Available online at www.sciencedirect.com
SCIENCE DIRECT
Computer Communications 29 (2006) 1133–1145
computer communications
www.elsevier.com/locate/comcom

Analysis of communication alternatives in a heterogeneous network for a supervision and control system☆

V. Sempere*, T. Albero[1], J. Silvestre

Technical University of Valencia, Ferr. y Carb. 2. 03801 Alcoy, Spain

Received 27 May 2004; revised 4 July 2005; accepted 4 July 2005
Available online 27 July 2005

Abstract

Different communication alternatives that form an Heterogeneous Network for a Supervision and Control System of the purification network of a large city are evaluated in order to determine their viability for the supervision and control of the system. In addition there is a study of which offers the best services and costs for different scenarios. Four communication alternatives (which assure a 100% geographic cover of the stations) for the interconnection of the Remote Station and the Central Station are analysed, all of which are situated in the metropolitan area of a large city: point-to-point connections over ISDN (Integrated Services Digital Network), Virtual Private Networks VPNs/IP over ISDN, VPN over ADSL (Asymmetric Digital Subscriber Line) and wireless link 802.11. For the communication between the Central Station and the mobile remote clients, the connection via GPRS (General Packet Radio Service) and the connection by means of UMTS (Universal Mobile Telecommunication System) are evaluated. For the measurements and posterior analysis, control information and images have been transmitted. The viability of these types of solutions in the proposed scenarios is shown and the costs involved in each solution are analysed.

Keywords: ISDN; ADSL; GPRS; UMTS; Images Transport; Virtual private networks; Supervision and control systems

1. Introduction

At the moment the Public Networks are giving more and more communications support to companies, for that reason, the study of the performance of a Control and Supervision system in whose operation different public networks of communication that create an Heterogeneous Network [1] has been considered important. The organizations need to be equipped with remote access infrastructures that allow them to guarantee confidentiality and control of access, protecting the resources of the organization. This opening to Internet of the information systems means implicitly a reduction of costs in communications because of using Public Networks instead of Private Networks, which are more expensive and difficult to manage. In spite of the advantages of the Public Networks, it is necessary to study if these offer the QoS needed and if the objectives for a supervision and control system are achieved.

The objective of the study is to find out under which conditions the technologies are suitable. The real bandwidth of the different interconnection networks, response time (time when there is a state change in the equipment of the Remote Station and an operator receives this in the Central Station) number of images per second, reliability, security and costs are evaluated. With the bandwidth, the number of images per second that the Remote Station can transmit to the Central Station has been calculated.

In previous works, the architecture of the system was analyzed in detail [2,3] and some alternatives were tested [4]. In [2], the improvements achieved were described, complementing the system in use until the moment that it operates with 'polling' [5,6] by radio frequency for the communication between the Central and the Remote Station.

With the current system, it is possible to exchange control information from whichever control equipment

☆This work was supported by the 'Ministerio de Ciencia y Tecnologia' of Spain under the profect TIC2003-08129-C01, which is partially funded by FEDER.
* Corresponding author. Tel.: +34 96 652 85 19; fax: +34 96 652 84 09.
E-mail address: vsempere@dcom.upv.es (V. Sempere).
[1] Supported by Generalitat Valenciana with the grant TS/03/UPV/09.

0140-3664/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.comcom.2005.07.001

(PLC, terminal, etc), and to obtain images from critical zones within the installation and transmit them to a station which functions as a supervision and processing centre, as well as allowing access to all the information obtained in remote form through the different access networks to Internet. The paper is structured in the following way: In Section 2, the architecture of the system is described. In Section 3, the operation and in Section 4 the advantages and disadvantages of the interconnection alternatives are described. For the connection of the different stations of the system, the wired connectivity is provided by ISDN (Integrated Services Digital Network) and ADSL (Asymmetric Digital Subscriber Line), and the wireless connectivity is provided by IEEE (Institute of Electrical and Electronic Engineers) 802.11 [7]. GPRS (General Packet Radio Service) as well as UMTS (Universal Mobile Telecommunication System) are used for the connection of remote clients to the system. The measurements are shown in Section 5. In this the monthly costs of the Central and Remote Stations are evaluated for the different communication alternatives and the analysis of results has also been made. The conclusions are presented in Section 6.

2. Architecture of the system

The system is made up of four fundamental parts, see Fig. 1: Central Station, Remote Stations, Communication Networks and Remote clients.

2.1. Central station

This schedules the information, which passes through the whole installation, and controls the communication between Central and Remote Stations. The slow cycles of polling by radio are eliminated now that it communicates simultaneously (using various TCP/IP connections) with the Remote Stations, and is now a redundant communication medium that works as a backup system.

The Central Station counts on equipment which operates like SCADA [8] in the new network and which houses the database of images and control information. A batch process is charged with maintaining coherence between the old database (updated by polling) and the new one to avoid incoherences. The Central also houses a Web Server, which allows consultation of information on the Remote Stations by Internet.

2.2. Remote stations

In each of the Remote Stations to be governed there is a PC that acts as a gateway between the communication network and the local control system of each Remote Station. It is able to communicate bidirectionally with any PLC on the market (in this case the protocol used is a Simatic S5/S7) and map in a simple way the variables of the process. The Remote Station process determines when variations susceptible to being sent to the Central Station have been produced, executing an automatic update. The parameterization is completely done from the Central Station, with this the PLC memory zones for orders and states are defined. The Remote Station captures information from different cameras, encodes it and then transmits it to the Central Station by the communication medium available.

2.3. Communications network

This gives communication support in concurrent form to all the Remote Stations, allowing the incorporation of new real time services such as image transport, states and orders transmission. The current system of polling by means of radio frequency is a redundant system acting as backup to operate in case of failure of minimum services.

After a detailed study of the diverse possibilities four possible alternatives for the interconnection of the stations have been studied:

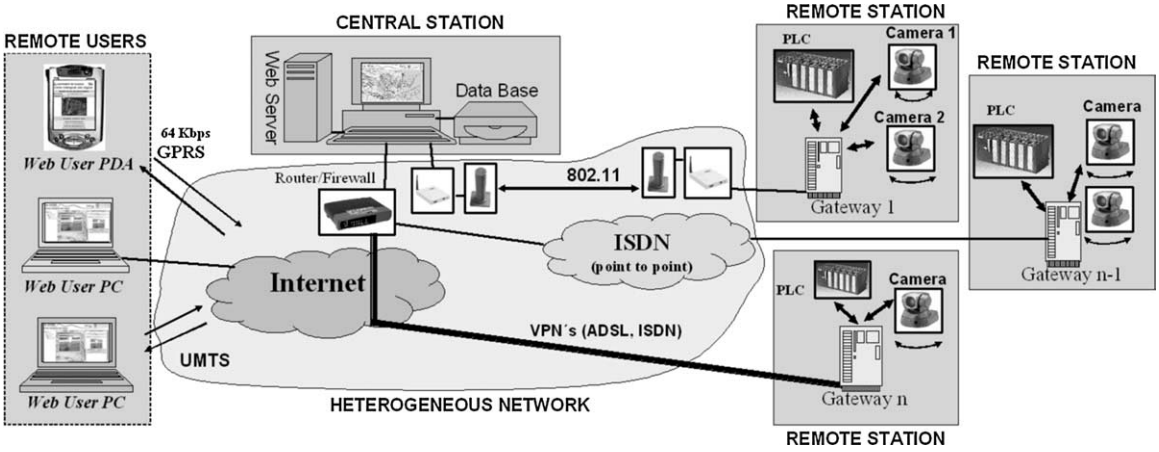

Fig. 1. Architecture of the system.