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Pricing Telecom Infrastructure in a Monopolistic Market: A Novel NPV-based Approach

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Abstract- *Telecom Infrastructure (TI) services have recently become popular due to the unbundling of legacy telecom business into smaller service segments across the value chain. TI service providers (TISPs) develop their proprietary basic infrastructure (such as ducts for laying fibre optic cables and/or dark fibres) and deliver that infrastructure on demand in such a way that customers neither incur the high fixed costs of building the required infrastructure on their own, nor commit to long-term fixed-price outsourcing contracts. However, given the high opportunity cost involved in this kind of projects, TISPs often find it difficult to mark the correct price for their offerings. We argue that the century-old cost-plus pricing method is especially inadequate for TI services, because these services have uncertain demand, high development costs, and a long life cycle. This is truer for a TISP operating in a monopolistic environment where it has to provide regulated services- say in an upcoming special economic zone or a satellite township with no such infrastructure in place. In this type of green-field projects, the initial growth pattern ought to be sporadic- there will be a few hubs (or concentrations) against some moderate-to-low demands distributed randomly. Further, the hubs will not be all equally spaced. So it is very difficult to predict and estimate the overall demand pattern in such a scenario. Thus, only an appropriate pricing methodology, which explicitly takes into account the inherent uncertainty in the pricing decision by modeling contingent factors, such as uncertain rate of adoption or demand elasticity, can account for opportunity as well as risk. The proposed methodology optimizes the expected "net present value (NPV)," subject to financial performance constraints, and thus improves on both the cost-based and value-based approaches found in the literature.*

I. Introduction

From 1970's to now, data communication has evolved from 56 Kbps (ARPANET) to 1 Gbps (Modern optical communication), a gain of more than a factor of 100 per decade. At the same time, error rate went from 10^{-5} per bit to almost zero in fibre optics [1]-[3]. There is a recent trend for the development of Fibre-to-the-Home (FTTH) optical networks [2] in order to take advantage of tremendous bandwidth of fibre optic cables. Availability of optical amplifiers has opened up a new avenue for multiplexing many wavelengths in the same fibre. This multiplexing of wavelengths is known as wavelength-division-multiplexing (WDM) [3]. Since bandwidth of a single fibre is about 2500 GHz, there is a great potential for multiplexing many channels together over a single fibre strand. However, a necessary condition is that the fibres are well protected within appropriate ducts which, in turn, are well shielded within GI pipes or concrete tubes. These infrastructures are now managed by third-parties (not telecom business houses) and offered to multiple telecom and/or network players according to their requirements.

Telecom Infrastructure (TI) services deliver telecom infrastructure on demand (as and when needed) in such a way that customers neither incur the high fixed costs of building the required infrastructure on their own, nor commit to long-term fixed-price outsourcing contracts. Instead, they receive the basic infrastructure they need and pay only for what they use. They can lease it (say towers to house antennas or ducts for laying fibre optic cables [1]) for a long time and ramp it up internally (say, by adding new antennas or new fibre strands as per the demand) either without incurring any extra leasing cost or at the cost of a nominal additional lease price (i.e., economy of scale). In fact, TI services industry represents a marked departure from the current ways of doing legacy telecom business. On one hand, they feature attributes that appeal to customers: short lead times in service provisioning, high reliability and survivability (a duct has an average lifetime of 20 years; a fibre has a very low error rate ~ 10^{-9} [1]-[3]), customized service level agreements, a reduced learning curve in the adoption of a new service (say voice-over-IP (VoIP)), and easy access to new technology (such as (WDM) [3]). On the other hand, TI services have direct financial benefits for the customer. *First*, TI services reduce the risk faced by the corporate (high-volume) customer because the costs to the customer are proportional to the portion of TI hired by him and the time interval for which that is hired (say, a year). These two are usually correlated with the number of transactions anticipated by the customer to be performed during the same interval, and therefore with the revenue stream of the customer. *Second*, financial advantage of TI services comes from economies of scale. TI services are designed to run on a shared infrastructure (e.g., duct), in which fibre-space can be shared among multiple customers (e.g., 24 pairs can be drawn through one duct and each pair can be allotted to one customer). As the number of retail (low-end) customers grows, the average duct utilization grows because of the spatial multiplexing of customer demand. As a consequence, duct costs are sub-linear in the total volume of bandwidth (BW) carried by the duct.

II. Pricing Challenges

Pricing is a crucial business decision in the life of any product/service. Services offered by a TI service provider (TISP) is no exception to that. A minor adjustment in price can dramatically affect the profitability of the product/service, its diffusion in the market, and its ultimate success. Since TI services require significant *ex ante* development and start-up costs in the face of uncertain demand, compared to the existing pricing practices for IT products and IT outsourcing services, this is the worst of both worlds as both the initial investment and demand uncertainty are high. In short, TI services pose several novel challenges (discussed next) for a TISP in determining an optimal tariff plan.

Contracts for on demand TI services usually have a minimum duration of one year, but this term could be as long as thirty years in future. This is in stark contrast with the currently typical terms of five to seven years for telecom outsourcing contracts. The core of the realized revenue is variable; i.e., it is proportional to customer demand. With a small customer base consisting of few customers (as could be the condition in a new township), a TISP faces the risk associated with fluctuations in demand. Durations of TI service contracts are already longer than the life cycles of related hardware and software products. Together with high switch-over costs from one TISP to another, the long contract duration deters customers to switch to the competitive technology. As a result, the life cycle of TI service offerings will be long and remotely correlated to technological cycles. Within the cost structure of TI service offerings, initial development costs for instrumentation, provisioning, and monitoring of new services, are much larger than the variable costs. All the afore-mentioned challenges become more compounded when the TISP is given their monopolistic "right of way" in a pseudo-regulated environment. Limiting our discussion to a TISP that provides only fibre optic platform, we shall try to answer the following questions.

Should a duct include guarantees on pits and/or fibres? Should the service offer duct and fibre separately, or should these two types of offerings be bundled as a single service? Notice that even a homogenous product can be differentiated by posting prices that depend on volume (say, length of duct and/or number of fibres). This is a special form of bundling, in which multiple units of the same service-unit (here fibre) are bundled together. Therefore, pricing is strongly related to the choice of a service line. However, assigning prices to each item in the service line is perhaps the most important task in the pricing process.

III. OFTI Sector Assumptions

In the underground duct-based optical fibre telecom infrastructure (OFTI) sector, we find two types of offerings:

- Ducts only- where a fixed-price contract is dominant. OFTI provider has either no or very little control over the fibres (and so volume plus content therein) drawn through the duct. It can only give the required permissions.
- Fibres in ducts- fibre pricing has strong similarities with instances of pricing in the retail industry. Fibre is sold on a per-unit (strand/pair) basis, but this simple unit pricing is supplemented by a variety of price schedule modifications, such as quantity discounts, bundling, and market skimming (gradual price reduction) and dealing (temporary price cutting).

Here, we address the problem of pricing a duct (shared infrastructure) with on demand attributes. We also focus on how to price the shared infrastructure when multiple units of fibres are delivered to multiple customers by the shared infrastructure. We leave the attributes (say, final applications running at the final user sites) of specific utility of each fibre in the background; that is, we take on the problem of pricing with a given set of attributes (such as BW, quality and life) of the fibres only. Whereas the attributes are important and affect the pricing decision, their impact is indirect and is captured in the price elasticity.

We observe that nonlinear pricing approaches (also known as second-degree price discrimination), such as bundling and quantity discounts, are not allowed when service resale is permitted- a very real possibility in the case of TI services. Second, there is circumstantial evidence that the demand level of an individual customer is not sensitive to price. For example, the actual traffic through a duct is independent of how much the duct owner is paying to the duct provider. Similarly, the load on a fibre is generated by the end-users of the company who took the connectivity, and is insensitive to the price paid by the company to the TISP. Given that demand is mostly exogenous, the impact of quantity discounts on the pricing strategy is likely to be less important than the selection of the unit price. Moreover, it should be noted that one of the most distinctive attributes of on-demand services is the high level of contractual standardization: prices are publicly available to customers, thus ruling out first- and third-degree price discrimination that posits different prices for different customers.

IV. NPV-based Model

The goal of the proposed model for a TISP is to incorporate the essential features of rational pricing and, at the same time, quantify the uncertainty associated with the market assessment of the demand and incorporate it in the decision process. Although the concept of a demand curve is an elementary and powerful one, it cannot be used for a TISP. The main obstacle to its adoption is the difficulty of estimating the demand curve, or equivalently, the price elasticity of demand. The problem is exacerbated in the area of TI services. The two major methods for demand estimation from transactional data, one based on time series and the other based on cross-sectional data, find little application here for a TISP, which is involved in a green-field project. Long term historical data on demand are not available. Considering only the expected demand curve would underestimate the risk associated with the investment and could lead to undesirable decisions.

The principle followed in the pricing model is that the TISP would get at the minimum a fixed rat of return irrespective of actual usage. The proposed model envisages a two-part tariff to guarantee a minimum rate of return on investment independent of usage. The usage-linked tariff is the third component in the pricing. The two-parts are essentially to cover variable charges and fixed expenses. Variable charges include employee cost, electricity charges and other overheads. Fixed charges include depreciation, debt service and the required return on equity. The levelized tariff is arrived at using projections for fifteen years (an example is shown in Fig 1).

We can use the above model to arrive at the following output parameters that a TISP is primarily concerned with a working Tariff Structure (with multiple options). Next we consider sample results based on a TISP specific data that decide upon the input values.

V. Sample Results

The following sample data for a TISP operating in an upcoming township in a developing country have been assumed while calculating the absolute vales.

- Total area of the township is about 40 square Km and the length to be covered is 800 duct-Km
- Cost for laying 100 duct-Km is about USD 0.75 million
- Financial amortization is considered over 8 years with two years of moratorium period, and the life of duct is taken as 15 years
- 13% of revenue is provided towards RoW (right of way) and Management charges
- One duct can carry at most 48 pairs (i.e., 96 strands) of fibre
- Debt-equity ratio of 2:1
- Borrowing cost 13%
- Return on equity 40%

First, we estimate the variable and fixed charges for fifteen years. Depreciation is estimated on the capital cost of duct. The land cost is considered on notional basis (since in our example the TISP at present has got the RoW free of cost). However, it is expected that the local authority might levy a royalty on RoW. The debt service is allowed on the notional land cost.

So our proposition is that, based on NPV calculation [4], there should be three price components, namely

(1) One time charge (per duct-Km)
(2) Annual maintenance/recurring charge (per duct-Km)
(3) Annual usage fee (per sq. ft. per fibre lit)

The one time cost for duct only should come bundled with: (a) the free license for drawing upto 'n' pairs (i.e., '2*n' strands) of fibres through the duct, and (b) two free pits/terminations (one entry and one exit). Either drawing any extra pair of fibre through the duct or adding more fibres to the duct and building any extra pit (for distribution/maintenance) will incur extra one-time plus extra recurring charge (as applicable for fibre-pair per duct-Km) payable to the TISP. This will certainly force the consumers to restrict themselves within 'n' fibre pairs and 2 pits as long as possible. So we need to carefully find the optimum value of 'n' such that it neither hinders the growth nor harms the life of the duct (taking out 12 pairs and then putting 24 pairs will cause some wear/tear to the duct). Currently possible values for 'n' are 12, 24, 48 (more than 48 are probably not feasible through 40 mm duct right now). Let us consider 24 to be the optimum number given the current growth pattern, i.e, n=24.

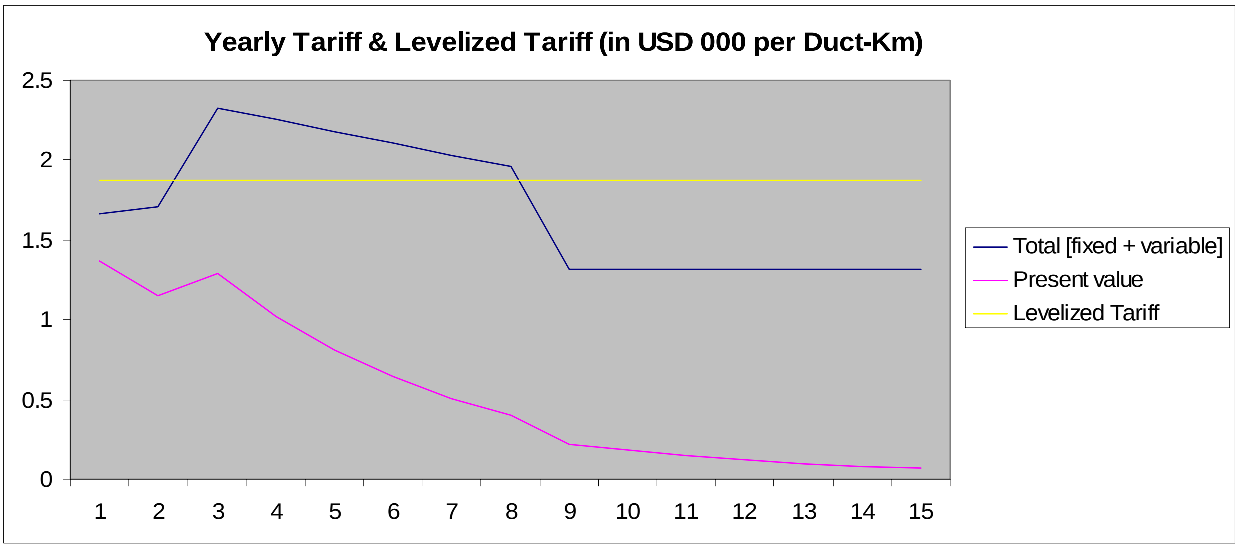

Fig1. Tariff per Duct-Km.

To find the annual usage fee, we notionally relate bandwidth (BW) to plot area in the following way. We assume that the BW usage will be minimum in the residential areas where each household of size 2,000 sq.ft. will consume about 1 Mbps BW in the present condition (this is an indicative figure only to show the calculations). Currently, one pair of fibre is capable of carrying at least 1 STM i.e., 155 Mbps [1]-[3]. So, in terms of sq. ft., one fibre pair can cater to 155*2000 =310,000 (or, roughly 300,000) sq. ft. Therefore, annual usage fee (i.e., connectivity charge) for one fibre pair should apply to 300,000 sq. ft. only; if this license fee be USD 300,000 then this translates into USD 1/sq. ft. as the granular usage fee. This microscopic view is necessary because it is always advisable that a TISP attempts to price its offerings in such a way that it becomes attractive to both the high (wholesale consumers of ducts wherein they will put their fibre) and low (retail consumers who will be interested in one pair of fibre-in-the-duct only) segments of customers. A customer of the TISP should pay the usage fee (for lighting the dark fibre pairs through the duct) in terms of sq. ft. of the plot it is serving to. This will put the usage fee in direct proportion to the business growth of the customer which will not object much because it does not have to shelve out any anticipatory cost. As the high-end consumer's business grows, license fee increases too. After the capacity of the existing fibre pairs exhaust, demand for more fibre-pair and/or pits are expected to grow. So the TISP can catch them at this point and charge their demands at some premium rate in order to virtually share their profit in a secondary manner.

TABLE FOR ONE-TIME CHARGES (PLOT WISE)

Plot Type	Cost of Land per 1000 sq.ft. (USD 000)	One-time charge per Duct-Km (USD 000)	One-time charge for every additional pit (USD 000)	One-time charge for a single fibre-pair in duct (USD 000)
A	2.5	4.44	1.28	0.27763
B	5.0	8.88	1.82	0.55526
*C	7.5	13.33	2.35	0.83289
D	10.0	17.77	2.88	1.11052
E	12.5	22.21	3.42	1.38815
F	15.0	26.65	3.95	1.66578
G	17.5	31.09	4.48	1.94341
H	20.0	35.54	5.01	2.22104
I	22.5	39.98	5.55	2.49867
J	25.0	44.42	6.08	2.77630

** used in the two alternatives as the sample*

Based on the above data and certain other relevant assumptions, we compute the tariff plan. We show next two alternatives for tariff planning with the assumption that the cost of land in the plot, where the duct lands to, is USD 7,500 per 1000 sq. ft. For instance, in the alternatives, the one-time upfront charge for 1 Duct-Km comes to about USD 13,300 and the charge for every additional pit comes to about USD 2,500. Naturally, these one-time prices will vary depending upon the type of plot (as shown in the Table above). Take another instance; say in Plot type G (see Table) the cost of land is a bit premium at USD 17.5 per sq.ft. Then, the one-time upfront charge for 1 Duct-Km comes to about USD 31,000 and the charge for every additional pit comes to about USD 4,500.

The recurring annual maintenance charges are estimated on levelized basis to smoothen the expenses to the user. The levelized tariff (figure 1) at a cost of capital of 22% per duct-Km comes to around $1880 (rounded off to $ 2,000 in tables). Similarly, the levelized tariff per fibre pair is estimated around $532 (rounded off to $550 in tables).

In **Alternative I**, in order to discourage clients from taking additional 12 fibre-pairs, the one time charge for additional 12 fibre-pairs is pegged at 80% of 24 fibre-pairs' one-time charge. It is assumed that the TISP will draw 48 pairs of fibre in duct when it will retail out fibre-pairs to players like cable operators.

In **Alternative II**, one time charge, as estimated in Alternative I, is amortized over (10-∂) year period in annual recurring charges, where ∂ indicates the number of years from the initial lease to the time when the additional fibre-pairs are demanded. For example, if somebody takes it in the beginning itself, ∂ = 10. It is felt that imposing one-time charge for additional fibre-pairs may act as a deterrent.

In both the alternatives, maintenance charges of pit are estimated at roughly 5% of one-time charge.

Alternative -I

	Offering Type	*One-time charge (in USD)*	*Annual maintenance charge (in USD.)*	*Annual usage fee (in USD)*
1(a)	One Duct-Km (40 mm) for 10 years <say, for plot type C i.e., USD 7,500 per 1000 sq. ft.>	13,300 (includes (i) permission to draw maximum 24 pairs of fibre, (ii) one entry pit and (iii) one exit pit)	2,000	1000# *[per 1000 sq. ft. per fibre pair lit]* (includes permission to serve 1000 sq. ft. with one lit fibre pair)
(b)	Permission for drawing additional 12 fibre-pairs per duct-Km during duct purchase	6,840**	1,000	1000
(c)	Permission for drawing additional 24 fibre-pairs per duct-Km during duct purchase	8,550*	1,880	1000
(d)	Permission for every additional Pit/Termination (One unit)	2,350	120***	
2	One Fibre-pair per Duct-Km****	1,000 (includes duct and pits)	550	1000
3	Entry pit	NIL	120***	

Note:

* Excludes cost of duct (USD 4000) and capex of an additional pit (USD 750).

** In order to discourage clients from taking additional 12 fibre-pairs, the one time charge is pegged at 80% of 24 fibre-pairs one-time charge.

*** Maintenance charges are estimated at roughly 5% of one-time charge of additional pit.

***** It is assumed that the TISP will draw 48 pairs of fibre in duct when it will retail out fibre-pairs to players like cable operators

\# One household will need 2 Mbps from one fibre pair which when lit up may provide up to 155 Mbps.

Alternative -II

	Offering Type	***One-time charge (in USD)***	***Annual maintenance charge (in USD)***	***Annual usage fee (in USD)***
1(a)	One Duct-Km (40 mm) for 10 years <say, for plot type C i.e., USD 7,500 per 1000 sq. ft.>	13,300 (includes (i) permission to draw 24 pairs of fibre, (ii) one entry pit and (iii) one exit pit)	2,000	1000# *[per 1000 sq. ft. per fibre pair lit]* (includes permission to serve one 1000 sq. ft. with one lit fibre pair)
(b)	Additional 12 fibre-pairs per duct-Km, ∂ years after the initial duct purchase	NIL	(1,000+ (6,840/ (10-∂))*	1000
(c)	Additional 24 fibre-pairs per duct-Km , ∂ years after the initial duct purchase	NIL	(1,880+ (8,550/ (10-∂))*	1000
(d)	Every additional Pit/Termination (One unit)	2,350	120	
2	One Fibre-pair per Duct-Km	1,000 (includes duct and pits)	550	1000
3	Entry pit	NIL	120	

Note:

* One time charge, as estimated in Alternative I, is amortized over (10-∂) year period in annual recurring charges. It is felt that imposing one-time charge for additional fibre-pairs may act as a deterrent.

VII. Conclusions

In a world that is changing so thoroughly because of the impact of telecom services, the pricing of TI that help provide these services plays an important role. Of course, a price must recover cost and generate profit; but that is only one of the many important reasons for pricing. In TI business, once an infrastructure (say duct) is built, the construction cost is largely a fixed cost, and the variable operating cost can be extremely small. But the opportunity cost may be high. At the same time, given a set of committed customers, the infrastructure can sell at a price that reflects its value to the customers rather than its production cost per se.

However, in a protected monopoly, prices tend to be usually based upon potential, rather than actual. Moreover, if it is for a TISP catering to an upcoming township, it is partially notional too as past data is not available. So a TISP should aim to price its TI attractively so as to stimulate demand, build customer base and catalyze network externality effects. Otherwise, it will always suffer from the problem of profit maximization. Since it is the only supplier of TI in this case, it is almost free to choose price (under the monopolistic condition), depending on the identity of the customer (in terms of the type of plot the customer is capable of serving) and also on the amount purchased by the customer. The TISP can offer quantity discounts sometimes. Since market segmentation (classes of customers) is not much clear at this point of time, the TISP should spell out a set of offers and then each customer can choose the offer he likes best. If prices are nonlinear, being defined for different quantities, it automatically takes care of "*quantity discount*" and "*bundling*" easily.

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