Decision support models for the selection of internet access technologies in rural communities

Sasidhar Malladi, K. Jo Min [*]

Industrial and Manufacturing Systems Engineering, Iowa State University, Ames, IA 50011, USA

Abstract

Recent developments in Internet technologies have resulted in a wide range of high-speed internet choices to rural communities. In this paper, we present decision support models to select the high-speed access technologies with different characteristics under a multiple number of performance criteria (cost quality and speed). Specifically, we first construct an analytic hierarchy process (AHP) model, which provides the overall priority weights for each access technology under the multiple criteria. Next, we examine the cases of communities pooling their budget resources for additional mutual benefit. This examination leads to a couple of mixed integer programming models to determine the optimal technology selections of the pooled communities, taking the economies of scale, homogeneity/heterogeneity of communities into consideration. Throughout this paper, the main features are illustrated via numerical examples.
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[*] Corresponding author. Tel.: +1 5152948095; fax: +1 5152943524.
E-mail address: jomain@iastate.edu (K.J. Min).

1. Introduction

In recent years, high-speed Internet has emerged as a means to improve the quality of life and facilitate economic development in rural communities. Furthermore, the effectiveness and efficiency of critical applications such as tele-medicine, e-government, and distance-education depend on the availability of high-speed Internet.

However, unlike in urban communities, competition may not ensure adequate high-speed Internet services in rural communities. Consequently, some rural governments are left with the task of Internet deployment. Under these circumstances, rural governments have an opportunity to plan and select an Internet access technology so as to meet the specific needs of their communities.

The choice of Internet access technology is critical to Internet deployment in rural communities as they typically have limited budgets and cannot afford to experiment. However, the selection process is complex due to (1) technological differences and (2) multi-criteria nature of the selection. For example, while cable-modem technology offers good download speeds (up to 10 mega bits per second), the actual speed varies with the number of users, leading to inconsistent speed. Digital subscriber line (DSL) has consistent speeds in both upstream and downstream directions. However, there is an attenuation problem with its signals requiring additional substations (repeaters) to amplify signals along the communication lines. Along with these technological differences, rural communities should also consider the multiple criteria for performance e.g., low cost, high speed, and high quality (better security and reliability) are all desirable but often inversely related (high cost and high speed).

In this paper, we first develop an analytic hierarchy process (AHP) model to select an Internet access technology (such as DSL, cable-modem and wireless) for a rural community under a multi-criteria decision making (MCDM) framework. The AHP model provides priority weights for the access technologies, based on the rural communities preferences on multiple criteria. The technology with the highest priority weight is then selected for the rural community. We believe that our model would be valuable to rural communities in selecting the technology that matches its needs and is cost effective.

Next, we consider the case of multiple homogeneous communities that have pooled their budgets for fixed and variable costs for mutual benefit. This is formulated as a mixed integer program that utilizes the priority weights from AHP to select access technologies. By homogeneous communities, we mean those that have identical costs associated with an access technology due to similarities in demographics, geography and other characteristics. Later, we extend our formulation to the more general case of heterogeneous communities. Heterogeneous communities are dissimilar in characteristics such as demographics and geography and the costs associated with an access technology are assumed to vary between communities.

In practice, rural communities often use various collaborative models for concerns such as Internet access deployment, e-government, and telemedicine. However,