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Economies of Scale for Antenna's Applications in Interior Regions

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Abstract: Implementing and sustaining an Internet service in interior regions is a difficult mission. In this paper, we present a study applying economies of scale for maintaining Wireless Internet Service Provider (WISP) built for interior regions. We present a descriptive study on systematic design and implementation of WISP in interior places along with the issues faced by WISP for long-term operation. This paper offer some important recommendations also for solving the problems for applying WISP in interior places with least cost and high return. The second part of the paper focuses on the antenna part by presenting how a low-cost integrated antenna design that can increase the robustness of the WISP and preserving a high transmission quality in interior areas. For the purpose of this we propose Code-division multiple access (CDMA) which is a channel access method used by various radio communication technologies. CDMA is an example of multiple accesses, where several transmitters can send information simultaneously over a single communication channel. This research also evaluates CDMA as a potential solution for interior data and connectivity. This study analyses economy of scale for CDMA, its advantages and disadvantages for the interior places, therefore this paper highlights both technical and economic vision and conclude that if used properly, these techniques can help in considerable cost profits.

Keywords: WISP, Economy of Scale, Antenna, CDMA, Transmitters.

Introduction

Economies of scale (EoS) refer to the cost advantage experienced by a firm when it increases its level of output. The advantage arises due to the inverse relationship between per-unit fixed cost and the quantity produced. The greater the quantity of output produced, the lower the per-unit fixed cost [1]. EoS also result in a fall in average variable costs (average non-fixed costs) with an increase in output. This is brought about by operational efficiencies and synergies as a result of an increase in the scale of production. EoS can be realized by a firm at any stage of the production process. In this case, production refers to the economic concept of production and involves all activities related to the commodity, not involving the final buyer. Thus, a business can decide to implement economies of scale in its marketing division by hiring a large number of marketing professionals. A business can also adopt the same in its input sourcing division by moving from human labor to machine labor. There are many effects of EoS on production costs; figure 1 gives the description of its effects [2].

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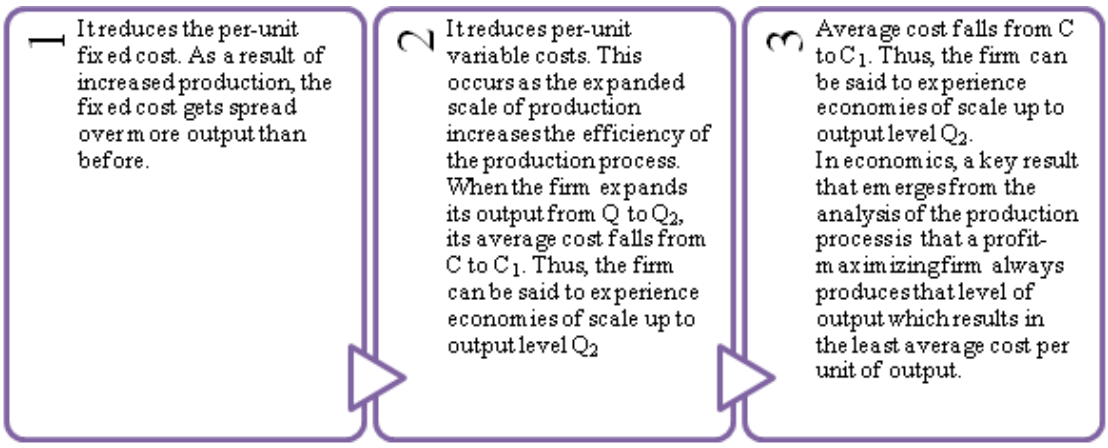

Figure 1: Economies of scale on production costs [3]

EoS is of two types: Internal Economies of Scale and External Economies of Scale. Table 1 presents the description of these two types.

Table 1: Types of EoS[4]

Types of EoS	
Internal EoS	External EoS
This refers to economies that are unique to a firm. For instance, a firm may hold a patent over a mass production machine, which allows it to lower its average cost of production more than other firms in the industry.	These refer to economies of scale enjoyed by an entire industry.

There are many sources of EoS and each has significance on the choice of antenna. Figure two gives the description on these sources.

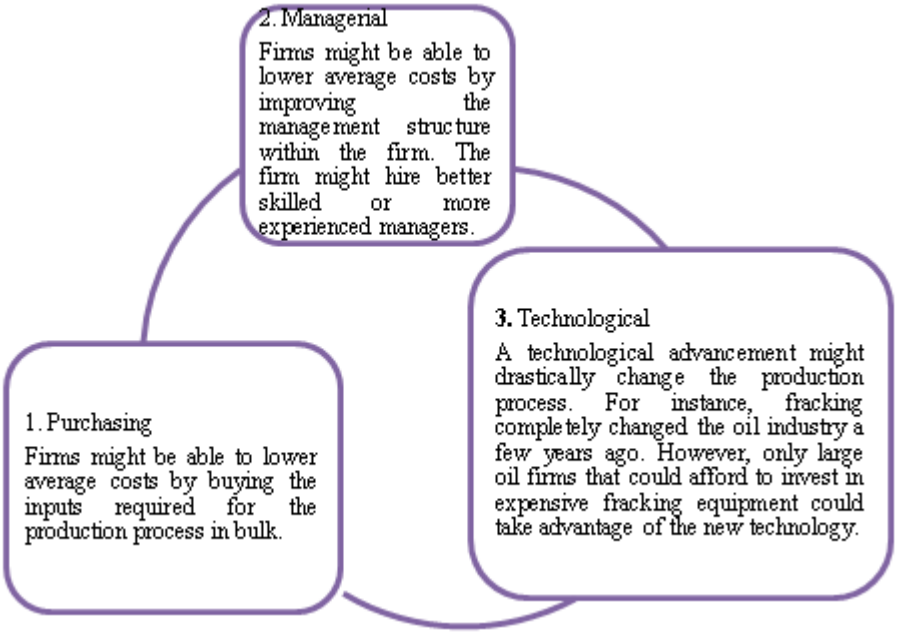

Figure 2: Sources of EoS [5]

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Literature Review

It is widely accepted that communication tech- nology is one of the most important enablers, increasing access to information and thus the standard of living. Recent advances have greatly reduced the cost of telecommunications infra- structure and worldwide mobile phone penetration has increased from 8.24 (per 100 inhabitants) in 1999 to 34 (per 100 inhabitants) in 2005 [6]. However, most of the gains of the telecommunications revolution have been restricted to the industrialized countries.

We start by giving an overview of the CDMA450 technology. We then present the most important advantages of CDMA450 as an appropriate technology for rural connectivity. We continue by discussing some of the potential limitations, both technical and economic [7]. We then proceed by analyzing the use of a fixed wireless model in combination with directional antennas, receive diversity, and high-powered fixed terminals to increase cell radius, and thus make rural deployments more cost-efficient. We continue by discussing the choice of providing voice services, data services, or both, and we conclude in the final section.

Discussion

CDMA2000 [4] is a family of third-generation CDMA cellular communications standards that supports voice and data traffic. CDMA20001x (also known as 1x, 1xRTT, or IS-2000) is the core air interface standard of CDMA 2000 and it uses a single pair of radio channels (1.25 MHz each for forward and reverse links) to transmit both voice and data with a peak data rate of 153 kb/s in each direction.

The newer data standard called CDMA 1xEVDO (Evolution Data Optimized) [8] adds capabilities of high speed data services to CDMA 2000 by devoting a second pair of channels for packet switched data transmission. The first version called Release 0 offers peak data rates of 2.44 Mb/s on the forward link (base station to handset) and 153 kb/s on the reverse link (hand- set to base station). The newer version known as Revision A will offer higher speeds (3.1 Mb/s for downlink and 1.8 Mb/s for uplink). The technology that is most interesting for rural emerging regions is CDMA, which is standard CDMA2000 technology operating in the 450 MHz band. As a result, CDMA can offer the same range of high-speed data technologies such as 1xEVDO, but at a potentially lower cost by taking advantage of the lower carrier frequency, which features better signal propagation, and thus allows for larger, fewer cells. Today, CDMA2000 has 264 million sub- scribers in 58 countries (as of 2006 [6]). There are several well-known reasons why CDMA is an appropriate connectivity solution for interiors areas. Some of these reasons arise from the advantages in using CDMA technology regardless of the frequency, while others arise from the particular characteristics of the 450 MHz frequency spectrum. In this section we present the main CDMA benefits, and the resulting implications for providing interior connectivity with EoS.

The applicability of CDMA in both interior and urban markets is an important consideration because of spectrum licensing and operator incentives and EoS. Given that spectrum for both urban and interiors areas is usually licensed together, the ideal situation for an operator is to be cost-advantage in production cost in both capacity-centric urban areas and coverage-centric interior areas using the CDMA This facilitates a more viable business model by which operators can use the more profitable urban operations to subsidize their rural expansion on the way to universal coverage. Code Division Multiple Access (CDMA) is a sort of multiplexing that facilitates various signals to occupy a single transmission channel. It optimizes the use of available bandwidth. The technology is commonly used in ultra-high-frequency (UHF) cellular telephone systems, bands ranging between the 800-MHz and 1.9-GHz. It has several benefits presented in the figure 3.

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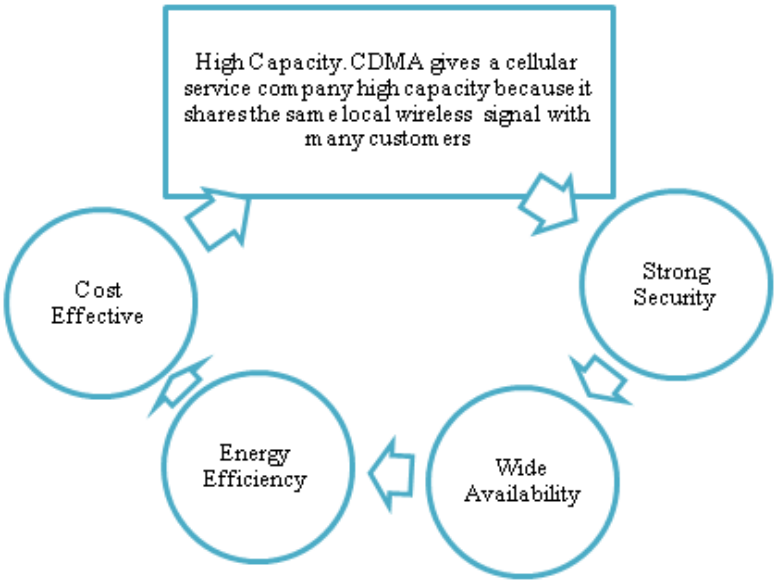

Figure 3: Benefits of CDMA [9]

Results

EoS CDMA for interiors areas provides the availability of low-cost, open-source hardware platforms such as Arduino-like boards is clearly an opportunity for building low-cost loT devices from consumer market components. For instance, boards like Arduino Pro Mini based on an ATmega328 microcontroller offers an excellent price/performance/energy tradeoff and can provide a low-cost platform for generic sensing loT with LoRa long-range transmission capability for a total of less than 10 dollars. In addition to the cost argument such mass-market board greatly benefits from the support of a world-wide and active community of developers. With the gateway-centric mode of LPWAN, commercial gateways with LoRa WAN specifications [10] for instance are usually able to listen on several channels and radio parameters simultaneously. They use advanced concentrator radio chips that alone cost more than a hundred euro. Here, the approach can be different in the context of agriculture/micro and small farm business: simpler "single-connection" gateways can be built based on a simpler radio module, much like an end-device would be. Then, by using an embedded Linux platforms such as the Raspberry PI with high price/quality/reliability tradeoff, the cost of such gateway can be less than 30 dollars [11].

CDMA technology provides a trade-off between capacity and coverage by leveraging its embedded power control mechanism to either serve large extended ranges when peak capacity is not required or to serve high capacity where extended coverage range is not needed. With CDMA 450 in particular, owing to the superior propagation characteristics of the 450 MHz frequency, this flexible trade-off can be realized at much larger ranges, making it a potentially suitable candidate for deployment in low density rural areas. To investigate this possibility, we presented the main strengths of CDMA 450: large, flexible cell sizes with competitive performance in both rural and urban morphologies. We also argued that despite some potential limitations resulting from cell breathing, potentially large antennas, low terminal volumes, and the requirement for a large number of users, the achievable capacity-coverage trade-offs are acceptable to enable real commercial deployments [12]. This lead us to believe that a business model in which the carrier uses urban operations to subsidize rural operations can be viable. We also presented techniques to enhance cell sizes in WLL scenarios. Specifically, we showed that by using directional antennas and receive diversity at the fixed terminals, one can increase the

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range of the cell and dramatically increase SINR, TCP download and upload bandwidths achieved at the higher ranges [13].

Conclusion

CDMA is a feasible and good technology to provide data services in interior areas with good security, and in low cost that eventually benefits the service providers too.

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