IPv6 Home Network Domain Name Auto-configuration for Intelligent Appliances

Tin-Yu Wu, Chia-Chang Hsu, Han-Chieh Chao

Abstract — *When network techniques advance dramatically, Network applications merge broadly into the daily lives of people. More electrical appliances now contain tiny embedded systems that support network interfaces within the home due to the great advances in IC design and semiconductor device manufacturing. Remotely controlling an information appliance (IA) in a home network has become a major request for nowadays consumers. IPv6 plays an important role because of the enormous number of device network interfaces needed in the home network around the world. In our work, a protocol that automatically integrates the user interface and command transmission is proposed. The proposed method also allows IA to acquire its domain name automatically without manual configuration. Through this initial automatic message communication protocol, users can "plug and play" the IA device with its unique ID.* [1]

Index Terms — IPv6, DNS, IA, OSGi

I. INTRODUCTION

There are relevant issues pertaining to the development of IA (Information Appliances). The burgeoning home network market was forced to use NAT (Network address translation) to set a private IP address because a large number of IP addresses cannot be easily obtained. Because the exterior host cannot establish a connection into a host in the NAT, the user generally cannot control IA through peer to peer at home unless a special NAT configuration is established. Another difficulty is getting IA a domain name through NAT because it is a private IP configuration. Confronting more IA support networks in the future, such as refrigerators, electric radiators, video recorders, the home gateway with a NAT function is not enough. The next generation IP protocol - IP version 6[1], provides more characters that can be used for embedded IA systems. The IPv6 protocol provides for enormous IP addresses. This system will give each IA one unique IP address that can be addressed automatically without a DHCP server. It also makes it convenient to register a domain name for an embedded system with a global IP address routed into a public network. It is not feasible at present time for every IA user to register a domain name through Ipv4 due to the limited space availability.

The most attentive home network architecture protocol is Open Services Gateway Initiative (OSGi)[2]. OSGi provides for a complex and large residential gateway mechanism in a home network. It supports various applications called bundles that can be installed in the OSGi service platform. User can start or stop the bundles according to their needs. OSGi uses Java Intelligent Network Infrastructure (Jini) and universal plug and play (UpnP) technology to assist the service platform in discover and service a device [3]. The Jini network technology enables devices to form impromptu communities that can be assembled without any planning, installation, or human intervention. The UPnP technology provides protocols that specify how a device joins a network and is controlled using XML messages through an HTTP server for a peer-to-peer network. These technologies can assist the user in decreasing the number of configuration actions. Configuration actions are significant in a home network because the OSGi organization is devoted to adding new techniques into OSGi.

Three other related windows server 2003 applications are applied for DNS and home network applications. They are explained thoroughly as follows.

(1) Dynamic DNS

Dynamic DNS have been used for a long time [4]. In IPv4, many organizations provide dynamic DNS services. Translate IPv4 dynamic DNS service into IPv6 is quite easy, but with a problem that the client application must be applied. The client application must configure by user, therefore IA owner cannot get domain name automatically through plus and play because IA has not any configuration inside beforehand.

(2) IPv6 Stateless DNS discovery

IPv6 Stateless DNS discovery is a new draft proposed in IETF [5]. It mainly supports a service that assist client host to configure DNS when Router Advertisements function cannot achieve it. The procedure can only assist host to con-

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figure DNS but it cannot get a domain name for host automatically.

(3) Peer-to-Peer Networking Name Resolution

The Peer Name Resolution Protocol (PNRP) [6] supports a service by Name Space Provider. It provides an API that permits the peer-to-peer resolution of names to endpoints. This protocol also is acting as a name resolution related protocol.

Another mechanism supporting same function as one of our proposing mechanism is Domain Name Auto-Registration for Plugged-in IPv6 Nodes [7]. This draft also supports domain name auto-registration function, but it cannot let device obtain a regular domain name that users expect for. It will reduce the popularity for this mechanism. The comparison is listed in table 1.

TABLE I
Related DNS services

Service / Function	Dynamic DNS	IPv6 Stateless DNS discovery	PNRP	Domain Name Auto-Registration for Plugged-in IPv6 Nodes	Domain name auto-configuration (We propose)
Register Domain name	Yes, but user must configure client host.	No support.	No support.	Yes, but user cannot anticipate type of domain name.	Yes, support registering domain name that can be anticipated.
Resolve domain name	No support.	Yes, must configure DNS.	Yes, but host must install API.	No support.	No support.

In this paper, we propose three mechanisms that add additional functions to home network architecture. The first function assists IA in acquiring a regular domain name without manual configuration. Because a domain name has wide utility in many applications such as SIP etc, this mechanism will carry more services into a home network. The second mechanism is similar to the previous one. It mainly provides session initiation protocol (SIP)-Uniform Resource Identifiers (URI) auto-configuration and SIP-URI register. This procedure will also become much convenient in VoIP devices. The third function is a mechanism that initiates communication messages between devices manages the residential gateway and configures the user management system interface simultaneously. It provides another, thin home network architecture.

II. HOME NETWORK ARCHITECTURE

Although the present IPv4 protocol has been in use for many years, it can no longer satisfy user requirements in many applications. For this reason, the newer IPv6 protocol was instituted. Besides the larger IP address, IPv6 can use Stateless Auto-configuration or DHCP6 to obtain IP when new devices begin network interface [8]. In the stateless auto-configuration, the device uses only a prefix that route advertises and the network MAC interface to compose an IP through EUI-64. Another Multihome characteristic allows a network interface to support more than two IP. Devices. One IP is used to configure, the other IP is used to communicate. Other characteristics provide more support for QoS, Security and enhance the home network architecture.

A wireless network is a far better choice in a home setting. Wireless networks provide both PC and IA access to network resources without being hampered by space limitations. Furthermore, AP can also be used as a home gateway in conjunction with a PC in a wireless environment without paying any extra cost. Another nice choice for a home network is the powerline device. Powerline network communications occur through a power cord, which is fitting for IA in a home network.

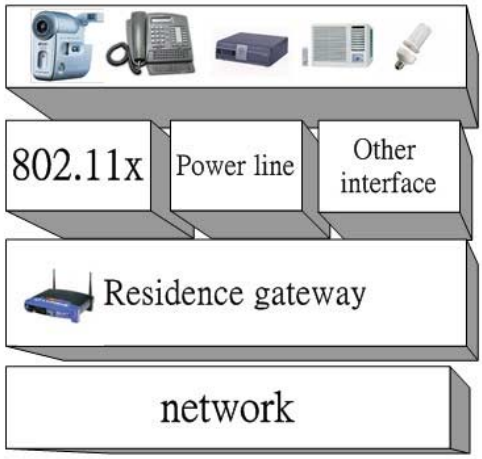

Fig. 1. Wireless home network architecture

Figure 1 illustrates home network architecture with AP and powerline devices. An AP or PC is used as the home gateway in this architecture. Any device that has a wireless interface or powerline device can connect to the Internet through the home gateway, i.e., wireless IA devices, printer, PC or Internet Telephone [9].

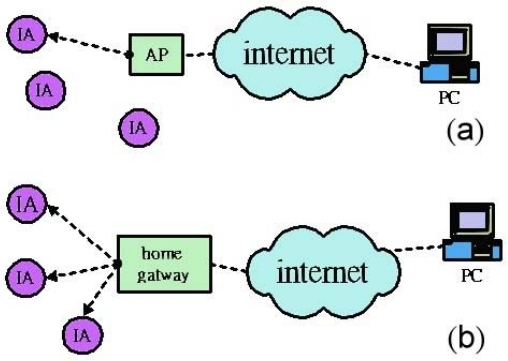

Fig. 2. Remote control methods

There are few control restrictions for IA devices in a home network because of the network interface. Controlling messages can be made of serial numbers, characters or any data. This produces nimble control and data exchange in a home network. Controlling IA with global IP is accomplished in two ways as illustrated in Figure 2. In Figure 2(a), the user can control IP directly through a program like BBS or a thin web server. In Figure 2(b), the user connects to the home gateway first and uses a management interface to controlling all IA devices. The later method provides more practicability with advanced designs to deal with commands and messages [10].

III. AUTOMATIC DOMAIN NAME CONFIGURATION AND SMALL MANAGEMENT INTERFACE

3-1. Domain name auto-configuration

We propose a procedure that enables a PC or embedded system to acquire a domain name automatically at extremely small cost. The manufacturer only needs to embed a program that runs during the system boot. The original system design needs to be modified to add different routines to the embedded IA system. IA uses a local IP to exchange messages with the home gateway and another global IP to communicate with a foreign network. Figure 3 illustrates how the embedded system acquires a domain name. This procedure can also be used in a PC or other network device. The following steps show how a Linux embedded system acquires a regular domain name.

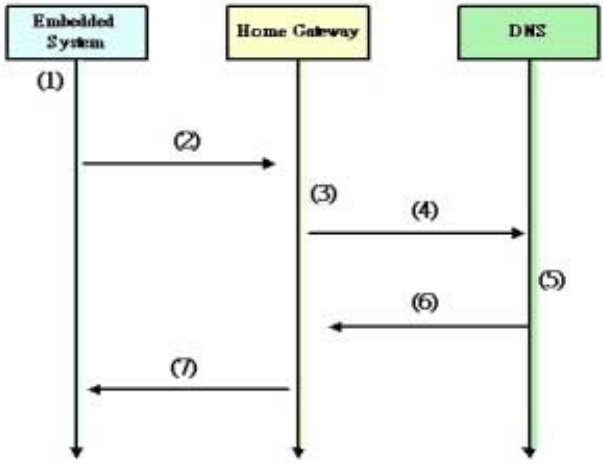

Fig. 3. The domain name auto-configuration procedure

(1) In the embedded system, a program installed in the file system is executed by the initiation procedure after the system loads the kernel. The IP address generated automatically through this program is then collected.

(2) The next step is to send the IP and appliances label defined in embedded system to the home gateway.

(3) After the home gateway receives the IP and appliance labels, a program in the home gateway combines the user's ID and appliances label to generate a combined string to register a domain. The program also records the IP and IA information in the home gateway mini database. This information can be used later to manage the home network.

(4) The home gateway program then sends a combined string to register at the DNS. The combined string is a domain name type string. For example, if the appliance label is "refrigerator", and the user ID is "user", the combined string the home gateway sends to the DNS is "refrigerator-user". If the DNS management domain is ".ia.tw", the registered domain name is "refridgerator-user.ia.tw". A regular domain name "type-user_ID.ia.tw" is produced.

(5) The program in the DNS that receives the domain name registration message from the home gateway writes the domain name and corresponding IP address into the DNS configuration file and reloads the DNS configuration. The domain name can be used after this procedure is completed.

(6) The DNS then returns a value that indicates successful registration to the home gateway. The home gateway then disconnects the connection to the DNS.

(7) The home gateway then returns a successful value to the embedded system. The embedded system then disconnects its connection to home gateway.

There are several advantages in the above procedures. For the embedded system, only new programs are added to the original system. Messages to the home gateway are received when the system boots up. If the home gateway does not accept these messages, the embedded system or home gateway is not affected. The program in the embedded system can be added to every IA that has a remote control function. The user can decide whether to use this function. AP manufacturers can insert programs like ours into the AP to make it a home gateway and support domain name registration. This is similar to the preceding state and will not affect the AP's original function. Another advantage is that the AP can cooperate with a PC to compose a home gateway without the presence of the program.

More detailed configurations will be discussed next. The appliance name affects its label. Every information appliance has a relevant name. Different embedded electric appliance systems must have different appliance labels identical to the appliance word set in the system. A refrigerator is "refrigerator", video recorder is "video-recorder", etc.. The string composed using two or more words is linked by "-"because of the domain name configuration requirement. If there are two electrical appliances that have same appliance label, the home gateway solves this problem by generating a different domain name for each appliance of the same type. The appliance label can be extended to refridgerator1, refridgerator2, etc. PC users can execute a program to send registered messages to the DNS or use the PC as an information appliance