx).

Table 1: Investment Cost Projection for the Project

Year	Year 0	Year 1	Year 2	Year 3
Wi-Fi APs	375	25	25	25
CapEx	$187,500	$12,500	$12,500	$12,500
OpEx	$562,500	$600,000	$637,500	$675,000

Capital Expenditure

Table 1 shows the cash flow projections for the life of the project. We assume the cost of installing a single access point is $500, and remains constant for the life of the project [4]. A single access point can cover 0.0102 square miles. We assume that in the first year the operator decides to install Wireless LANs in 1/6th of the total coverage area, in strategic locations covering downtown Manhattan. At the end of the life of the project, the company would have coverage in 1/5th of the Manhattan area.

Operational Expenditure

We assume the cost of a single business DSL line is $75 per month and maintenance cost of $50 per month [4]. The OpEx numbers shown in Table 1 are based on the total number of access points at the end of each year.

The present value of the investment cost K is $2,109,819.34 using a WACC of 10.8%.

Subscriber Base

We calculate the subscriber base of our hypothetical company in downtown Manhattan as 120,000, based on traffic engineering information. Within this base, the percentage of data users starts at 7.5% and increase to 15% towards the end of the project. Furthermore, we assume 70% of the above data subscriber base to be subscribers of the integrated network.

Revenue Projections

Scenario A: Revenue from Integrated Network only

In Scenario A, we present the revenue projections from subscribers of integrated network, and calculate the present value of future cash flows S_{01}, from figures shown in Table 2.

Table 2: Revenue Projection for Scenario A

Year	Year 0	Year 1	Year 2	Year 3
Existing Subscribers	6,300	8,904	11,798	15,007
Revenue	$245,700	$347,256	$460,114	$585,265

We calculate the revenue for the integrated network based on the pricing model proposed by Harmantzis et. al [5]. Figures at Table 2 are calculated assuming additional revenue of $1.3 per connection and 30 connections per year on average (this is a conservative estimate). We discount the revenues using WACC of 10.8% for the time of the project to calculate the present value S_{01} of future cash flows as $1,231,190.25.

Scenario B: Revenue from Integrated and Wi-Fi Network
Table 3 revenue projections consist of revenue from both scenario A and from the Wi-Fi subscriber base.

Table 3: Revenue Projections for Scenario B

Year	Year 0	Year 1	Year 2	Year 3
Existing Subscribers	6,300	8,904	11,798	15,007
Wi-Fi Subscribers (New)	8,000	8,000	8,000	8,000
Revenue	$645,700	$747,256	$860,114	$985,265

Revenue figures in Table 3 are based on a connection fee of $5 to the Wi-Fi subscribers (new), and a total of 10 connections made per year [3]. Calculated revenue, we have assumed a conservative Wi-Fi subscriber base of 8,000. In Section 5, we study the effect of changes in cash flows due to changes in Wi-Fi subscriber base. The present value of future cash flows S_{02}, discounting at 10.8% again, is $2,477,486.36.

4 VALUATION

Scenario A: Revenue Generated from Existing Subscriber Base.

Traditional Approach (No Option)
From a traditional Discount Cash Flow (DCF) analysis [2], the net present value (NPV_1) of this project is negative, i.e., -$878,629.09.

Option to Expand
Our hypothetical company is considering expanding the network to provide an integrated network (GPRS + WLAN) in downtown Manhattan any time within next three years. We calculate the value of this expansion option using the following parameters: present value of future cash flows $1,231,190.25, present value of investment cost $2,109,819.34, volatility 31.225%, time to expiration 3 years, and risk-free interest rate of 2.62%.

The value of the option to expand by integrating GPRS and Wi-Fi, is $90,067.47 only, using equation (1). The combined value of NPV_1 and value of the option to expand (NPV_2) is still negative, i.e., -$788,561.62. *We see that it is not viable to integrate the network when only revenue from existing subscriber base is considered. If the goal is to retain the existing subscriber base then the investment decision needs to be re-considered.*

Scenario B: Revenue Generate from Integrated Network and Wi-Fi Network.

For our calculation now we use the present value S_{02} of future cash flows, which equals to $2,477,486.36.

Traditional Approach (No Option)
From a traditional Discount Cash Flow (DCF) analysis point of view, the net present value (NPV_1) of the project is positive, i.e., $367,667.03.

Option to Expand
The option parameters remain unchanged, except for the value of S_{02}. The value of the option to expand is $779,567.66, which makes the project even more valuable, as NPV_2 is $1,147,234.69. *We see that when the operator considers revenue from outside subscriber base then the expansion by integrating the 2.5G network with Wi-Fi network seems viable and profitable.* In Section 5, we study the effect of key parameters in decision making process considering Scenario B.

5 EFFECT OF KEY PARAMETERS IN DECISION TO EXPAND

In this section we want to study the effect of key parameters in the decision to expand in Scenario B.

Effect of Investment cost on Option Value

Figure 1 shows the effect of investment cost to the net present value. The investment cost K is varied from $1,000,000 to $3,000,000. We keep the rest of the parameters unchanged i.e., present value of future cash flows from integrated and Wi-Fi network S_{02} =$2,477,486.36, volatility σ=31.225%, risk-free interest r_f =2.62%, and maturity T =3years.

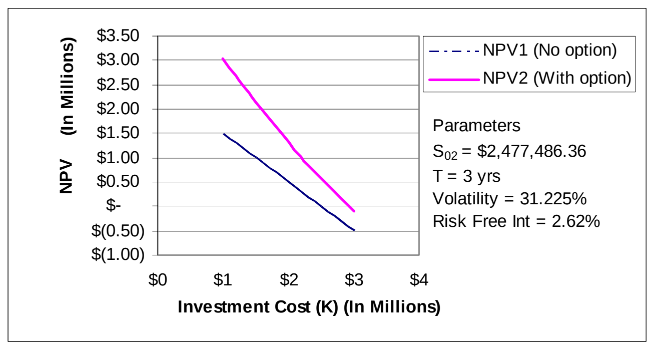

Figure 1: Effect of Investment cost to Net Present Value

From Figure 1, we observe that both NPV_1 (no option) and NPV_2 (with option to expand) decrease, with increases in the investment cost. The value of the option to expand is the difference between NPV_2 and NPV_1. As the investment cost, i.e., the strike price, increases the value of the option decreases, as expected (call option). For lower values of investment cost, the option is in the money and therefore it should be exercised. We find that the exercise of the option is not viable for an investment cost threshold limit of $2.924m (price of the option is zero for that strike)

Effect of Volatility on Option Value

Figure 2 shows the volatility with respect to the net present value of the project with and without option to expand. The rest of the parameters are kept unchanged. The volatility is varied from 10% to 100% (annual).

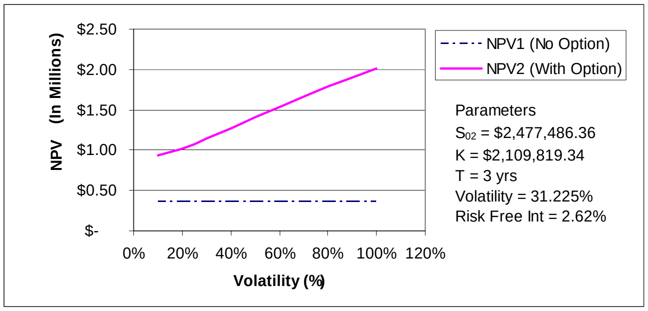

Figure 2: Effect of Volatility to Option Value

From Figure 2, we observe the NPV_2 (with option to expand) increases linearly with increases in volatility, while NPV_1 remains constant (no implicit impact of risk in the traditional valuation). Therefore, the value of the option (NPV_2-NPV_1) increases linearly with respect to volatility. It can be observed that, the more volatile the industry the more valuable the option to expand is, and also the volatility at the lower end does not have an impact.

Effect of Cash Flows to Option Value

In Figure 3, we study the effect of Wi-Fi subscriber to the valuation of the project. The present value S_{02} of future cash flows is changed; we keep the other option parameters unchanged.

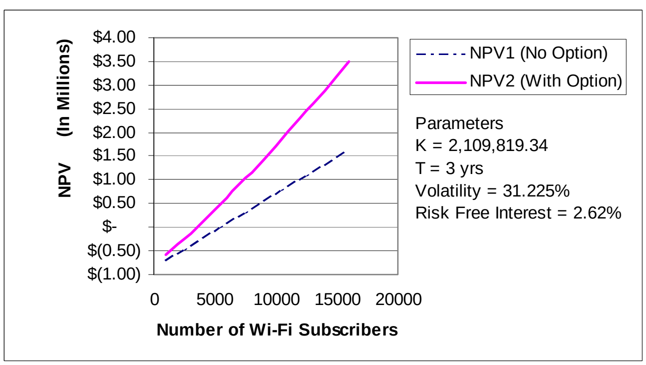

Figure 3: Effect of Number of Subscribers to Net Present Value

From Figure 3, we see that both NPV_1 and NPV_2 increase with the number of Wi-Fi subscribers. The value of the option also increases, as it is expected (call option). We see that when the Wi-Fi subscriber base hits 4,000, the NPV_1 combined with the value of the option becomes positive. For Wi-Fi subscribers below 4000, NPV_1 and NPV_2 are negative thus; as the investment cost is high and the revenue stream weak, the project does not look promising.

6 CONCLUSION

From the above analysis we see that integration of GPRS with WLAN is not a profitable solution, when operators consider revenue from integrated network subscribers only. The option to expand is more valuable in the case when the operator is able to attract new subscribers to its Wi-Fi network on top of its subscribers of the integrated network. Our analysis suggests that besides the subscriber base, both the investment cost and the business risk play an important role in the valuation. The question remains though, if the investment is profitable, in the case where we only hold on to the existing mobile subscriber base. We assume that licenses for 3G technology with be available soon. In that case, the investment decision needs to be re-analyzed incorporating the license cost.

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