

# Home-Network Security Model in Ubiquitous Environment

Dong-Young Yoo, Jong-Whoi Shin, and Jin-Young Choi

**Abstract**—Social interest and demand on Home-Network has been increasing greatly. Although various services are being introduced to respond to such demands, they can cause serious security problems when linked to the open network such as Internet. This paper reviews the security requirements to protect the service users with assumption that the Home-Network environment is connected to Internet and then proposes the security model based on the requirement. The proposed security model can satisfy most of the requirements and further can be dynamically applied to the future ubiquitous Home-Networks.

**Keywords**—Home-Network, Security, Vulnerability, Response, Countermeasure.

## I. INTRODUCTION

RECENT advancement of information technology is bringing many changes in our daily lives. Of such changes, the Home-Network service can be considered as the one that can have the most significant impact. Home-Network includes the wired and wireless network protocol, middleware to support the protocols and household devices. As shown in (Fig. 1), Home-Network applies different technologies to support the demand for the various user services [1].

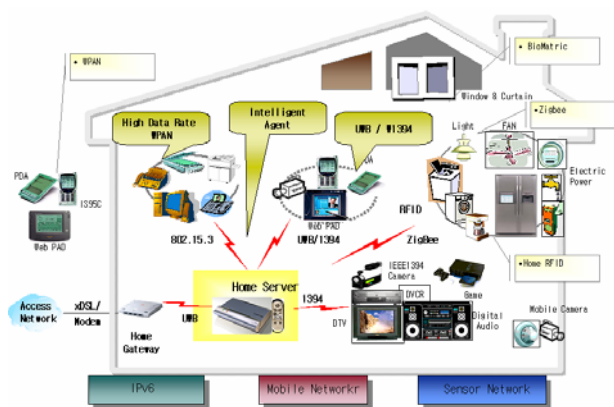


Fig. 1 Different Technologies of Home-Network

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Intuitively, one can divide the Home-Network into the household network and the access network to the household network. In that regards, the types of the security vulnerabilities can be hacking of the home device, virus attack, information leak, content fabrication and privacy violation. The detailed nature of intrusion for each protocol can be described as follows:

The access network is the one that connects the home gateway to the outside service provider. The financial data, user ID and other information can be exposed when the attacker collects the network packet at the household network connection point. Currently, the login data of the Home-Network user are protected by the encryption channel of the Home-Network service provider. However, except those of pilot service providers, the security measures of others are not yet known. We show that the possible threats when the attacker connects to the home gateway and collects the user information. The household network can be deployed using the technologies already available in the household or installing the new line. For that, the wired and wireless lines are used together [6].

## II. RELATED WORK

Home-Network contains the wired and wireless network protocols, middleware supporting the protocols and household appliances. As shown in (Fig. 2), Home-Network features the various technologies to satisfy the user's service demand [6]. Intuitively, one can divide the Home-Network into the household network and the access network to the household network. In that regards, the types of the security vulnerabilities can be hacking of the home device, virus attack, information leak, content fabrication and privacy violation. The detailed nature of intrusion for each protocol can be described as follows:

### A. Access Network Vulnerability

The access network is the one that connects the home gateway to the outside service provider. The financial data, user ID and other information can be exposed when the attacker collects the network packet at the household network connection point. Currently, the login data of the Home-Network user are protected by the encryption channel of the Home-Network service provider. However, except those of pilot service providers, the security measures of others are not yet known. (Fig. 2) shows the possible threats when the attacker connects to the home gateway and collects the user information.

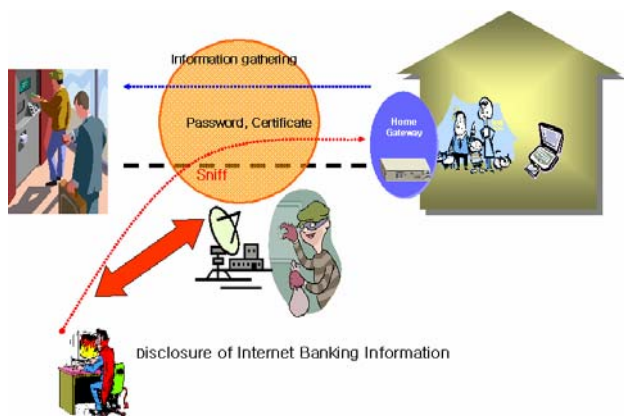


Fig. 2 Home-Network Access Network Security Vulnerabilities

### B. Vulnerability in Home-Network

The household network can be deployed using the technologies already available in the household or installing the new line. For that, the wired and wireless lines are used together [6]. The security threats are exposed due to the vulnerability from linking of the network technologies with house home appliances and vulnerability of the technology itself. Types of security threats are described as follows:

#### 1) Home Appliance

The household appliances can be connected to the wired or wireless network through the home gateway. (Fig. 3) shows the vulnerability of the home gateway itself. Typically, home gateway has the Web based management program installed. Its problem is that the attacker can attain the administrator privilege using Web server or CGI vulnerability. Since the home gateway is the point that connects the household with outside, attack against it can directly lead to the attack against the whole household network. Therefore, security measures of the home gateway are more important than anything and development of technology to protect it is essential [7][8].

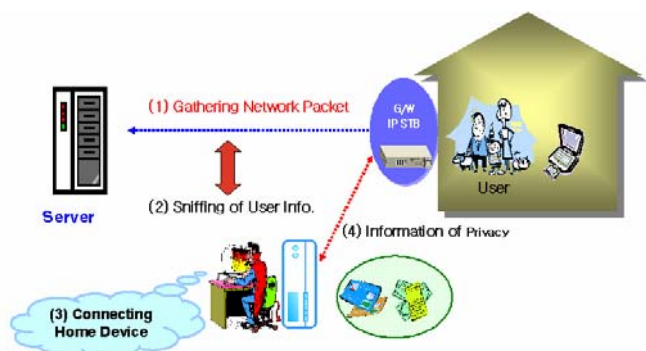


Fig. 3 Illegal Connection to Home Gateway

Furthermore, there is the possibility that the attacker can disguise itself as the internal user through the interactive DTV, IP set top box or home pad or access it illegally through other means to control the home appliances. Physical problem or malfunction of the home appliance can also leak the

information, or problems of the device can cause inconvenience to the user when needed.

#### 2) Wired Communication Protocol

For the household network, Ethernet (IEEE802.3), PLC and IEEE1394 are the most widely used protocols. PLC monitors the electricity consumption of the household and has the privacy violation threat since it contains the pattern of the users. Particularly since the Internet access network and wired household network (mostly Ethernet) inherits the threats (hacking, virus, worm, etc.) of Internet, the currently available security measures must be quickly applied to prevent the threats to other protocols. In general, the wired Home-Network of Ethernet, PLC and IEEE1394 can be accessed by the attacker disguising as the internal user and can be controlled by the illegal user, causing the physical problem, malfunction or Home-Network communication interruption. (Fig. 4) shows the security threats of wired Home-Network.

#### 3) Wireless Communication Protocol

The wireless protocols available for Home-Network are wireless LAN, HomeRF, Bluetooth, UWB, ZigBee, and etc. Wireless protocols are liable to bootlegging in their nature. Therefore, security arrangements between the transmitter and receiver are very important. At least, the control signals for the in-house devices in the Home-Network service require encryption. Unless this feature is enabled, unauthorized or illegal access and/or control will be possible, and physical failure or unwanted operation may occur. Furthermore, communication failure in the house may occur by attack to the service interruption using cycled wireless access request on the basis of the characteristic of wireless network. Fig. 7 illustrates security threats to a wireless network on the basis of the fire, gas, and invasion detection sensors and bootlegging of internal wireless communication.

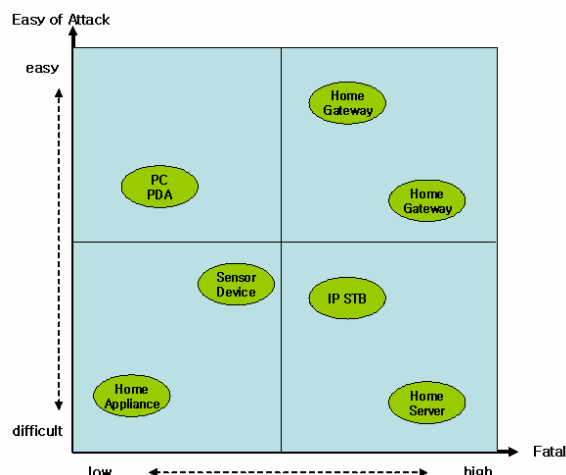


Fig. 4 Priorities of Home-Network Service Protection

For the present, Home-Networks are constructed using wired network protocols, however, wireless protocols have high possibility of replacing the wired protocols except the approach

network. Wireless protocols satisfy the requirements of ubiquitous Home-Network environment with their easiness of installation and excellent mobility [8]. Therefore, considering the possibility of linkage with such infrastructures as RFID and USN, technological development will be required for protection against security threats.

TABLE I  
 HOME-NETWORK PROTECTION METHODOLOGIES BY LAYER

| Module 1: Base Layer, Management Activities |  |   |
|---|--|---|
| Security Features                           | Security Goal: SNMP, HTTP, Telnet, FTP, TFTP   | Countermeasures   |
| Access Control                              | Application layer checks the authority of the access request.  | PKI authentication technology, user authentication, access control, RBAC                                  |
| Authentication                              | Conduct user authentication for access request.  |   |
| Non-repudiation                             | Record the identification of the source that has sent the authentication information, time stamping, random number, etc. should be used in the authentication procedures.                        | Invasion detection & blocking, traffic control technology, IPSEC, NAT, TLS                                |
| Data Security                               | Protected with encryption protocol. The control information such as user authentication information controlled at the network connection point should be protected.                              | Non-repudiation technology, IP security technology, transmission layer security technology                |
| Communication Security                      | Protect by using encryption protocol.  | SSH, IP security technology, transmission layer security technology, detection & interruption of invasion |
| Data Integrity                              | Protect communication information from unauthorized change, deletion, creation, and copy.  |   |
| Availability                                | Protective techniques against the active attacks such as service denial and the passive attacks such as the change/deletion of administrator's information (password, etc.) should be available. | Counter-invasion technology, transmission layer security technology                                       |
| Privacy                                     | Communication information should be protected from use   |   |

|  |                                   |  |
|--|-----------------------------------|--|
|  | by unauthorized person or device. |  |
|--|-----------------------------------|--|

### III. SECURITY MODEL FOR HOME-NETWORK

Various information technologies and home appliances are applicable for Home-Networks. A common structure of Home-Networks controls and uses in-house services by connecting to Home-Network (hereinafter, "HN") through remote access terminal (hereinafter, "RAT"). In Fig. 5, two models are defined for general HNs; the first is the HNSC based Indirectly Service Model (HBISM); and the second is the Home-gateway-based Directly Service Model (HBDSM).

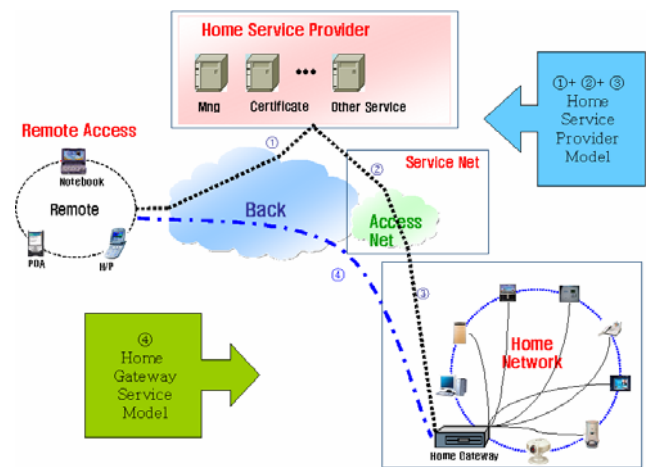


Fig. 5 Home-Network Model

The characteristics of the two models are described herein below:

#### A. HBISM

HBISM assigns the authority of user authentication and access control to Home-Network Service Center (HNSC) when the in-house user uses HN control service. The authorized HNSC provides the service according to the users' request. The problems of the HBISM are the concentration of the services on the service management of HN and related reliability. For the present, the model service providers in Korea are adopting the HBISM model, which has a security function in dual structure of HNSC and home gateway. However, even the simple security filtering function is not used due to the performance degradation of the home gateway. Therefore, the security level of the entire HN services depends on the security level of the HNSC, which is the case of present HN model service providers. The extra cost incurred by using HNSC which is required by the structure of the HBISM should be solved by the differentiated services.

#### B. HBDSM

In the HBDSM model, HN users directly control home appliances by accessing home gateway, thus, depends on the security capability of the home gateway. That is, the

performance of the home gateway and the security are closely related. This model will be able to solve the reliability and cost issues by direct control of the users, not relying on external proxy. However, cautious consideration should be taken because all the on-house information can be disclosed if the home gateway is hacked. The technologies required to solve the security issue of HN are classified by section. This sectional classification will be applicable for these two service models. As shown in Fig. 6, remote access terminals require user authentication, which is implemented with ID and password, for the present. Using ID and password may incur problems because weak points may be exposed to network packet collection. In the future, diversified user authentication techniques such as authorized certificate or biological identification should be implemented for better convenience and safety.

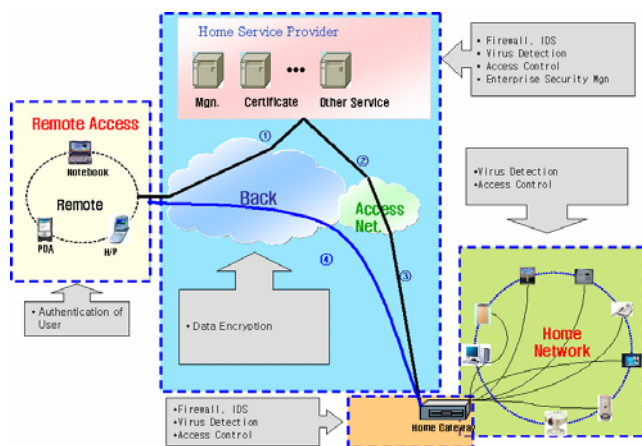


Fig. 6 Security Issue of Home-Network

The considerations on the security of the transmission network are mostly focused on the risk of data exposure. For the present, data encryption of the in-house control signals is required. In addition, there are further issues to be considered, such as invasion blocking, invasion detection, weak point diagnosis, virus detection, user and device authentication, and integrated management (personnel and equipments). Especially, HNSC requires various managerial considerations. To this end, the roles and responsibilities of the service provider and user should be clearly defined in SLA, etc., regarding the assignment of the authority of approaching the subscriber information and access into the house.

#### IV. CONCLUSION

In the future, when the wide-area network is connected with FTTH(Fiber To The Home) for the integration of communication and broadcasting, the hardware and software structures of home gateway need to be developed to implement BcN-based Home-Network performance in addition to the security technologies for network. Therefore, HN is expected to evolve into more complicated and diversified structure, demanding high importance of the security needs.

In conclusion, it is recommended to develop a safe HN service model taking the basic HN security issues, before entering full-scale HN services. It is said that “A disease must not be hidden, but disclosed.” Similarly, security issues should be disclosed to be solved by system improvement and technology development. The service providers shall recognize the importance of the security, as their basic responsibilities, and the users should be aware of the security and observe relevant rules. In addition, differentiated security services should be developed for better service quality, and users should recognize the necessity of security and that safety can be guaranteed according to the service level.

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