Personal Handyphone Systems in Urban Infrastructure

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ABSTRACT: The personal handyphone system (PHS) service began in Japan in 1995. As this new communication service matched social needs well, the number of subscribers quickly reached 7 million in just two years. The changes of the social needs for telephone services progressed from the age of “phones to more homes” to one of “a phone for each person.” This means that we have entered the age of personal communication. In addition, a user’s needs for anytime, anywhere voice and data communication have also increased recently. Against the backdrop of this, the recent immense strides in multimedia, mobile switching and radio communication technologies are attracting attention for the implementation of personal land mobile communications. Hitachi Ltd.’s main components of the PHS network including: the PHS switching system, high-efficiency remote line concentrator, cell station (CS), and CS maintenance system are introduced.

INTRODUCTION
RECENT years have seen active attempts to establish the foundations of the land mobile communication facilities to realize more convenient communications. On the other hand, the opportunity space of people is expanding, and the importance of communication is increasing. These circumstances led to the evolution of the

First generation
- Analog cordless telephone
- Analog cellular telephone
- Pager

Second generation
- PHS: personal handyphone
- Digital cellular telephone
- High-speed pager

Third generation
- Third generation mobile communication system FPLMTS
- Satellite communication system

FPLMTS: Future Public Land Mobile Telecommunication System

Fig. 1—Evolution of Public Land Mobile Communication Systems.
PHS service in Japan, in 1995. The personal station of PHS can be used not only as a cordless telephone in the house but also in the daily living space such as business districts and downtown. The selling point of PHS is that this public communication service is available at a reasonable cost compared to the existing ISDN service.

This article describes the personal handyphone system (PHS) network, which supports personal communication, its components, and technical implementation strategies.

OVERVIEW OF PHS NETWORK
History of Mobile Communication Systems

Fig. 1 illustrates the history of main public land mobile communication systems. PHS is the second-generation mobile communication system for the personal use in the public domain. It is a digital cordless telephone which evolved from the analog cordless telephone, and has developed into a public mobile communication system.

Extending and Evolving Mobile Communication Systems

One of the key features of PHS is that it provides a service with less congestion even in areas of heavy traffic such as downtown, stations, and business districts. This is accomplished by installing radio cell stations every 100 to 200 meters of radius (micro-cell zone configuration). Other features reside in its use: The terminal is quite small and easy to carry and can be used in offices, homes and outdoors.

In addition, the deployment of radio cell stations that have a low transmission power of tens to hundreds of milliwatts contributed to the compact and lightweight design of the terminal and cell stations.
Functions of PHS Network System

The PHS communication fulfills the public’s needs for the following items:

• Mobility and portability: The capability to enable communication anywhere.
• Connectivity: The capability to allow communication with anybody (ordinary phones at the home, mobile phones, pagers, etc.).
• Real-timeness: The capability to enable communication anytime.
• Universal terminal use: The capability to be used not only as a conventional cordless phone (for communication between the base unit and cordless terminal) at the home or office, but also outdoor use.
• Cost effectiveness: Low charges (including call charges, subscription fees, and terminal price).
• Speech quality: High speech quality (good sound quality).

To meet these needs, the PHS network is provided with the crucial functions listed in Table 1. The table also shows the service needs and PHS functions.

**PHS NETWORK CONFIGURATION EXAMPLE**

This section describes an example of the PHS network which Hitachi established. Fig. 2 shows the configuration of the PHS network, and how the provisioned functions are deployed. The function of the major components are as follows:

• Gateway switch: The gateway switch has connection and relay switching functions with other networks (PSTN, ISDN, cellular networks, etc.) and handles all the connections with those networks.
• PHS switch: This switch handles PHS-specific mobile switching and call control such as location registration, handover and paging, as well as ordinary

<table>
<thead>
<tr>
<th>Service needs</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility and portability</td>
<td>Radio communication</td>
<td>Allows radio communications with mobile terminals.</td>
</tr>
<tr>
<td></td>
<td>Roaming</td>
<td>Assures communication even among different service areas (different providers).</td>
</tr>
<tr>
<td></td>
<td>Handover</td>
<td>Assures communications even if the user moves among radio zones.</td>
</tr>
<tr>
<td></td>
<td>Location registration</td>
<td>Traces the location of the terminal and registers it automatically.</td>
</tr>
<tr>
<td></td>
<td>Terminal authentication</td>
<td>Prevents unauthorized use from an invalid terminal.</td>
</tr>
<tr>
<td></td>
<td>Encryption</td>
<td>Assures the security of the radio communication line (prevents eavesdropping).</td>
</tr>
<tr>
<td></td>
<td>Routing</td>
<td>Selects and connects the terminating network and terminating line from the telephone number of the terminating terminal.</td>
</tr>
<tr>
<td></td>
<td>Paging</td>
<td>Pages all the personal stations in the area based on location data.</td>
</tr>
<tr>
<td>Connectivity with other networks</td>
<td>Inter-network connection</td>
<td>Connection with existing telephone networks and ISDN network (subscribers).</td>
</tr>
<tr>
<td></td>
<td>Routing</td>
<td>Connection with a network having a different numbering system</td>
</tr>
<tr>
<td>High quality and advanced functions</td>
<td>Digital communication</td>
<td>Voice quality improved by using error correction and retransmission scheme</td>
</tr>
<tr>
<td></td>
<td>Encryption</td>
<td>Any digital encryption technology can be used.</td>
</tr>
</tbody>
</table>
• Remote line concentrator unit: This unit has a line concentrator function to accommodate cell stations dispersed in remote areas effectively into the PHS switch.

• Home location register (HLR): The HLR station supports the location registration, authentication and location information reading functions. Location information database: Database which retains the location information of each terminal. Authentication information database: Database which retains the authentication information.

• Common channel signaling network: Dedicated network to send and receive control signals (terminal location information, subscriber information, etc.) between exchanges, between exchange and HLR, etc.

• Radio cell station (CS): Carries out digital radio communications with the terminal.

• CS maintenance system: Performs maintenance and operation of all the cell stations. Collects and sets the operation state and control information of each cell station.

In addition to these components, the PHS network has a billing and customer management system to register new subscribers and to bill customers.

**COMPONENTS**

**PHS Switching System: Characteristics of the PHS Mobile Switching**

Table 2 lists the major specifications for the PHS switching system. The following are the main features of the PHS switching system which Hitachi delivered.

1. Merged office classes

   One switch supports all the functions of the gateway switch, PHS switch, HLR and VLR (visitor location register). This eliminates the necessity of installing multiple switching systems to allow setting up a cost-effective switching system. The switch can support not only PHS services but also ISDN services.

2. Wide area handover

   Handover in a wide area is implemented by switching the connection of the PHS switch to the radio cell stations that connect to the moving terminal, one after another. If a different PHS switch is to be used to maintain the connection, the system switches over the communication between switches.

   However, this handover switching complicates the switching system. It is therefore desirable that the PHS switch have the highest possible accommodation capacity for radio cell stations. Hitachi has built a large-capacity switching system with an accommodation capacity of 20 thousand cell stations.

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable office classes</td>
<td>LS, GS, HLR, STP classes merged</td>
</tr>
<tr>
<td>Number of accommodated cell stations</td>
<td>20,000</td>
</tr>
<tr>
<td>Number of accommodated PHS subscribers</td>
<td>The database accommodates data of about 400,000 subscribers.</td>
</tr>
<tr>
<td>Handover range</td>
<td>Among 20,000 cell stations</td>
</tr>
<tr>
<td>Concentration of cell stations</td>
<td>Can be concentrated remotely (connected by 1.5-Mbit/s lines)</td>
</tr>
<tr>
<td>Connection with other networks</td>
<td>Complies with TTC-standard No. 7 signaling system (ISUP, INAP, etc.)</td>
</tr>
</tbody>
</table>

*Table 2. Major Specifications of the PHS Switch*

A PHS switch can accommodate many cell stations. It also merges all the switches which used to be required for each office class to implement multiple office classes by one switch.

TTC: The Telecommunication Technology Committee; LS: line switch; GS: gateway switch; STP: signal transfer point; ISUP: ISDN user port; INAP: intelligent network application port
and a database for 400 thousand subscribers. This enabled wide area handover on a prefecture basis.

(3) High-efficiency remote line concentration of cell stations

One of the characteristics of PHS is that much more cell stations are installed compared with cellular systems, because PHS adopts a micro-cell zone configuration with cell stations having a low transmission power. For this reason, the system cost-effectiveness depends on the efficient concentration of these cell stations and connection of them to the PHS switch. To meet this challenge, a remote concentrator is placed between a group of radio cell stations and the PHS switch to concentrate them and connect them to the PHS switch by high-speed digital lines. Since this improves the line concentration efficiency, dispersed installation of several PHS switches is unnecessary. A single switch can cover a wide area such as an entire prefecture. This helps provide an economical system.

(4) Services supported

In addition to the origination and termination functions by voice bearer channels, the PHS provides a 32-kbit/s digital data communication mode using PIAFS (PHS Internet Access Forum Standard) protocol. This mode is used to either access an Internet provider or for other purposes. Moreover, PHS supports supplementary services which are available with ISDN, such as the call forwarding service and voice mail services.

Cell Station (CS): PHS Cell Station

Two types of PHS cell station are provided: CS which can accommodate two lines and CS which can accommodate three lines on the network side. Table 3 lists the major specifications of these cell stations.

The cell stations are also classified by their applications: a multi-channel type, which is effective where a busy condition should be avoided by deploying many cell stations in a busy place such as in the vicinity of a station, and a single-channel type, which effectively supports a service area with less comings and goings of the population and accommodates communication traffic with a reserve of capacity, mostly in residential areas.

For each cell station, equipment is configured using the common design base. The cell station has the following features:
• A high-sensitivity receiver circuit for a transmission power of 300 mW to implement the optimum transmission/reception balance.
• It can accommodate multiple channels or a single channel into the same housing, so it can be installed flexibly according to the installation location.

### Table 3. Major Specifications for the Cell Station

<table>
<thead>
<tr>
<th>Item</th>
<th>Single-channel type</th>
<th>Single-channel type</th>
<th>Multi-channel type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission power</td>
<td>20 mW (average)</td>
<td>300 mW (average)</td>
<td>300 mW (average)</td>
</tr>
<tr>
<td>Radio zone</td>
<td>Radius: 100 to 200 m</td>
<td>Radius: 400 to 550 m</td>
<td>Radius: 400 to 550 m</td>
</tr>
<tr>
<td>Number of antennas</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Diversity</td>
<td>Delayed detection switching</td>
<td>4-branch maximum ratio composition</td>
<td>4-branch maximum ratio composition</td>
</tr>
<tr>
<td>Transmission power switching</td>
<td>Fixed</td>
<td>20 mW/100 mW/300 mW</td>
<td>20 mW/100 mW/300 mW</td>
</tr>
<tr>
<td>Power</td>
<td>100/200-V AC with battery backup</td>
<td>100-V AC with optional battery backup</td>
<td>100-V AC with optional battery backup</td>
</tr>
<tr>
<td>Number of speech paths</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Number of network lines</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
• It can control the transmission power in three steps to flexibly apply the traffic density according to needs.
• It uses the same frequency repeatedly, and is provided with a radio synchronization function to avoid any radio slot overlapped with another cell station.
• It adapts to needs for higher-speed data communication by, as standard, equipping it with a radio control codec which supports even future data communications (64-kbit bearer communication).

CS Maintenance System
In a PHS system, tens of thousands of cell stations are usually installed in locations which are hard to access such as on poles or in the ceiling of underground arcades. This means that the establishment of a quick and proper maintenance method for already installed cell stations is a crucial issue for operation and maintenance personnel.

The CS maintenance system collects alarms and control information from such dispersed cell stations to save time and cost in maintenance and operation of CSs. The main features of this system are as follows:
• Centralized management of data for 20 thousand cell stations by one database.
• Improved reliability by the duplicated server and disk.
• A graphical user interface (GUI) to increase the efficiency of the CS maintenance. Fig. 4 is an example of the maintenance screen.

CONCLUSIONS
We have seen an implementation example and strategies of the PHS network which supports personal communications in Japan. PHS is suited for mobile communication in urban districts. It is expected that PHS will spread all over the world in the future.
In addition, it is said that the trend of personal communication such as PHS will be furthered in the field of public land mobile communication. We would like to contribute to build a more convenient and user-friendly public communication network.

REFERENCE
(1) PHS MOU Group, Public Personal Handyphone System: General Description of Network and System Configurations, Ver. 2, B-NW 0.00-020TS (1996).