Application Customization, Profit Zones, and the Design of a Delivery Network for Mobile Commerce Services*

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Abstract

Wireless industry has enjoyed an impressive growth over the past few years. However, recent developments in the marketplace suggest that future growth depends on offering customized mobile commerce-related data services targeted at commercial customers. A theoretical framework that we introduce in this paper shows that such key parameters as the client network size, performance of the delivery network, expected market demand, and degree of required customization lead to the formation of *profit zones* within the marketplace. Different profit zones call for different designs of the delivery network and its corresponding business model. Profits generated within each zone vary because of the tradeoffs between potential revenues from services and costs of customization. Our analysis also shows that under certain conditions the dominant industry form might be evolving towards a vertically integrated service provider.

1 Introduction

Wireless communications business has enjoyed an impressive growth over the past few years. Until recently, the subscriber base in the US has been growing at the average annual rate between 25% and 30%. However, in 2001 the rate dipped to 18% and it is expected to fall even further. The consensus among CEOs and analysts is that no longer the industry, which earned $85 billion in 2001, can only rely on new subscriptions to basic voice services for its growth. The focus is now on the future growth in mobile commerce-related data and Internet services (Elstrom, Green, Crockett et al. April 1, 2002).

However, so far mobile commerce services, or m-commerce services, have had a lukewarm reception by consumers. A survey found that in June 2000 32 percent of consumers using mobile phones were interested in mobile commerce services, but only 1 percent was interested in January 2002 (Sutherland March 25, 2002). Educated by this experience, this time, mobile operators are planning to follow what seems to be a better strategy: in addition to offering basic data services to consumers, they will also target commercial customers (Elstrom, Green, Crockett et al. April 1, 2002). Verticals that are being considered are banking, healthcare, tourism, and retail, among many others.

One of the difficulties in providing m-commerce services to commercial clients is that mobile applications might require tailoring to the specific needs of an industry and to the needs of each individual client. Under such circumstances, a basic question is: Are wireless operators well positioned to deliver mobile services that require customization and intimate knowledge of various industries, such as, for example, healthcare?

In this paper, we develop an analytical framework that expresses this managerial quandary in clear terms. We show that such key parameters as the client network size, performance of the delivery network, cost of the data network, expected market demand, and degree of required customization lead to the formation of *profit zones* (Slywotzky and Morrison 1997) within the marketplace. Different profit zones call for different designs of the delivery network and its corresponding business model. Our analysis builds on the literature in the fields of economics of buyer-seller networks and economics of traditional telecommunications (see, for example, work by Economides and associates, Minehart and Kranton 2001, and Laffont and Tirole 2000). We extend and modify the theory found in that literature to the realm of wireless data applications.

This paper might be of interest to the many participants in the wireless marketplace, such as, mobile operators, equipment vendors, and policy makers.

In the following section we give a brief account of a vertical that is a strong potential market for m-commerce services. Then we present our model, its analysis, and explain the emergence and importance of profit zones. The last section concludes and outlines our future work.

2 An Example of a Market for M-Commerce Services

To better understand the motivation for our analysis, let us examine the healthcare industry, which is one of the verticals that have great demand potential. According to some estimates, the healthcare related e-commerce will be worth $205 billion by 2003 (Parente 2000). If indeed most of the applications that can be offered through fixed networks can be adapted for wireless devices (Frenkiel, Badrinath, Borras et al. 2000), then mobile operators may have a sizable role to play in the healthcare e-commerce.

The demand for medical m-commerce might be spurred by healthcare's need to act on its numerous financial, quality and delivery problems (Institute of Medicine 2001), and by the recent legislation, called Health Insurance Portability and Accountability Act (HIPAA). Major provisions of HIPAA are standardization and increased security of medical records (Health Forum 2001, Wilmer 17 September 1999). Some believe that an infusion of new technologies into healthcare will cure the industry (Christensen, Bohmer and Kenagy 2000).

There are various mobile medical applications being developed. One of them is the mobile telemetry that allows monitoring and transmission of health parameters of a patient over mobile networks. This technology targets cost and quality of patient care (Scanlon 2000 and Newsweek June 25, 2001). For example, a patient with ischemic cardiomyopathy might be spending 20 to 30 days per year in a hospital and has about 50 home-care nursing visits, which could cost up to $21,000 (Newsweek June 25, 2001). Since remote monitoring and tracking makes it unnecessary for the person to be admitted to the hospital (Freiherr 1998), a hospital can potentially save as much as $21,000 per heart patient by adopting the mobile telemetry technology. Additionally, a wireless monitoring device can give early warnings of a heart attack (Raths 1999).

However, as Christensen, Bohmer, et al. (2000) note, the medical device market is very difficult for novel technologies to penetrate. A typical mobile operator might not have the medical knowledge, the reputation, and the *connections* (Kranton and Minehart 2001) within the healthcare industry to be successful in the new marketplace. Therefore, a mobile operator might choose to work with other companies that have already invested in learning the healthcare market and that have working relationships with a wide range of health organizations. This strategy might be especially attractive to the mobile operator in the early stages of the market development.

3 The Mobile Services Delivery Model

The above-mentioned two alternatives that a mobile operator faces are schematically shown in Figure 1. In the rest of the paper, we will refer to the three-layered delivery network as D1 and to the two-layered network as D2.

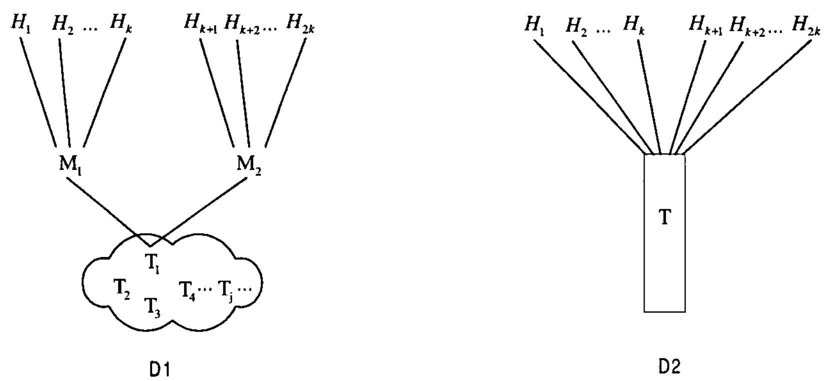

Figure 1: Two Service Delivery Networks

We assume that there are *2k* commercial clients, each denoted by H. In D1, they are serviced by two Application Service Providers (ASPs). We use M to denote an ASP. We assume that each provider offers a different service, and therefore each of them has its own market segment. In the case of healthcare, we could think of M_1 offering medical telemetry, and M_2 offering mobile prescription service. Each client H needs some customization of the service, which requires the knowledge of clients' needs on the part of the ASP. We denote such connections between ASPs and customers by drawing *links* (Kranton and Minehart 2001).

It has been noted that cellular telephone companies offer relatively homogeneous products (Parker and Roller 1997). This has fueled the expectation among the mobile operators that wireless data transmission will be a commodity. We capture this by providing an exogenously given set of identical mobile operators T, all offering identical transmission service. Mobile operator T has two *primary customers* (Kranton and Minehart 2001) that are linked to T. These two ASPs try to transmit using the network of mobile operator T. That attempt is successful with probability q_T.

If service is not available from mobile operator T, virtual operator switches to another mobile operator in the cloud. Then, the probability of the transmission event, q_t, equals the sum of probabilities of transmission events from available mobile operators, though, because it is a probability measure, it cannot exceed one, that is, $q_t = \min\left(1, \sum_T q_T\right)$. A similar business model has been successfully tested in Europe by Mobile Virtual Network Operators, which are companies that offer mobile services, but do not own any radio frequency or the physical network, and therefore buy data transmission from mobile operators (Matthews and Sweet 2000).

If a mobile operator chooses to provide the end service, the industry structure is no longer the three-tier model of D1, but rather the two-tier structure of D2. In such a case, the mobile operator delivers the entire value chain of the mobile application service: data transmission and the value added service. The mobile operator also has to do the customization of the service, thus the links between clients and the mobile operator.

3.1 Application Performance

Tanenbaum writes: "Unfortunately, understanding network performance is more of an art than a science" (Tanenbaum 1996, p. 555). This comes as no surprise considering many factors that affect performance of telecommunications systems (Pandya 2000). Consequently, there are a number of measurement indices of performance. For this simple model we will adopt a definition of network performance offered by Pandya (2000): performance is " the probability that a system can perform a required function under stated conditions for a given time interval" (Pandya 2000, also Frenkiel, Badrinath, Borras et al. 2000 offer a similar definition). This definition allows a simple interpretation: the measure equals one, if the service is available any time, and equals zero, if the service is never available. Note that terms *performance* and *reliability* are often interchanged with respect to mobile networks (Pandya 2000).

Furthermore, many information technology products can be thought of as composed of components (Economides and Lehr 1994). Here they are: data transmission, which we denote with subscript *t*, and mobile application, which we denote with subscript *a*. Consistent with the view that performance of a system depends on the performance of its components (Odlyzko 2000), quality of application service, q_s, is

$$q_s = q_a q_t \tag{1}$$

Here q_t is the quality of data transmission and q_a, corresponds to the quality of the application.

Definition (1) assumes that performance of two components is independent. In general, this is a simplification, as various elements of a system can impact the perception of performance of other components. For example, "smart" applications may "hide" the low quality of data transmission (Noble 2000). Moreover, some cellular technologies, such as those based on Infostations, create islands of coverage that result in the perception of ubiquitous data transmission even in geographic areas that are not completely covered (Frenkiel, Badrinath, Borras et al. 2000).

We assume that the performance of the value-added service, q_a, stays the same regardless of the delivery network, D1 or D2. However, the probability of a successful transmission event, q_t, is different in D1 and D2. In the three-layered delivery network, D1, we assume that there is at least one network that can pick up the signal. In terms of probabilities this implies that the probability of transmission over the space of all mobile operators is unity, that is, $q_{t,D1} = 1$. Then probability that application service performs as intended, equation (1), becomes:

$$q_{s,D1} = q_a q_{t,D1} = q_a \tag{2}$$

In D2, all data transmission is provided by one mobile operator, which means that the quality of transmission, $q_{t,D2}$, is equal to the performance of the network of that mobile operator, q_T, that is, $q_{t,D2} = q_T$. Here we no longer have ubiquitous connectivity, as in D1. Then service quality (1) is

$$q_{s,D2} = q_a q_T \quad (3)$$

3.2 Demand for Mobile Service

Let us now review the demand function for mobile service. Assume that there is some *potential benefit* that a customer may gain from the service. We denote such benefit q_s^β. Here, q_s is the performance of the application service and $0 \leq \beta \leq 1$ is some parameter. This functional form is the traditional Cobb-Douglas production function that tells us that: (i) better application performance leads to greater benefit, and (ii) there is diminishing marginal gain from the performance improvement. The service is completely useless to the customer if it never performs as intended, i.e. $q_s = 0$; and the customer receives the maximum benefit when it always performs as intended, i.e. $q_s = 1$.

However, the *realized benefit* that the customer receives might be different from the *potential benefit.* For example, not all hospitals are equal in their efficiency of how they use available resources, such as, doctors, nurses, operating rooms, etc. (Litvak and Long 2000). A mobile service of given quality is just another resource and it is up to the hospital to take the full advantage of the technology. Consider this scenario: a hospital issues mobile telemetry devices to all its heart patients. The hospital records data transmitted by these devices, but fails to implement and enforce response procedures for the cases when a device transmits a heart attack alarm signal. The lack of the procedures results in some of the benefit associated with the device being lost.

We formalize this idea of efficiency by adding a multiple to the potential benefit equation. The realized benefit is

$$B = Hq_s^{\beta} \tag{4}$$

A client that is capable of capturing all the potential benefit of a mobile application will score a $H = 1$; the other end of the efficiency is $H = 0$. The efficiency of a typical client is somewhere between these extreme values.

A common method used by purchasing managers, including in the healthcare industry, to decide whether or not to adopt a new technology is the cost-benefit analysis (Folland, Goodman and Stano 1997). Accordingly, we assume that a customer wants mobile service if net benefit

$$NB = B - C \tag{5}$$

from the service to the customer is positive, that is $NB \geq 0$. Here C stands for cost of the service. We assume that cost is equal to the price of the application service, p_s. For simplicity, we assume that potential benefit is the same for all customers and we normalize the potential benefit by assuming that $\beta = 1$. We substitute the benefit production function (4) into the net benefit equation (5) to find that

$$NB = Hq_s - p_s \tag{6}$$

Imposing the condition of non-negativity implies that $Hq_a - p_a \geq 0$. From this equation we obtain a condition that describes a customer that chooses to buy the application service:

$$\frac{p_s}{q_s} \equiv \overline{H} \leq H \tag{7}$$

That is a customer with a given efficiency level, H, is not interested in the mobile data service if the price-performance index p_s / q_s is above some threshold value $\overline{H}$. Also, the ratio p_s / q_s tells us that firms might be willing to pay a premium for a high quality application.

Only clients with efficiency levels above the threshold $\bar{H}$, that is, $H \in [\bar{H},1]$, satisfy condition (7), and therefore subscribe to the application service. Assuming that efficiency values are distributed randomly, the proportion of buyers that subscribe to the wireless service is $1 - F(\bar{H})$. Adopting a common simplifying assumption that agent preferences for quality are distributed uniformly, $f(H) = 1$ (Economides and Lehr 1994), we find that

$$F(\bar{H}) = \int_0^{\bar{H}} 1 dH = \bar{H} \tag{8}$$

and $1 - F(\bar{H}) = 1 - \bar{H}$. Assuming that the mobile application that is available to clients is of the same quality and the same price, and that each client can buy an indivisible unit of service, the total number of units of application service bought by $2k$ organizations is

$$D = 2k\left(1 - \bar{H}\right) \tag{9}$$

Substituting threshold equation (7) for $\bar{H}$ in (9), we obtain

$$D = 2k\left(1 - \frac{p_s}{q_s}\right) \tag{10}$$

That is demand is a function of price and application performance. This expected demand curve captures the fact that mobile application service is a normal good: given some quality of service, more service is demanded as price falls[1].

3.3 Analysis of the three-layered delivery network

Because of our assumption that transmission services are homogeneous (in other words, a commodity), pricing for transmission services is uniform. We assume that mobile operators sell a unit of transmission for price p_t. Then, *expected profit* of each ASP, M, is

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[1] Indeed, $\frac{\partial D}{\partial p_s} = -\frac{k}{q_s} < 0$

$$\pi_M = q_s p_s \frac{D}{2} - q_s p_t \frac{D}{2} - kz \qquad (11)$$

Here the first term is the *expected revenue* from selling the value-added service at unit price, p_s; the second terms is the *expected payment* from the ASP to mobile operators for use of their radio network; the third term is the *cost of maintaining links* that is required for customization for each of the k clients of the ASP. Note that expected profit (11) is an additional profit to other profit that the company might be making from the regular voice services.

The expected profit of a mobile operator T is equal to the expected revenue from the sales of transmission services to the two ASPs, less the cost of providing those transmission services:

$$\pi_T = q_a q_T p_t D - c(q_T)$$

In general, providing transmission services requires expenditures on equipment and network maintenance and optimization. Optimization and deployment of more base stations to create redundancy, which result in lower unavailability (Varshney, Snow and Malloy 1999). However, there is decreasing marginal effectiveness of each dollar invested into a network – continual investment in quality will run into diminishing returns, and the curve that measures performance versus investment will flatten out. We model this situation with a constrained quadratic cost function

$$c(q_T) = \gamma q_T^2 \qquad \gamma \geq 0 \qquad q_T \in [0,1] \qquad (12)$$

Parameter γ is the cost of the infrastructure that guarantees perfect transmission ($q_t = 1$). For the purpose of this paper we assume that parameter γ is constant.

Substituting equation (10) for demand, D, equation (12) for cost of data network, $c(q_T)$, and (2) for service quality, q_s, the First Order Conditions (FOCs) of profit functions for virtual operator

M [2] and mobile operator T [3] suggest a set of sustainable prices. They are: T charges M the price of $p^*_{t,D1} = \frac{q_a}{2}$ and M charges the end user $p^*_{s,D1} = \frac{3}{4}q_a$. Note, that, as expected, the price of the service to end-users is greater than the cost of data transmission, $p_s > p_t$. The equilibrium level of data network performance that maximizes mobile operator's profit is

$$q^*_T = \frac{q_a^2 k}{8\gamma} \tag{13}$$

The boundary condition for the performance parameter, $q_T \leq 1$, implies that in this equilibrium analysis we limit the maximum network size to $\overline{k} = \frac{8\gamma}{q_a}$. For these prices, and the optimal network performance level, equilibrium profits are

$$\pi^*_M = \frac{q_a^2 k}{16} - kz \tag{14}$$

and for the mobile operator it is

$$\pi^*_T = \frac{1}{\gamma}\left(\frac{q_a^2 k}{8}\right)^2 \tag{15}$$

3.4 Analysis of the two-layered delivery system

Now the mobile operator T sells services to end-users. It is also now responsible for forming and maintaining links to end users, which were previously the domain of ASPs. Firm T makes profit

$$\pi_T = q_{s,D2} p_s D - c(q_T) - 2kz$$

[2] FOC: $\frac{\partial \pi_M}{\partial p_s} = k(p_t + q_a - 2p_s) = 0$

[3] FOC: $\frac{\partial \pi_T}{\partial q_T} = q_a p_t 2k\left(1 - \frac{q_a + p_t}{2q_a}\right) - 2\gamma q_T = 0$ and $\frac{\partial \pi_T}{\partial p_t} = \frac{k^2 p_t (2p_t^2 - 3p_t q_a + q_a^2)}{2\gamma} = 0$

Given quality of transmission q_T, the optimal pricing strategy for the integrated firm is [4]

$p^*_{s,D2} = \frac{q_a}{2} q_T$. Then, the equilibrium profit for the mobile operator, *T*, is

$$\pi^*_T = \frac{q_a^2 q_T^2 k}{2} - \gamma q_T^2 - 2kz \tag{16}$$

4 Profit Zones

In their well-publisized book, Slywotzky and Morrison (Slywotzky and Morrison 1997) write about *profit zones* which are the arenas "of a company's economic activity where high profit happens." They give examples of successful CEOs that were able to identify such profit zones and design their businesses to take advantage of the zones. The theory we develop in this paper explains the emergence of profit zones in the marketplace for mobile data services.

To show the emergence of profit zones, we introduce a two-dimensional Cartesian space with the horizontal axis defined by the network performance metric, q_T, and the vertical axis by the size of the client network, k. Pair (q_T, k) describes the strategic position of the firm within this plain. The position changes if (i) the firm adjusts its investment in network infrastructure, which leads to the change in the network performance, and (ii) the size of the customer network changes. The size of the customer network might be a strategic variable that a mobile operator controls directly, as in D2, or indirectly, as in D1 through the number of intermediaries that it works with.

Let consider a scenario in which a mobile operator offers mobile services through intermediaries, that is, it adopts the three-layered business model D1. Then equation (13) suggests an optimal

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[4] FOC: $\frac{\partial \pi_T}{\partial p_s} = k\left(2q_a q_T - 4p_s\right) = 0$

equilibrium path for a profit-maximizing mobile operator. The map for that equation is shown in Figure 2. It is reasonable to assume that network quality is improving over time, and the size of the client network grows. This suggests that strategically the firm will move in the Northeast direction along the path shown in Figure 2. Any deviation from the optimal path below the line results in the excessive spending on the network performance. Any deviation above the path leads to the quality of the network that is below the optimal performance level; in such a case, the operator may want to invest more into improving the network.

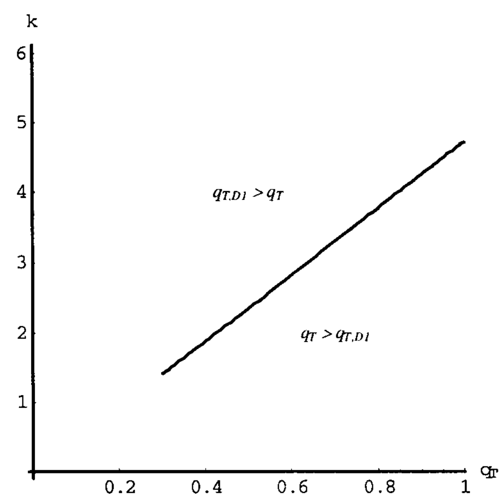

Figure 2: Half Planes Associated with Optimal Network Performance

As the operator moves along the path, it must remember that to be competitive, the mobile operator must offer service that results in some positive net benefit to the customer. Which business model, D1 or D2, gives the greatest net benefit? To answer this question, let us plot a locus described by the equality $NB_{D1} = NB_{D2}$. This equation defines a line, we denote it l_{NB}, that separates the kq-plane into two half planes. For client of some given efficiency H the equality means that

$$H q_a q_{t,D1} - p_{s,D1} = H q_a q_T - p_{s,D2}$$
$$q_{t,D1} = 1$$
$$p_{s,D1} = \frac{3}{4} q_a$$
$$p_{s,D2} = \frac{q_a}{2} q_T$$

This equation diagramed in Figure 3. We see that to the right of the line, prices and quality of the service that can be offered in system D2 result in the superior net benefit to the customer. Of course, this implies that business model D2 is competitively superior to D1 in the right half plane.

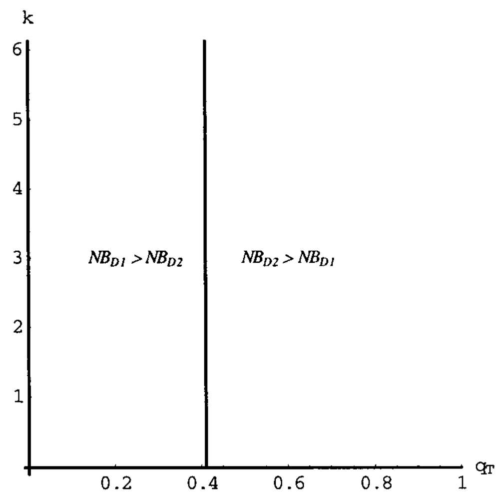

Figure 3: Half Planes Defined by l_{NB}

But even though clients might prefer a vertically integrated operator of D2 to deliver services, the mobile operator might still choose not to sell such services directly. Figure 4 illustrates this point. The line, we call it l_{D2}, corresponds to equation $\pi_{T,D2} = 0$. Substituting equation (16) for profit, we obtain that curve l_{D2} is defined by

$$\frac{q_a^2 q_T^2 k}{2} - \gamma q_T^2 - 2kz = 0$$

The profit of a mobile operator in D2 is positive for any combination of quality and client network size to the right of the curve. Only in this area the mobile operator might start contemplating offering mobile services directly to customers.

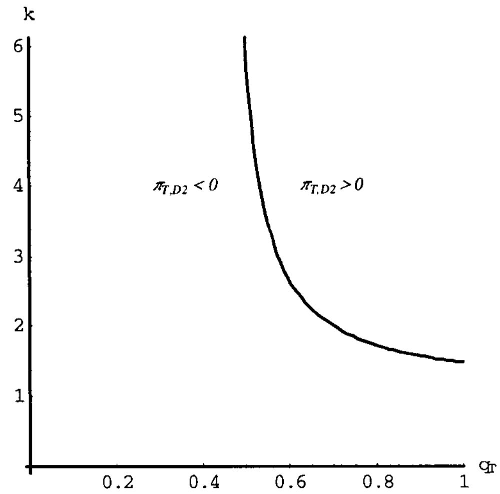

Figure 4: Regions associated with l_{D2}

However, as the graph of Figure 5 suggests, the three-layered business model D2 might not be the best option until the marketplace reaches the area to the right of curve l_π. The curve defines a frontier set by equality $\pi_{T,D2} = \pi_{T,D1}$. Using equations (15)and (16), the equality becomes

$$\frac{q_a^2 q_T^2 k}{2} - \gamma q_T^2 - 2kz = \frac{1}{\gamma}\left(\frac{q_a^2 k}{8}\right)^2$$

Combining Figures 2 to 5 we obtain the graph of Figure 6. The figure shows eight regions in the kq-plane that we call *profit zones*, following the terminology of Slywotzky and Morrison (1997). Each zone differs in terms of the mobile operator's profitability, customer's net benefit, and the performance level of the mobile operator's data network. Properties for the regions are summarized in Table 1.

From the table it is clear that regions in which the mobile operator might choose to switch to the business model of D2 are VII and VIII. Why? Because these are the only zones in which business model D2 is profitable ($\pi_{T,D2} > 0$), provides superior net benefit (Max *NB*), and delivers superior profit (Max π_T).

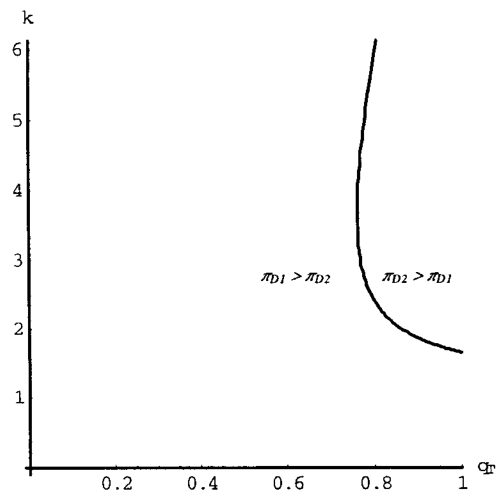

Figure 5: Regions Associated with l_π

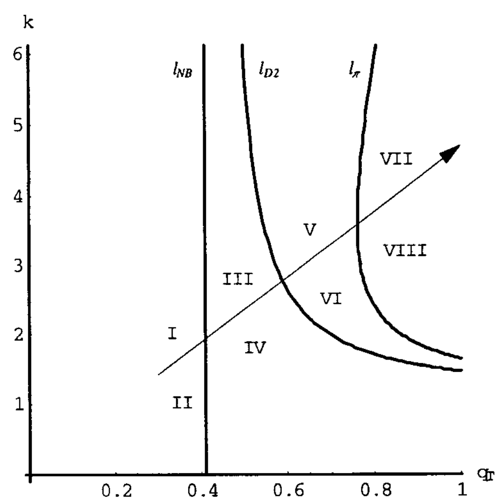

Figure 6: Profit Zones

Table 1: Summary of Properties for Various Regions

Region	Max π_T	Max NB	$\pi_T^{D2} > 0$
I	D1	D1	
II	D1	D1	
III	D1	D2	
IV	D1	D2	
V	D1	D2	√
VI	D1	D2	√
VII	D2	D2	√
VIII	D2	D2	√

Figure 7 shows the effect of lowering the level of required customization, z , of the mobile service. New profit zones are shown with dashed lines. As the reader can see, profit zones shift to the left. Of course, this implies that if the need for customization is not as great as before, then there is smaller need for intermediaries that bear the cost of the customization at the initial stages of the market development.

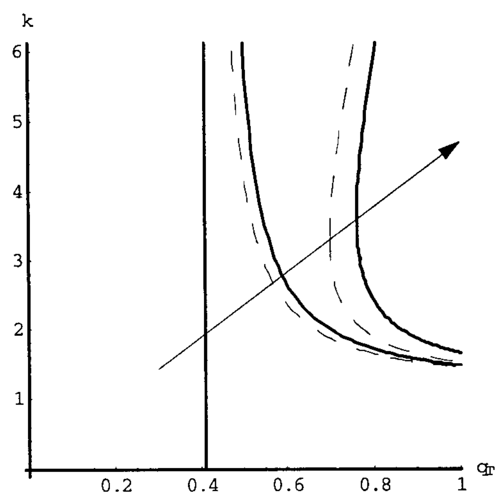

Figure 7: Expansion of Profit Zones in Response to Lesser Need for Customization

5 Conclusion

This paper built a theoretical formalism for the discussion of a topic of mobile commerce services. Clearly, no model can capture all the intricacies and complexity of the real world, and even best models are only metaphors of the reality. However, a good model can illuminate patterns that lie beneath the apparent chaos of the real world. This is what we aspired to achieve with this model.

Our analysis showed that such key parameters as the client network size, performance of the delivery network, expected market demand, and degree of required customization lead to the formation of profit zones within the marketplace. Different profit zones call for different designs of the delivery network and its corresponding business model. Profits generated within each network vary because of tradeoffs between potential revenues from services and costs of customization. Our analysis showed that under certain conditions the dominant industry form might be evolving towards a vertically integrated company. Interestingly, consolidation is a trend that is currently observed in the wireless industry (Elstrom, Green, Crockett et al. April 1, 2002).

Future models may consider issues such as price discrimination, subscription fees, roaming, and sophisticated sharing of costs (e.g., who pays for the mobile device?), etc. Also, regulation can be studied in greater detail in the spirit of work performed for the traditional telecommunications industry (see Laffont and Tirole 2000). Framework introduced in this paper can serve as a foundation for more complete computer models. Additionally, our current model may be extended to incorporate the notion of flexible adaptive architectures for a firm and emerging industry standards. We have started working in some of the directions outlined in this paragraph.

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