Power Line Carrier를 이용한 XML 기반의 홈 게이트웨이 설계 및 분석

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Design and Analysis of XML based Home Gateway using Power Line Carrier

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Abstract

In this paper, the architecture for the residential gateway is designed for the traffic statistics of home environment. The suitability of 10 Mbps power line communication is investigated for the control and the video data distribution through simulation. The design issues are discussed for a residential gateway and the network design that is based on the power line communication is presented. Traffic models are established from the actual traffic traces. They are used for performance evaluation of residential networks.

I. Introduction

A new network requires studies on home gateway architecture, power management, and performance evaluation. This paper addresses these issues for the residential network. Our design is based on the existing Ethernet technology for its low-cost and large installed base. A key concern, however, has been whether ethernet is capable of supporting compressed digital video in addition to existing data traffic or satisfying the constraint of control periods.

To obtain a realistic answer to this question, traffic characteristics of data applications has to be carefully examined for the residential network. All the existing traffic characterizations are based on office network, and not necessarily applicable to residential network.

An energy management system that is possible when a home automation communications network is available. The home automation network provides the signal links the home gateway for energy management and all the affected appliances in the house. The network may be composed of the power line to carry the data using established techniques. The energy management gateway has the responsibility for balancing an energy expenditure target with consumer preference for the operation of appliances.

II. Residential Network Design on PLC

2.1 comparison of media performance

The network load is normalized so that the comparison between network efficiency for each media can be made in order to get the true network load. The load value is multiplied by the network bandwidth (shown in Table 1).

Protocol	PL	TP1	TP2
Contention	≒75	≒75	≒75
Registration	11.9	1.68	0.53
Enrollment	19.1	3.84	1.32

Table 1 Times to Complete Contention. Registration and Enrollment

The collision protocols PL and TP2 have poor delay and throughput performance. On the PL media the number of collisions increases as the network load increases: there is no collision detection so once a collision occurs the total transmission time is wasted. This effect is compounded by relatively low random back-off period of < 42 msec coupled with a small number of discrete random intervals between the each transmission resulting in many devices retrying transmission at the same time. This is especially important when there are a large number of active devices such as periods during initialization. In order to avoid a single device hogging the network a 125msec inter-transmission delay is included which improves the fairness of access to other devices. But has the detrimental effect of reducing the maximum throughput of any single device to approximately 65%.

In TP1, during the initial phrase of the transmission collisions are avoided by devices successively backing off. The maximum throughput is limited due an initial idle period of 12.9 msec before each transmission. The degradation is lower when long frames are transmitted[2].

2.2 Architecture of Home Gateway

It is to allow an home appliance to communicate on any home automation communication network. It is being developed for all appliance commands and message. The basic concepts of proposed home gateway are described.

Providing the complete home network functionality depends on the addition of other products such as more complex user controls, appliances including and application-specific gateway for energy management, security, and home traffic scheduling.

It is including HNMS(Home Network message specification on SNU) that is based on the manufacturing message specification (MMS) protocol and XML. MMS is the protocol proved and verified by engineer for over 10 years. It is a part of the Manufacturing Automation Protocol (MAP) project to promote interoperability among heterogeneous industrial devices and more conventional computers.

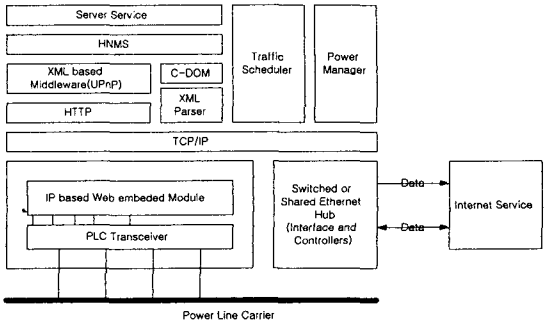

Fig. 1 Home Gateway Structure

Fig. 1 shows the architecture of home gateway to connect between home and internet service.

XML based middle_ware protocol(i.e. UPnP) is an application-level distributed network architecture where the logical nodes on the network are user control points, controlled device and bridges. These classifications refer to functionality rather than physical entities. Their functionality can be packaged into physical entities in any combination. After the initial communication, user control points can receive events from controlled devices. Controlled devices are responsible for storing the state of services. User control points are required to synchronize to the state on controlled devices and to share state directly among themselves.

III. Home Network Traffic

3.1 Traffic measurement and Modeling

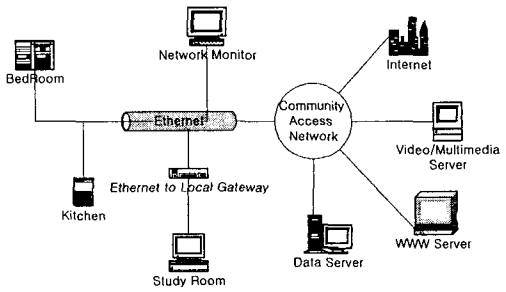

Fig. 2 Testbed for collecting residential traffic

Realistic traffic modeling is fundamental to network design and planning. While these studies have profound impact on network research and planning, they are not necessarily applicable to the residential environments.

As shown in Fig. 2, it consists of a residential Ethernet network with three computers and a printer. For example, it was observed in academic LAN's that about 10% of LAN traffic are WAN related, and the remaining 90% are confined within the LAN. This is clearly not the case of residential network, which are likely to communicate outside the home more often. This study was undertaken to measure and characterize residential traffic, and analyze the performance and suitability of TCP/IP protocols for the residential network. Traffic was collected and analyzed from both testbed and actual networks for LAN and WAN data traffic.

3.2 WAN Data Traffic

Future wide-area data services are generally perceived to be similar to activities on today's internet through graphical user interfaces. Applications from education, training, home shopping, catalog browsing, searching, video movie clips, photographs, speeches, music clips, and etc. are just a few uses that have been developed in internet servers. The residential network of the near future will more than likely carry internet traffic to and from the information highway as the dominate application for WAN traffic[3].

3.2.1 Document Size Distribution

The internet document size distribution was studied by Crovella and Bestavros. The found the sizes of both the retrieved documents by clients and available documents on servers follow a Pareto distribution which has probability density function

$$p(x) = \alpha k^{\alpha} x^{-\alpha-1}$$

where k is the minimal value of the random variable x and the exponent α determines the shape of the distribution. Its cumulative probability function is given by

$$F(x) = Prob(t \leq x) = 1 - (k/x)^{\alpha}$$

In particular, the value of α = 1.03 was reported for retrieved document sizes.

Pareto distribution has infinite mean when $\alpha \leq 1$, and infinite variance when $\alpha \leq 2$. Pareto distribution is heavy tailed in the sense of $P(X>x) \sim x^{-\alpha}$ for sufficiently large x. The analytical results would then suggest that the aggregation of a large number of internet sessions may cause self-similarity. Self-similarity, however, is not a direct consideration for residential network, for there are few nodes in the home to generate self-similarity[4].

3.2.2 Document Inter-Arrival Distribution

It has less impact on the residential network performance than the head distribution, while the distribution of inter-arrivals is the interest to the study of aggregate traffic. It is chosen to consider the inter-arrival times below 60 sec only. It is suggested that this subset of data include approximately 95% of arrivals. The model that derived from them can be considered as a model for normal, i.e., not extremely idle, traffic.

The detection of distribution was carried out using probability plots. The traffic data do not appear to fit for Pareto distribution, but a Weibull distribution. Weibull distribution has probability density function.

$$p(x) = \frac{k}{\theta}\left(\frac{x}{\theta}\right)^{k-1} e^{-\left(\frac{x}{\theta}\right)^{k}}$$

and cumulative distribution function

$$F(x) = Prob(t \leq x) = 1 - e^{-\left(\frac{x}{\theta}\right)^{k}}$$

Similar to Pareto distribution, Weibull distribution has more mass at the tail than the exponential distribution. But it has more mass at the head than the Pareto distribution. This characteristic provide a mathematical connection to the physical events of in-line images, which causes several separate, but nearly back-to-back document requests when a user chooses a new page. This would intuitively suggest that Weibull distribution might be a more reasonable model than Pareto for internet document inter-arrivals.

IV. Energy Management

The energy management has the responsibility for balancing an energy expenditure target with the consumer preferences for the appliance operation.

The scenario described for user interaction with a appliance implied that energy consumption decisions were on an appliance-by-appliance basis. This may be required if sophisticated software is developed for the energy management gateway.

An intelligent energy management gateway could optimize the consumption and the convenience parameters across all appliances. It would require a data vase containing. The electrical loads presented by each appliance. The modes for operating each appliance at the reduced energy consumption. The communication messages for initiating these modes.

Eventually, the features of artificial intelligence might be incorporated into the energy management controller. The controller would learn the habits and preferences of the occupants automatically. For example, the gateway then would determine temperature set-points and appliance operating modes in order to meet an energy budget established by the user of imposed by the utility. User input would be required only if a change of routine occurred.

The technology of energy management is based on fuzzy-control. This controller can subsequently be tested in the simulation environment SIMULINK.

There is an increasing requirement for the electric and power utilities to manage energy consumption with increasing efficiency. As part of this effort, many of the utilities employ telecommunications to control the use of energy where it is used at the home. The goal is to reduce the peak demand for energy in areal-time fashion and to control the power of appliance at home. By enabling the user to control the customer's appliances that use the smallest power.

For the successful interconnection to the power management, these high level functions must be mapped to the data structures and protocol services available through the power line. The remaining technological gap between the home network and the home gateway is that there is no definition for connectivity between external networks.

V. Conclusion

In this paper the architecture of a home gateway was described. A key element of the proposed architecture is its communications networks, which was described. Furthermore, several future data traffic scenarios are considered with bandwidth up to 10 Mb/s by scaling up current data traffic. The simulation results on performance reported here suggest that proposed XML based residential gateway architecture using power line carrier can be used as a cost-effective residential network for power management.

Reference

[1] Harald J. Zainzinger, An Artificial Intelligence Based Tool for Home Automation Using MATLAB, Tenth IEEE International Conference on , 1998 Page(s): 256 -261

[2] HC Ferreira, HM Grove, O Hooijen and AJ Han Vinck, Power Line Communications : An Overview, AFRICON, 1996., IEEE AFRICON 4th , Volume: 2 , 1996 Page(s): 558 -563 vol.2

[3] Maurizio Molina, Paolo Castelli, and Gianluca Foddis, Web Traffic Modeling Exploiting TCP Connections' Temporal Clustering throung HTML-REDUCE, IEEE Network , Volume: 14 Issue: 3 , May-June 2000 Page(s): 46 -55

[4] Shuang Deng, Alan R. Bugos, and Paul M. Hill, Design and Evaluation of an Ethernet-Based Residential Network, Selected Areas in Communications, IEEE Journal on , Volume: 14 Issue: 6 , Aug. 1996 Page(s): 1138 -1150

[5] HweeHwa Pang, Bobby Jose, and M.S. Krishnan, Resource Scheduling In A High-Performance Multimedia Server, Knowledge and Data Engineering, IEEE Transactions on , Volume: 11 Issue: 2 , March-April 1999 Page(s): 303 -320

[6] H. Brooke Stauffer, Smart enabling system for Home Automation, Consumer Electronics, IEEE Transactions on , Volume: 37 Issue: 2 , May 1991 Page(s): xxix -xxxv

[7] R.M. Vatson, A. Munro and M.H. Barton, A Performance Analysis of the ESPRIT Home System Specification, Teletraffic Symposium, 11th. Performance Engineering in Telecommunications Networks. IEE Eleventh UK , 1994 Page(s): 16B/1 -16B/9