Computer Networks 55 (2011) 264–281

Contents lists available at ScienceDirect

Computer Networks

journal homepage: www.elsevier.com/locate/comnet

Design and implementation of the KioskNet system

S. Guo, M. Derakhshani, M.H. Falaki, U. Ismail, R. Luk, E.A. Oliver, S. Ur Rahman, A. Seth *, M.A. Zaharia, S. Keshav

David R. Cheriton School of Computer Science, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1

ARTICLE INFO

Article history:
Received 2 March 2010
Received in revised form 18 June 2010
Accepted 1 August 2010
Available online 10 August 2010
Responsible Editor: Ying-Dar Lin

Keywords:
Ictd
Mechanical backhaul
Delay-tolerant networks
Architecture
Rural communication
WiFi

ABSTRACT

Rural Internet kiosks in developing regions can cost-effectively provide communication and information services to the poorest sections of society. Yet, a variety of technical and non-technical issues have caused most kiosk deployments to be economically unsustainable. KioskNet addresses the key technical problems underlying kiosk failure by using robust 'mechanical backhaul' for connectivity, and by using low-cost and reliable kiosk controllers to support services delivered from one or more recycled PCs. KioskNet also addresses related issues such as security, user management, and log collection. In this paper, we describe the KioskNet system, outlining its hardware, software, and security architecture. We describe a pilot deployment and how we used lessons from this deployment to re-design our initial prototype.

1. Introduction

Rural Internet kiosks in developing countries provide a variety of services such as birth, marriage, and death certificates, land records, and consulting on medical and agricultural problems. A typical kiosk has a Windows-based PC and a dial-up or VSAT connection to the Internet, and is operated by a computer-literate kiosk owner who maintains the system and assists end users. To effectively serve its users and be profitable to its owner, a kiosk should be highly available and should have a reliable connection to the Internet. Moreover, it should be low-cost, so that it can be sustained with a minimum of user fees. Unfortunately, due to limited electrical power, pervasive dust, mechanical wear-and-tear, and computer viruses, kiosk computers often fail, requiring frequent (and expensive) repairs. Similarly, network connectivity is often lost due to failures in the telephone system, inability to power the VSAT station, or loss of alignment of long-range wireless links. Faced with high costs and unreliable service delivery, customers quickly lose interest. Due to these factors, in addition to several other non-technical issues, kiosk deployments are often found to be unsustainable in the long term Toyama [1].

KioskNet attempts to make a kiosk more robust without increasing its cost, thus addressing at least the technical aspects that lead to lack of kiosk sustainability. It builds on two key concepts. First, it uses a single-board computer-based, low-cost, low-power kiosk controller at each kiosk. The controller can communicate wirelessly with another single-board computer mounted on a vehicle (as was pioneered by Daknet [2]). These vehicles carry data to and from a gateway, where data is exchanged with the Internet. This 'mechanical backhaul' solution described in Seth et al. [3] avoids the cost of trenches, towers, and satellite dishes, allowing Internet access even in remote areas. In areas where dial-up, long-range wireless or cellular phone service is available, the kiosk controller can be additionally configured to use these communication links in conjunction with

* Corresponding author.
E-mail addresses: sguo@uwaterloo.ca (S. Guo), mhfalaki@uwaterloo.ca (M.H. Falaki), uismail@uwaterloo.ca (U. Ismail), eaoliver@uwaterloo.ca (E.A. Oliver), surrahman@uwaterloo.ca (S.U. Rahman), a3seth@uwaterloo.ca (A. Seth), mazahari@uwaterloo.ca (M.A. Zaharia), keshav@uwaterloo.ca (S. Keshav).

1389-1286/$ - see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.comnet.2010.08.001

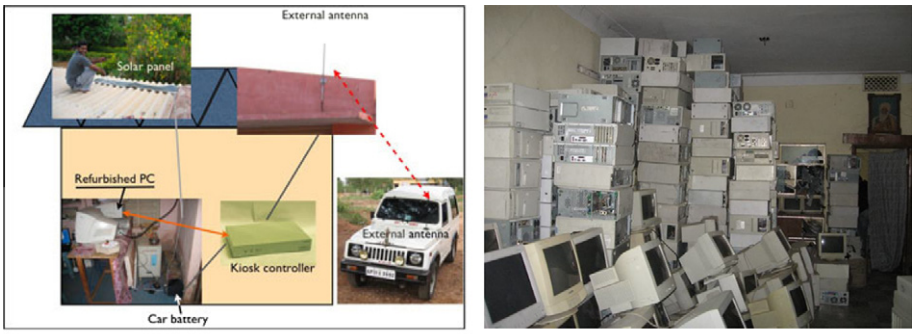

Fig. 1. KioskNet in action.

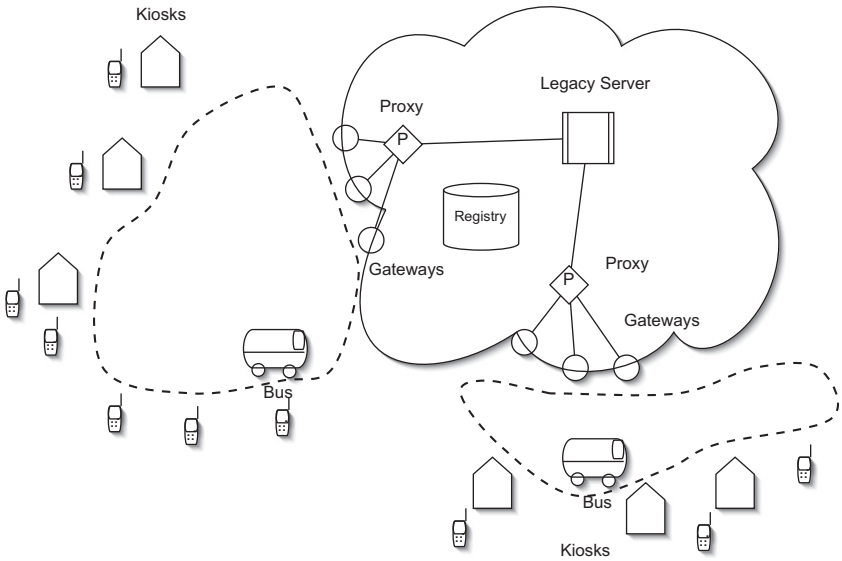

Fig. 2. KioskNet overview.

mechanical backhaul. Second, KioskNet allows refurbished PCs to boot from the kiosk controller. Kiosk controllers are reasonably tamper-proof so they offer reliable virus-free boot images and binaries. We do not use the PC's hard disk, thus avoiding hard disk failures and disk-resident viruses. Moreover, refurbished PCs are cheap and spare parts are widely available. Fig. 1 shows some pictures from our pilot deployments, described later in Section 9.

KioskNet has the following key features:

- The system is low-cost (see Section 8 for details) and appears to be economically viable. We estimate that our system requires a capital expenditure of $100–$700/kiosk, depending on the configuration,[1] and an operating expenditure of $70/kiosk/month. These rough estimates include the cost of field technicians and capital depreciation. This is 4–10 times cheaper than other solutions.
- The solution is rapidly deployable: we successfully installed a prototype in Anandapuram village, Vishakapatnam district, AP, India in two days during May 2006.
- Kiosk controllers are low-power (6–8 W), therefore they can be run off a solar panel.
- Recycled PCs can run either the (Linux) binaries that are packaged with the kiosk controller, which are guaranteed to be virus free, or can boot into an existing operating system (typically Windows) from their hard drive for stand-alone computing.
- We can provide private and authenticated communication among kiosk users, and between a kiosk user and a secure node in the Internet.
- Our software is shipped in the form of a LiveCD that can be booted on any Windows or Linux PC. The CD is used to copy OS images directly onto hard drives, which are then installed in single-board computers.
- Our code is free under the Apache open-source license with no patent, copyright or intellectual property restrictions.

[1] All figures are in US dollars.