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Abstract

This paper compares the approaches taken by the managers of a small regional power grid utility cooperative and a small, privately held local loop telephone company who sought to make high-speed internet access available to their rural customers. Both the power cooperative and the telephone company set out to extend their product service mix, revenue streams, and profit margins by implementing new revenue-producing services more commonly offered only in high-density, metropolitan areas. The power company setup a small network of 8 wireless transmitters, each with a 5 to 7 mile radius service area. The telephone company implemented a cable-based xDSL connectivity solution within its existing telephone wire infrastructure. This study compares each set of manager's efforts at technological innovation and revenue generation in rural settings by overlaying them with the Technology Adoption and Technology Implementation theory of Bonnal et al. (2002) and Kumar et al. (2002). It offers a practical six phase technology innovation project management methodology for small business managers.

Keywords: Wireless, xDSL, rural, broadband internet, technology adoption, technology implementation, innovation

Introduction

In a change fueled partly by technological progress, and partly by legislative mandate to free up scarce wireless spectrum (USFA 1996), Digital TV (HDTV) will soon replace analog TV broadcasts (Ahrens 2002). Satellite reception of hundreds of crisp digital radio streams is also rapidly gaining popularity (Sirius, 2003). Rich *inbound* channels of digital information and entertainment are available to businesses and households regardless of their physical location.

In contrast, *outbound* channels are severely restricted. The majority of small businesses and households in rural areas still depend upon slow dial-up modems to connect to the outside world, and so are limited to two-way connection speeds much too low to support increasingly important business forms of communication like n-way videoconferencing, virtual document sharing, and collaborative audio-visual applications (Peden and Young 2001; Radley 2002; Kleinrock 2001). This one-sided bottleneck is known as the Last Mile Problem (Fowler 2000; Bell and Gemmell 1996; Pramataris, Zahariadis, and Zervos 2002).

This paper compares the efforts of two sets of innovative small business managers, the managers of a small power grid cooperative, and the managers of a privately held local loop telephone company, as they sought to serve their communities and generate revenue for themselves by solving the Last Mile Problem for their rural customers. The presentation is organized into the following sections. First, the telephone company and power company service areas are briefly described. Then a summary of available solutions to the Last Mile Problem is outlined. The next section describes the solution selected by the managers of each company within the framework of a practical six-step project adoption and project implementation methodology adapted from the theory of Bonnal et al. (2002) and Kumar et al. (2002). The remaining section presents a set of conclusions and practical information for small business information technology managers.

Small Business Service Areas

The inherent geographic isolation, low education and income profile, and population sparsity of rural areas makes them often seemingly unattractive for investment and so particularly vulnerable to the Last Mile Problem.

The managers of the telephone company investigated in this study are headquartered in rural Knott County, Kentucky. The company is a small business that provides analog telephone services to about 8,500 paying customers. In addition, the company for about 10 years has offered dial-up internet access services, currently to a customer base of 3,500, as well as analog television re-broadcast services to an audience estimated at 6,000. In essence, the company faces little outside competition. The company's rural service area is sparsely populated (50 people per square mile) and is statistically underserved for purposes of state and federal assistance (QuickFacts 2003). The average annual per capita income is around $11,000. The company implemented an Asymmetric Digital Subscriber Line (ADSL) solution at about $45 per month to address the Last Mile Problem within it rural service area. This technology fit well with the company’s existing telephone infrastructure.

The power company's managers are based out of Fleming County, Kentucky. Their company serves over 22,000 individual customers and businesses in 8 neighboring counties. The principal revenue of the company comes from the generation and distribution of electrical power. A newly-created subsidiary of the company was entrusted with the implementation and marketing of wireless internet services within the company's service area. Like the telephone company, the power company functions in a statistically underserved service area. It is located in a rural area with a population density of only 39 persons per square mile and $14,000 annual per capita income. National averages are respectively 80 persons per square mile and $22,000 (QuickFacts 2003). The company chose a wireless solution to the Last Mile Problem within its service area. Federal Communications Commission (FCC) Part 15 makes the Industrial, Scientific and Medical (ISM) wireless frequencies available to all on a license-exempt basis (FCC Code 47:15).

Overview of Possible Solutions to the Last Mile Problem

Currently there are several solutions available that can provide two-way high-speed internet and digital multimedia services. These include:

1. Copper based xDSL, or Digital Subscriber Lines, where the “x” stands for any of Symmetric, Asymmetric, and Very High Speed.
2. Hybrid Cable-TV and broadband internet access;
3. Two-way satellite internet access (StarBand, Pegasus Express, Teledesic and Tachyon);
4. ISM and xMDS (i.e. LMDS, Local Multipoint Distribution Service, and MMDS, Multi-channel Multipoint Distribution Service).

The most widely adopted access network technologies are xDSL over POTs (Plain-Old Telephone lines). This was the solution selected by the managers of the small telephone company in this study. The monthly cost to the customer is typically around double the price of a second, dedicated dial-up telephone line, for approximately 20 times the performance of a dial-up modem (Peden and Young 2001; Fowler 2000). Figure 1 below depicts a typical DSL connection scenario. The home is connected to the central office with a small xDSL modem box installed at the customer's facilities. The connection takes place over ordinary copper-based telephone pole wires. Before an xDSL solution can be offered to customers, significant improvements to the local telephone system infrastructure are often needed. These improvements are needed because xDSL is sensitive to interference from adjoining copper bundles (called cross-talk), and because the quality and performance of the signal transmitted rapidly degrades as the transmission distance increases (called fading and attenuation). The necessary improvements may include replacing some of the physical wires atop telephone poles, and providing repeaters at regular intervals to increase the maximum distance between the customer's premises and the telephone company's central office. In the end an xDSL subscriber must typically be within about 18,000 feet, or about 3.5 miles, of the nearest telephone company xDSL switch. As was the case with the rural telephone company in this study, this distance limitation means only about 80% of today's ordinary telephone subscribers are within the reach of xDSL services (Peden and Young 2001; Fowler 2000).

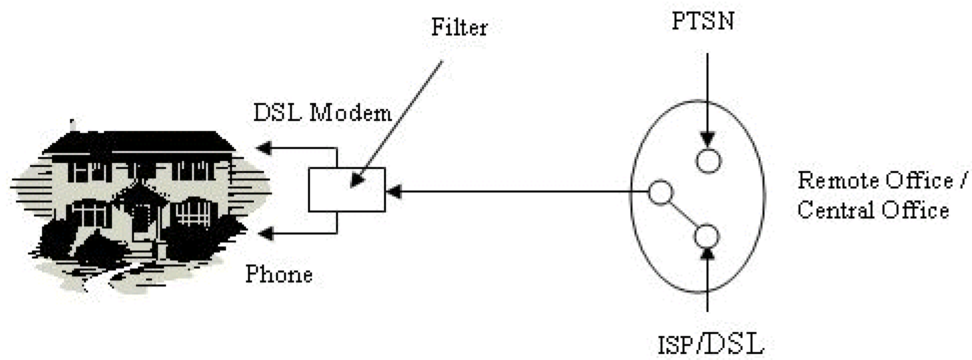

Figure 1. xDSL solution to the Last Mile Problem, as adopted by the rural telephone company. PSTN: Publicly Switched Telephone Network. ISP: Internet Service Provider. DSL: Digital Subscriber Line.

The telephone company currently does not offer cable TV-based broadband internet access. Cable TV-based broadband internet access is almost identically positioned to the xDSL solution the telephone company did chose to implement. Distance limitations also apply, and repeaters must be used when seeking to serve greater distances. Around 75% of homes are typically able to access broadband internet cable-TV services (Fowler 2000). In the end, both the cable-TV and xDSL based Last Mile Problem solutions both exclude an estimated 20-30% of potential customers (Fowler 2000).

Two-way satellite internet connectivity is also an option in rural areas. However, in addition to a clear line of sight to the equator, two-way satellite internet connections require the installation of an approximately two-foot by three-foot satellite dish, the configuration of two modems (one for the uplink and one for the downlink), and, importantly, a coaxial cable connection between the satellite dish and the modems, all of which make the installation often troublesome and expensive, particularly in rural settings. Monthly connect charges can also be high and currently often come bundled with the requirement to also subscribe to satellite TV services at considerable additional cost (Baumgartner 2002).

The distribution of xMDS and ISM wireless technologies for applications in the home, airports, office buildings, and even shopping centers has been discussed in several papers (Tcha 2003; Fernandes et al. 2002; Varshney and Vetter 2000). These short range wireless technologies do enable high bandwidth internet connectivity for multiple users, but only over short distances. Table 1 below summarizes several short range wireless options that are currently available, including the ISM solution selected by the managers of the power company in this study.

Table 1. Comparison Of FCC License-Exempt, Short Range Wireless Technologies. After Pramataris et al. (2002).

Wireless Solution	HiPerLAN/2	802.11a	802.11b	802.11g	ISM
Frequency (Ghz)	5.0	5.0	2.4	2.4	0.9, 2.4, and 5.8
Data Rate (Mbps)	≤ 54	≤ 54	≤ 11	≤ 22	11 - 52
Range (m)	10	≤ 300	≤ 300	≤ 300	8000-11000 (5-7 miles)
Video Channels (count)	10	5	1-2	2-3	8-10
Power (mW)	30-50	10-50	10	20	10 – 1000

Field Study

This section briefly discusses the individual project management approaches used by the managers of the small telephone and power company in this study as they sought to solve their local Last Mile Problem and generate revenue for their companies by providing fast internet access to their rural customers.

Small Business Information Technology Project Management Strategies

The telephone and power company's technology implementation efforts are discussed below in a six-phase theoretical model based on an adaptation of the Technology Adoption and Technology Implementation half-cycle theories of Bonnal et al. (2002) and Kumar et al. (2002), as extended by Tapp et al. (2003):

A. Theoretical Technology Adoption Half-Cycle Phases:

1) **Opportunity**: Identifies the perceived prospective value of the innovation project;
2) **Feasibility**: Determines the technological, economic, and organizational viability of the innovation;
3) **Sponsorship**: Serves to obtain management buy-in to the project in the way of funding, and identifies the project champion with the authority and responsibility for the use of allocated resources (budget and staff, man-hours), the measurement of the expected results (success dimensions and metrics) and the project milestones (deliverables and timeframes).

B. Theoretical Technology Implementation Half-Cycle Phases:

1) **Logistics**: Provides information on the detailed particulars of the tasks, timetables, resources, and events associated with the project.
2) **Acceptance**: Ensures that the company changes its functioning as needed to benefit fully from the innovation.
3) **Assessment**: Did the project achieve its intended objects with respect to the initial opportunity?

Opportunity

For the telephone company the innovation opportunity could be clearly identified from the convergent nature of the company's 3 current business areas (telephony, dial-up internet, and television services). Several key reasons for the adoption of new technology were identified from interviews with the principal project manager, one of the telephone company's vice-presidents. These were:

1) Fear of being left behind and thereby becoming vulnerable to outside competition;
2) The ability to consolidate the 3 core business areas under the broadband umbrella;
3) The potential to add lucrative value-added services to the existing product range;
4) The identification of video over IP as a future billable videoconferencing product.

In addition, the telephone company was receiving on average about 15 inquires per month from its customers for broadband internet services and approximately 15 complaints per month regarding the speed and stability of the existing dial-up service.

Unlike the telephone company, the power company lacked an existing delivery channel for its broadband internet offerings. It did not own the local telephone wiring infrastructure in the 8 counties served by the parent power company and therefore had to approach the broadband internet service concept from an entirely different perspective. For the power company, the opportunity arose when they first became aware of, and then acquired a LMDS spectrum license during an FCC spectrum auction in 1997. This purchase was made possible through a Rural Utility Services (RUS) grant. However, even with the spectrum under license, the power company had no experience in wireless communications arena and ultimately had to hire the services of an experienced radio communications engineer. In the end the LMDS spectrum was not used, and the initial deployment of wireless services took advantage of the license-free capabilities of the wireless ISM solution shown in Table 1.

Feasibility

The telephone company managers had invested heavily in their communications infrastructure in 1992 to provide a dial-up internet service to its core telephony customers (about 8,500 subscribers). The improved telephone infrastructure presented the logical upgrade path towards a broadband internet service that would be available to 80-90% of their existing 8,500 customers. The feasibility analysis of the project was simplified by the maturity of the chosen DSL technology, as well as the ready availability in-house of the technical skills necessary to carryout the implementation. ADSL was seen as providing several inherent benefits over its sister xDSL technologies:

1) It provides the existing 3,500 dial-up customers with a configurable two-way high speed internet option;
2) Investing in ADSL maintained the telephone company technologically competitive at a relatively low cost;
3) In principle, ADSL could support two videoconferencing channels to each broadband internet customer. This would allow the eventual convergence of the company's analog TV offerings with two-way enhanced broadband internet and digital Voice over IP (VoIP) telephone services.

For the managers of the power company, the selection of the ISM solution rested on their analysis of some compelling organizational, technological, and economic factors:

1) Its sparsely populated customer base was distributed over 8 counties having widely varying geographic and topological features and anomalies;
2) No access to the wired telephone infrastructure, which was owned by its competitor;
3) The company had already purchased the wireless LMDS spectrum in 1997 with the notion of providing two-way videoconferencing and multimedia wireless services.
4) Rural Utility Services (RUS) grant and loan monies were available to offset equipment and licensing costs.

Particularly appealing to the power company was that a wireless based internet service immediately removed the need for accessing any of the wired infrastructure owned by its potential competitors, the local telephone company and a new cable TV provider that had recently started to advertise within the power company's service area. Very appealing to the power company was that the wireless ISM solution software centralized customer account billing. At the same time, the customer premises equipment (CPE) for the ISM solution was costlier and harder to configure than xDSL equipment. The power company decided to absorb a truck roll expense to mount the external antenna and configure the CPE at no charge to its customer.

Sponsorship

The upper management sponsorship decision for the telephone company came from the CEO. One of the company vice-presidents with an ownership interest in the company was given the responsibility and authority to see the project through. The telephone company's investment in ADSL was financed out of current income. The implementation of the ADSL solution was facilitated significantly by improvements the company had made to its telephone infrastructure in 1992, at the time when dial-up internet services were implemented. As a result the telephone company's investment in xDSL hardware was less than $100,000.

In the case of the power company, the management decision on sponsorship came from the Board of Directors. The board members were generally visible and influential local business leaders who lived and worked within the service area of the power company. Together with the word of mouth from early adopters, they provided an important built-in peer marketing outlet before other leaders and institutions within the community. The power company's Board of Directors recommended the hiring at the level of a vice-president of an experienced wireless chief engineer to oversee the project. The board took advantage of Rural Utility

Services (RUS) grants to enable the payment of LMDS spectrum licensing fees and wireless equipment purchases. The power company's investment in customer premise equipment and base station equipment was around $175,000. The power company had also purchased a LMDS spectrum license in 1997 at a cost of $310,000 which it is currently not using.

Logistics

The telephone company's detailed logistical implementation of its ADSL solution began with a two month pilot study of a preferred vendor's equipment. The company had previously done business with this vendor, and so management's comfort level with the vendor was high. This pilot study allowed the company to assess the xDSL equipment's performance and pitfalls on site at the company's central offices location without having to make an upfront financial outlay. This approach had three key advantages in the eyes of the telephone company's managers. First, the telephone company was under no obligation to pay for the DSL equipment until satisfied with the vendor's performance. Second, the equipment was installed and configured at the company's central office by the vendor's expert technicians. This allowed the telephone company technical support staff to gain valuable insight into the equipment installation and maintenance process it would later need to deploy the equipment at 15 remote signal conditioning field stations. Third, it also enabled a seamless start to customer billing cycles, thus helping pay for the new equipment out of new revenue.

Upon the satisfactory completion of the evaluation period the telephone company purchased the equipment needed to upgrade 15 remote area signal conditioning and redistribution offices. These upgrades were necessary to ensure that ADSL internet services could be marketed broadly to about 90% of the company's customer base without significant geographic coverage holes. Existing company expertise was allocated in an ad hoc manner to perform the equipment installation and subsequent testing. The only unanticipated obstacle to installation was the discovery of some older signal conditioning equipment that had to be replaced. The time window from the project's initial logistical efforts to broadband services being offered was approximately one year. Service rates were 384Kbps downlink/56Kbps uplink connections for about $45 per month.

The power company's wireless logistical implementation was planned more formally than that of the telephone company, partly because of the strict public reporting accountability engendered by the public RUS grant-funded nature of the project. Project milestones and timetables had to be documented in detail, and the expenditures of capital carefully budgeted and accounted for. Wireless transceivers require high physical mounting points to be effective. Due to the tight capital restraints, the use of existing structures (grain silos, water towers, etc.) had to be incorporated into the deployment plan. As the company did not own these structures, a reciprocal arrangement had to be negotiated with the property owners. Typically these agreements involved the free use of the wireless high-speed internet service in exchange for free housing of the wireless equipment in wiring closets and service sheds at the base of the transmitters shown in Figure 2. Individual customers were connected to the wireless high-speed internet system using the primary equipment vendor Alverion. This customer equipment included the mounting of a free fixed external antenna with a line of sight to one of the wireless transmitters of Figure 2.

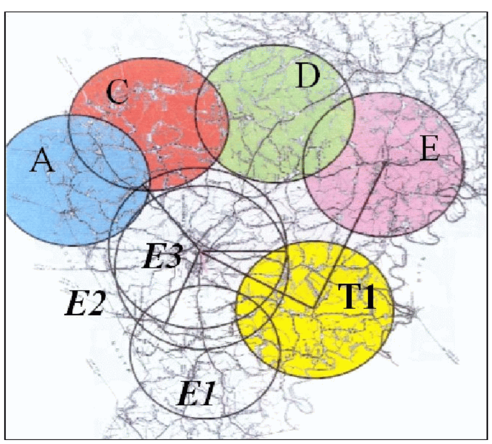

Figure 2. Power Company's Wireless Expansion Plans. Legend: *A:* Repeater 1, service to approximately 800 residents. *B:* Repeater 2, 500 residents. *C:* Repeater 3, 500 residents. *D:* Repeater 4, 1,000 residents. *E*: Repeater 5, 1,000 residents. *T1*: 2-Hop Point-to-Point bridging link at 5.8Ghz.

The power company's main data pipe to the internet backbone consisted of three T1 lines for a total of 4.5Mbps of bandwidth. This limited the amount of bandwidth that could be sold to any one customer. The residential customers were allowed basic asymmetric network connections at 128Kbs for a monthly fee of $29.95. Businesses were supported by symmetric network connections ratable based on additional monthly payment, up to 512Kbps. The billing and allocation of resources was centrally managed with software provided by the wireless equipment vendor.

Acceptance

For the telephone company, the acceptance of the new ADSL-based high-speed internet service was disappointingly low. One year after the implementation had been completed, there were only about 50 high speed internet subscribers. Less than 2% of its dial-up internet customers had converted to the new technology. Apparently the relative high monthly cost of the service, about $45 per month, was seen as too high for the increased performance and "always-on" functionality afforded by the new ADSL service. The ADSL system did allow for the introduction of monitoring software which improved the reliability of the internet service, invited fewer calls to technical support, and generally resulted in higher degree of customer satisfaction over what was typically experienced by a dial-up internet customer.

For the power company, the initial acceptance of the wireless broadband service was strong, exceeding company forecasts. The power company had approximately 175 customers one year after the completion of the broadband project. Adopters tended to be smaller businesses that could not afford to step up to T1 connections, and the offices and homes of highly educated professionals like attorneys, CPAs, and medical offices who desired the better performance and the "always-on" connectivity associated with a broadband internet service.

Very importantly, both the power company and the telephone company greatly benefited in the acceptance of their offerings from the fact that their household and business customers liked being billed for the broadband internet service on the same monthly bill they were already receiving for power or telephone services. The additional monthly charges were transparent to both the customer and to the service providers.

Assessment

The low uptake of the service in the case of the telephone company is disappointing. The company managers did not undertake a detailed survey of its existing dial-up customer base prior to implementing the project. The lower than expected acceptance of the new service leads inevitably to a lower return on investment (ROI). It is possible the company was not anticipating a favorable ROI; in the end the rationalization was that the intent had merely been to put in place the required technological infrastructure to allow the future delivery of billable Video over IP videoconferencing services, in the example of the earlier 1992 upgrade that had been conducted to support a then rapidly growing customer base of dial-up internet customers.

In the case of the power company, several institutions benefited from reciprocal agreements. The local public library and various municipal offices were provided with free broadband internet access in exchange for free access to municipal water towers on which to mount some of the wireless antennas of Figure 2. This arrangement affords free internet access to library users. The library is saving about $1,400 a month over what it had been paying for the displaced T1-based internet connectivity services. Similarly, the local newspaper receives free high-speed wireless internet access at its main offices in exchange for periodic free advertising space for the service.

The impact on how the power company did business on a daily basis was minimal. Two full time employees and one part time employee were necessary to install, maintain, and run the broadband internet service. The billing of customers was controlled through the power company's existing billing infrastructure.

Unlike the telephone company, the power company prepared detailed forecasts at the outset of the project, so a comparison with actuals was possible across several quantitative dimensions:

1) Gross business additions;
2) Gross residential additions;
3) Recurring monthly revenue;
4) Aggregate capital expense write off;
5) Back haul expense;
6) Equipment depreciation;
7) Payroll expenses.

At present the power company is satisfied with the performance of the ISM based system. Its new revenue stream currently offers a gross profit margin of about 22%. This service has been shown to be reliable and robust with a high level of customer satisfaction, and the number of account subscribers continues to grow steadily.

Conclusions and Small Business Managerial Implications

Both companies featured in this paper are typical of small businesses in a rural setting. They generally have limited financial resources to implement new technologies, function with only a small and highly focused work force, and have a potential local customer base that is thinly dispersed over relatively large areas.

The two companies successfully implemented new technology and provided new and existing customers with access to high-speed two-way internet services. Each company chose very different technologies to solve the Last Mile Problem faced by its rural customers.

The same 6-phase project management model (Tapp et al., 2003) was able to account for and help manage all the key project phases: Opportunity, Feasibility, Sponsorship, Logistics, Acceptance, and Assessment, as detailed above.

It was apparent from this study that the perceived customer demand for two-way high-speed internet overstates the actual demand. Neither the power grid company nor the telephone company dial-up customers seemed to be entirely captivated by the basic advantages of high-speed two-way internet access:

1) The "always-on" availability of ADSL and wireless technologies over the dial-up delay and nuisance of an modem was not a persuasive selling factor;

2) The prospect of improved connection speed did not entice potential household customers to any meaningful degree; acceptance was higher for businesses and individuals within higher educated subpopulations of the general customer base.

3) Freeing up of the household's primary telephone line did not seem to be a driving factor either;

4) The lack of immediately available "see and hear" audio and video on demand, virtual multimedia collaboration software, and videoconferencing precluded the users from experiencing the magic of the new technology to a meaningful degree.

Parallels in operational aspects of the technology innovation can also be identified:

1) The decision to sign up for two-way high-speed internet services was facilitated by the ability to pay for all services based on a single, combined monthly bill, or barter for services. Subscribers were very sensitive to the size of the recurring monthly charges and any installation charges.

2) In order to improve customer acceptance both companies provided free customer premises equipment; free installation; and free technical support. The single most advantage to the customer was a very simple and predictable billing scheme: a fixed monthly fee added to the customer's monthly telephone or power bill.

3) The technical implementation of the high-speed internet solution in the case of both the telephone company and the power company was dependent upon external resources. The telephone company relied initially on the expertise of its equipment vendor, and the power company on the expertise of a newly hired expert.

Although the wireless ISM solution implemented by the power company offered only two to three times the speed of a dial-up internet connection, it was better received than the xDSL. The higher acceptance rate achieved by the power company may have been due to the high visibility marketing campaign aimed at selling into its existing community goodwill and a large existing power grid customer base, and the absence of competition from an established local xDSL provider and sufficiently aggressive local marketing by two-way satellite-based internet providers.

Both companies' managers have well defined future upgrade paths for their internet services. The telephone company's next offering is centered around making available, based on a per-use fee structure, two Video-Over-IP videoconferencing channels to their current ADSL customers. The power company managers are interested in providing a similar service but using its currently unused LMDS spectrum license. The LMDS solution could in principle provide around 40 video channels (compared with 8-10 with the current ISM solution, see Table 1), but would require some costly upgrades the current transmitter sites (Figure 2), the size of the pipe for the company's back haul connection to the internet, and to the already deployed customer premises equipment.

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