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Web Service Definition and Validation, and Performance Analysis and Implementation of Control Tower for CCTV Sites

YoungWook Cha and ChoonHee Kim

Andong National University, Daegu Cyber University
ywcha@andong.ac.kr, chkim@dcu.ac.kr

Abstract

It is required to implement an integrated management as to the configuration, failure and power in order to stop the service of devices installed CCTV sites and minimize the on-site dispatch of maintenance staffs. This thesis defined RESTful web service based R4CSM-API (RESTful web service for CCTV Site Management-API) instead of SNMP that had some limitations for the purpose of implementing an integrated management of CCTV sites. In this thesis, the performance analysis was conducted using Emulab environment of KISTI as to the main functions of CCTV site integrated management. Also, an effective CT4CS (Control Tower for CCTV Sites) was designed and implemented for an integrated management of large-scale CCTV sites by utilizing the performance analysis results. Moreover, we validated the R4CSM-API that would be conducted at CT4CS by utilizing RESTClient that is an experimental tool of RESTful web service.

Keywords: *CCTV site, integrated management, RESTful web service, R4CSM-API, CT4CS*

1. Introduction

IRTF (Internet Research Task Force) recognized that web service based management was a good technology to address the data expression limitation, transaction and security related problems of SNMP [1]. Twente University proved that the performance of web service was as good as SNMP (Simple Network Management Protocol) [2]. RESTful (REpresentational State Transfer) web service is able to access only with basic request-types of HTTP, GET/POST/PUT/DELETE to those resources that allow for a variety of expressions. In addition, RESTful web service allows providers to offer resources directly to requesters without any intermediary whose job is to register and store [3, 4]. For this reason, RESTful web service is widely used in a variety of fields ranging from telecommunication to Internet service [5-7].

In South Korea, the deployment of video controlling system will be completed at all the municipalities nationwide until 2015 under the leadership of the government. The main functions of video controlling system are real-time monitoring of video data through network and search and log management of saved video data [8]. There are still some disruptions to the normal operation resulting from a failure of the equipment caused by an abnormality associated with the use and installation of equipment despite the rapid development of ICT technologies. The consequent service absence and input of manpower for recovery have resulted in a considerable amount of loss to large enterprises that had a high degree of dependency on network. A majority of failures associated with equipment located at CCTV site are recovered only through a restart action of turning on power again. It is required to implement an integrated management

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as to the configuration, failure and power in order to stop the service as to hundreds of CCTV sites and minimize the on-site dispatch of maintenance staffs.

This thesis defined RESTful web service based R4CSM-API (RESTful web service for CCTV Site Management-API) instead of SNMP that had some limitations for the purpose of an integrated management of CCTV sites. In this thesis, the performance analysis was conducted using Emulab environment [9] of KISTI as to the main functions of CCTV site integrated management. Also, CT4CS (Control Tower for CCTV Sites) was designed and implemented for an integrated management of large-scale CCTV sites by utilizing the performance analysis results. Moreover, we validate R4CSM-API that would be conducted at CT4CS by utilizing RESTClient that is an experimental tool of RESTful web service.

2. Related Studies

2.1. SNMP and Web Service Based Management

SNMP is the Internet management protocol using the connectionless transport layer. Thus, it can hardly respond effectively to an increase in network size and management information due to the limited data expression, limited message length and reliability [1]. The network management research group of IRTF recognized web service based management as a solution for the limitation of SNMP, transaction and security related issue. Twente University proved that web service was as good as SNMP in terms of bandwidth, memory use, CPU usage time and round-trip delay [2]. The NetConf working group of IETF (Internet Engineering Task Force) standardized the web service based configuration management using SOAP (Simple Object Access Protocol) [11] between managers and agents [12].

PING (Packet Internet Grouper) is widely used for real-time failure management as a complementary tool of SNMP used in the general-purpose network management. In [13], the network load state for the campus network using the delay time and response presence of PING message was verified, whereas PING was utilized to confirm the degree of packet loss and the access status and path of system in [14].

2.2. Comparisons of Web Services and Applications of RESTful Web Service

SOAP based web service [11] was initiated for the inter-working of applications in a business environment. In contrast, RESTful web service [4] was initiated for the purpose of allowing Internet service providers to offer data conveniently to application developers. SOAP based web service is developed through the strict standard and well-equipped infrastructure of W3C. RESTful web service, which requires only the basic Internet standards, can access those resources allowing for various expressions (XML, JSON, HTML, image, *etc.*) only with the basic types of HTTP. Furthermore, it's another distinctive feature is that the status information of clients is not managed at the server. With this simplicity and convenience of development, such Internet giants as Google, Amazon, Yahoo, Twitter, *etc.* are opening their own information resources through RESTful web service based API and 85 percent of open-type API at Amazon is RESTful web service [3] .

In [5], RESTful web service functional structure of short messaging, payment and account management was designed in order for IT developers to create applications by using communication elements. The number of transactions per second (TPS) at the service gateway that includes web services was measured. It presented a possibility of new service generation by using TPS measurement and the proposed web service functional structure. In

[6], the web service implementation of character string connection and floating point addition was placed in the Glassfish application server of Sun Microsystems; thereby, showing that the message size and response time of RESTful web service is better than SOAP. CoRE (Constrained RESTful Environments) working group of IETF proposed a draft version of RESTful web transmission protocol that redesigned several functions of HTTP for M2M application in a small-sized device such as a sensor node in 2010 [7].

2.3. Video Controlling System and Power Distribution Unit

The most prominent CCTV video controlling systems in overseas include 3VR and Verint in the United States and Bosch in Germany. In South Korea, TYBIS VMS (Video Management Solution) of Innodep and XIDE-SD of RealHub are widely utilized. The main functions of these video-controlling systems include vehicle number recognition, illegal parking crackdown and children protection through remote video equipment rather than site-wide integrated management [15]. PDU (Power Distribution Unit), which is installed for the site power management, is classified into meter-type PDU allowing for current measurement and intelligent-type PDU allowing for on/off control of each power port. Only 20 percent of those rack-installed PDUs sold in 2011 was an intelligent PDU and the intelligent PDU products are estimated to grow at a twice faster rate than those non-intelligent types until 2017 [16].

3. RESTful Web Service of Integrated Management for CCTV Sites

3.1. Configuration and Functions of Integrated Management for CCTV Sites

Figure 1 shows the integrated management configuration based on centralized integrated management system (CT4CS) and intelligent power distribution unit (IPDU) for the purpose of minimizing service interruptions as to numerous CCTV sites.

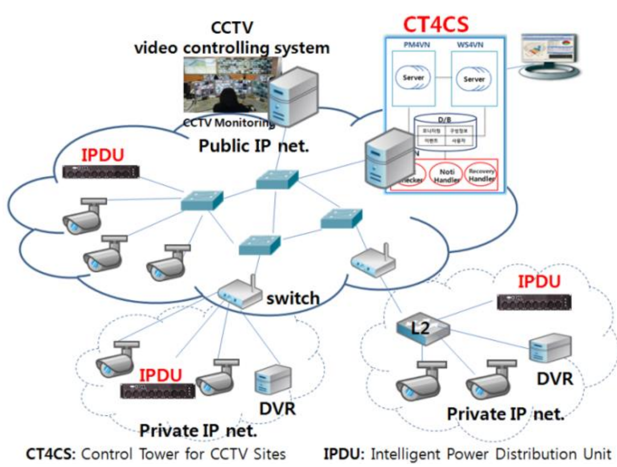

Figure 1. Configuration Diagram of Integrated Management for CCTV Sites

The following information describes the main functions of CT4CS that would perform comprehensively the configuration and failure management for the video and network equipment at CCTV sites and also the remote power management through IPDU.

1) Configuration management and power management of CCTV sites

- Management of configuration in the unit of region and function as to the sites of private and public IP address environment
- System information of CT4CS (name, address, installation location, contact information, OS version and H/W specification)
- Basic operation environment (temperature and humidity) of IPDU and threshold setting of each power port and current monitoring
- Statistical data processing of CCTV sites (IPDU installation, camera type and event statistics)

2) Failure management of CCTV sites

- Failure detection of CCTV sites using network connectivity and current usage status diagram and automatic recovery of failed equipment through restarting the power port of IPDU
- Event log inquiry (type, equipment, place and time) and event filter setting
- Real-time display of events that took place in CCTV sites by using national map
- Notice on the events in real time to smart devices through Google's GCM (Google Cloud Messaging) service and notice on the recent events by using email

3) Account and access log management

- Authority setting to grant differential authority for administrators and users and log-on/log-out management
- Log management for administrator's access to CT4CS to modify and set

4) Backup management of important data

- Daily backup of site registration information, log data and current monitoring information (everyday 01:00)
- BP (backup period), DKD (data keeping duration) and DRP (data removal period) based backup management

3.2. Definition of R4CSM-API

RESTful web service based R4CSM-API is defined for the integrated management of CCTV sites as it is commonly used between web and application based management terminals and CT4CS. R4CSM-API provides GET, GET-BULK, and SET functions of SNMP by using GET, POST, PUT and DELETE request types of HTTP message. The information form of R4CSM-API is classified into management object, group and table. The management object is a target to be managed just like the system name of SNMP MIB2 [1], and a group also represents a collection of management objects that have a high correlation in terms of management. A tale lists entries that will be configured as management objects [17].

URL of R4CSM-API request message commonly includes "CT4CS address/information type (table, group, object)/information name/" and leveraged URL usage rule defined in [18]. The main function of CT4CS is the real-time failure detection of IPDU, network and video equipments located at hundreds of CCTV sites. Table 1 shows the request types and ~~URL~~ URLs of R4CSM-API for power port control of IPDU, event notification and log for failure management.

Table 1. R4CSM-API's Request Types and URLs for Fault Management

type	URL/parameters: description
PUT	/table/ipdu/entry/restart-flag: setting of IPDU port's power on/off
GET	/table/event-log/entry/default: event query from all sites
GET	/table/event-log/indexes/ipdu-name/{ipdu-name}/default: event query about a specific site
GET	/table/event-log/entry/indexes/start-time/{start-time}/default: event query from a starting time
GET	/table/event-log/entry/indexes/area/{area}/counts/{counts}: recent event query on a specific area
GET	/table/event-chart/entry/indexes/area&start-time&end-time/{area&start-time&end-time}: ratio of event classes as to a specific area/a designated duration
GET	/table/event-chart/entry/indexes/start-time&end-time/{start-time&end-time}: number of failures as to a specific area/a designated duration
PUT	/table/notification-filter/entry: setting of event filter
GET	/table/notification-filter: query about event filter
POST	/object/gcm-id: ID registration for GCM
DELETE	/object/gcm-id: deletion of ID
PUT	/object/gcm-flag: setting of GCM flag to use or not

CT4CS determines operation interruption or failure of equipment in real time by utilizing the information on the current consumption and network connectivity of equipment. Also, it performs failure recovery by re-operating the power port of IPDU connected to the equipment. Among the entries of IPDU table, the schema and XML representation of setObjectsInEntry for switching on and off the power port as to a particular IPDU are as shown in Figure 2.

Figure 2. Schema of Set Objects in Entry and XML Representation of Power Port Setting

3.3. R4CSM-API Validation

3.3.1. Testing Environment for Validation: CT4CS verifies the XML information contained in the request message by using the schema as to R4CSM-API of POST and PUT types. It verifies URL and parameters as to GET and DELETE. RESTClient 2.3.1 tool [10] to be used for the verification can generate and check out various web service messages of normality and abnormality. The web service request is transmitted to CT4CS since it selects the input of URL and request type, which correspond to R4CSM-API. It is possible to upload those already created XML files when POST or PUT is requested. The status line information of HTTP included in a response message is confirmed at the screen of RESTClient; thus, it is possible to validate R4CSM-API conducted at CT4CS and test the implementation result hereof.

3.3.2. Validation Items and Results: The validation items and status codes of R4CSM-API are as shown in Table 3. When an error takes place in a request-API, such status phrases as schemaError, paraError, opsError, loginError, gradeError, *etc*. will be transmitted to an administrator in the form of response message together with the status code in accordance with the error type.

Table 2. Validation Items and Status Codes for R4CSM-API

R4CSM-API	request type	status code	
		normal	error
/table/users/entry	POST	201	400
/table/users/entry/indexes/id/{id}	GET	200	400
/table/ipdu/entry	POST	201	400
/table/ipdu/entry/indexes/ipdu-name/{ipdu-name}	DELETE	204	400
/table/ipdu/entry/indexes/area/{area}/all	GET	200	400
/group/power-sensors	PUT	200	400
/table/ipdu/entry/restart-flag	POST	201	400
/table/event-log/entry/indexes/area/{area}/counts/{counts}	GET	200	400
/table/notification-filter/entry	PUT	200	400
/table/hour-current-log/entry/indexes/ipdu-name&start-time&end-time/{ipdu-name&start-time&end-time}	GET	200	400
/table/access-log/entry/indexes/start-time&end-time/{start-time&end-time}	GET	200	400
/object/gcm-id	POST	201	400
/group/ipdu-chart	GET	200	400
/group/camera-chart	GET	200	400
/table/event-chart/entry/indexes/area&start-time&end-time/{area&start-time&end-time}	GET	200	400
/table/event-chart/entry/indexes/start-time&end-time/{start-time&end-time}	GET	200	400
/group/sysInfo	PUT	201	400
/group/sysInfo	GET	200	400

The validation result of "/table/ipdu/entry/restart-flag" API for switching on and off the power port as to a particular IPDU is as shown in Figure 3. “201 Created” is returned as a status line of response message when the schema validation of setObjectsInEntry in the body of POST type message and setting process are successfully completed. When the schema validation is failed for the XML information of request message, the status line with "400 Bad Request" and the character string representing the failure reason and location will be returned in the body of response message.

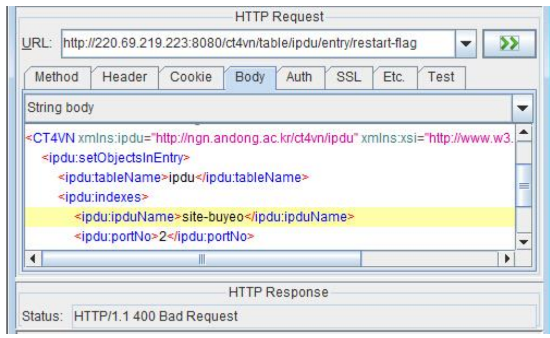

Figure 3. Setup Failure of Power Port Setting

4. CT4CS Performance Analysis and Implementation

4.1. Configuration of CT4CS

As shown in Figure 4, CT4CS is composed of WS4C (Web Server for CT4CS), IM4C (IPDU Manager for CT4CS), DM4C (Device Manager for CT4CS) and the database saving the configuration and account information, and log data.

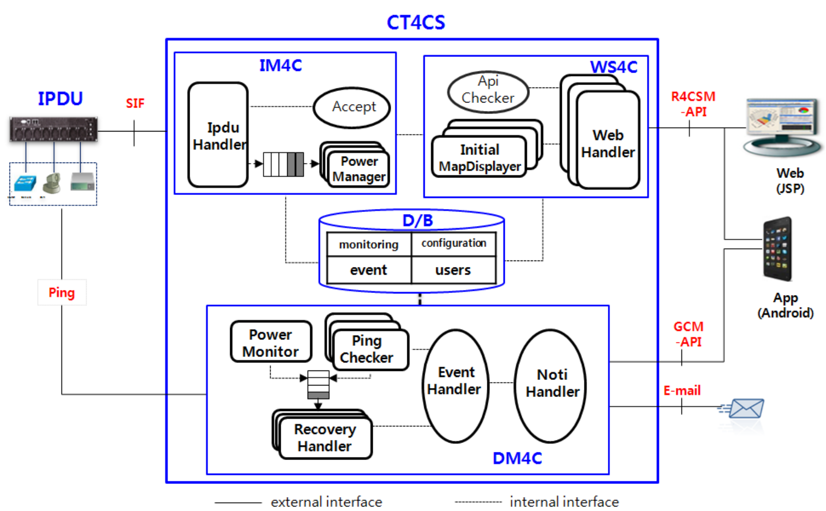

Figure 4. CT4CS Configuration

WS4C provides an integrated management function of CCTV sites through the application and web based management interface (GUI), and IM4C performing the power management has a socket based external interface with IPDUs. DM4C performing failure management has PING interface for network inspection of remote equipment, email and GCM-API for event notification as an external interface. It has an internal interface for Java method call and database access between CT4CS modules. To determine an effective CT4CS implementation structure, we carried out the performance analysis in accordance with the thread structure of IM4C and DM4C. Since it is not possible to construct IPDU and equipment of CCTV sites on a large scale just like an actual environment, this study conducted the experiment by constructing the emulator of CCTV sites on a large scale in Emulab of KISTI [9]. Emulab provides an environment that supports for the control on a number of actual PCs remotely and allows users to configure and use a network.

4.2. Performance Analysis and Implementation of WS4C

WS4C module is consisted of WebHandler thread generated for each request through GUI as shown in Figure 2 and ApiChecker and InitialMapDisplayer that are called from each thread. ApiChecker verifies the URL effectiveness of HTTP request message through Matches class of Java. Also, it validates XML information contained in a message by using SchemaValidator class. When the validation is successfully completed, it performs the integrated management function of inquiry, generation, deletion and modification through PostgreSQL D/B by using the parameters and request types extracted from XML information and URL. It has internal interface with the IM4C module for the management of IPDU through GUI.

It is required to access to the server twice with Naver's open API in order to represent an area of CCTV site on the map. First, it is required to inquire the coordinate values of a site by using the address and access to the server once again to represent the site location on the map. Saving and using the coordinate of each site in D/B violates the copyright of Naver’s map open API; thus, it is required to obtain the coordinate of each site through open API having the address as a parameter whenever necessary. InitialMapDisplayer performs the function of outputting locations of CCTV sites registered in D/B on the map whenever the event monitoring is requested by an administrator. It took 37 seconds for InitialMapDisplayer of a single thread implementation and 7 seconds for 5 multiple threads in the case of outputting 100 CCTV sites. InitialMapDisplayer was implemented through the multiple threads in order to minimize the time to take for outputting locations of numerous sites.

4.3. Performance Analysis and Implementation of IM4C

IM4C module controls power ports of IPDU, sets up temperature and humidity and processes real-time and periodical notification of IPDU. IpduHandler thread communicates with IPDU of each site with asynchronous socket. It calls Accept method when requesting for a connection so that it can register and manage a client socket of IPDU. The response and notification message received from IPDU will be transmitted to the message queue in order for PowerManager thread to process those messages. Figure 5 represents the processing time in accordance with the arrival rate of IPDU notification message as to the implementation structure of PowerManager thread. The arrival rate of a message is a variable to be determined in accordance with the number of IPDUs managed by CT4CS and notification cycle.

The dynamic structure generates a thread to process a message whenever a message is arrived. The static structure with only one thread has a drastically increased message processing time with an increase in the arrival rate. When the message arrival rate is 60 or higher, the processing time of dynamic structure becomes better than the static structure having 3 threads. The dynamic structure has an advantage in terms of processing time as compared with the static structure. However, it may also increase system load due to the excessively generated threads resulting from a high message arrival rate and also the complexity of operation. Since the number of IPDU to be managed by CT4CS is few, it shows a similar performance regardless of the implementation structure of thread when the arrival rate is less than 20. PowerManager thread of IM4C was implemented through two static structures in order to process notification messages in real time, which are received from IPDUs of numerous CCTV sites.

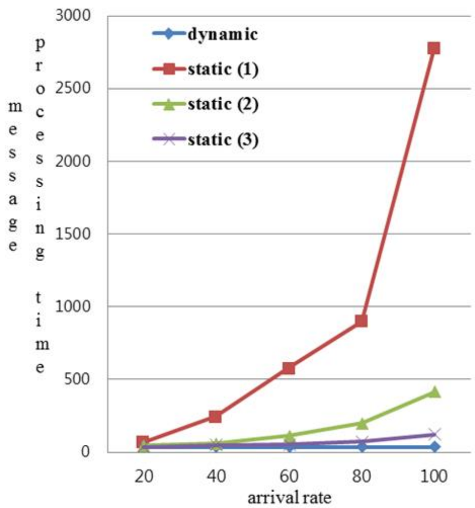

Figure 5. Message Processing Time as to Implementation Structure of Threads

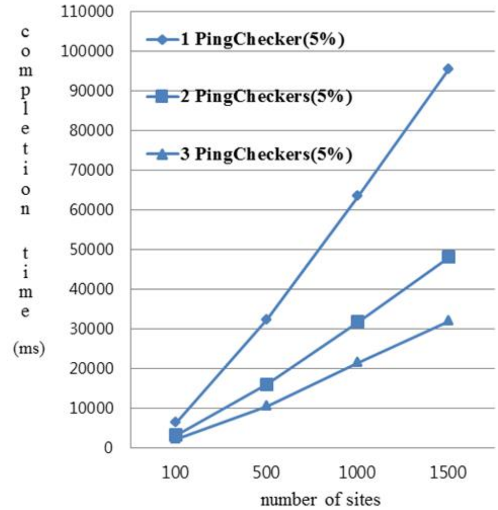

Figure 6. Inspection Time in Accordance with Failure Rate and the Number of Threads

4.4. Performance Analysis and Implementation of DM4C

DM4C is the module that verifies the network status of equipment in a site periodically and performs failure detection and recovery in real time. PingChecker thread checks out the network status of each device periodically by using PING and inserts a recovery event into the message queue whenever a failure is detected. RecoveryHandler thread dynamically generates a thread that will recover a failure by reading the recovery event of the message queue. A recovery thread recovers a failure of the equipment remotely since it turns on again the power of equipment through IPDU. EventHandler detects a failure of the equipment in accordance with the network status diagram and saves an occurred event in D/B. NotifyHandler notifies an occurred event to the email and smart devices and outputs an event in the location of a site in which an event occurs by utilizing the map open API in real time.

Figure 6 represents the inspection completion time of PING in accordance with the number of CCTV sites, the failure rate of PING and the number of PingChecker threads. This study assumed that each CCTV site has 3 devices to be checked by PING message and granted a delay time and PING failure rate for a similar performance analysis to an actual environment. The inspection completion time is the mean value of 200 tests for each item and the failure rate of PING is the most important influencing factor on the completion time. PingChecker, which was implemented through a single thread, can inspect the devices sequentially. Also, it can perform PING inspection concurrently when it is implemented through multiple threads. In the case of sequential inspection, it will be on standby until the completion of PING response time as to a device having a failure. Thus, the overall inspection completion time will be increased. It is imperative to select the number of threads that can perform PING inspection of CCTV sites on a large scale concurrently while minimizing the load of CT4CS system. When the number of threads for PingChecker was 2, the inspection completion time was measured at 31,836ms for the failure rate of 5 percent in relation to the 1,000 sites. As for the requirement of conducting PING test periodically with 60 second cycle on the 1,000 sites, PingChecker could be implemented through at least 2 threads in an environment with 5 percent failure probability.

5. Conclusion

This thesis described the configuration of integrated management of CCTV sites and the functions of integrated management by using IPDU and CT4CS. This thesis defined RESTful web service based R4CSM-API for the integrated management and presented the verification items and status codes for the effectiveness validation of API. It confirmed that the validation check of CT4CS was properly operating as to the normal and abnormal API generated through RESTClient.

We performed the performance analysis as to the main functions of integrated management in order to determine an effective CT4CS structure for a large-scale CCTV site. PowerManager of IM4C was implemented through 2 static threads in order to process in real time the notification messages received from IPDUs of numerous sites. PingChecker of DM4C was implemented through 2 static threads for PINC inspection of 60 second cycle at an environment having 5 percent failure probability in relation to the network status of equipment installed at the 1,000 sites. InitialMapDiplayer of WS4C was designed to minimize the required time to represent locations of numerous CCTV sites on the online map. It was confirmed that the implementation of 5 multiple threads was decreased by 81 percent as compared with the implementation of a single thread for the output of 100 sites.

As for a follow-up study item, it is planned to expand RESTful web service based management on overall by leveraging COAP (Constrained Application Protocol) of IETF instead of the proprietary socket interface defined between IPDU and CT4CS.

Acknowledgements

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Authors

YoungWook Cha. Professor YoungWook Cha obtained his PhD in Computer Engineering from the Kyung Pook National University in South Korea. He is currently a professor of Computer Engineering Department at Andong National University in South Korea. His research interests include SDN, open interface, and network control and management.

ChoonHee Kim. Professor ChoonHee Kim obtained his PhD in Computer Engineering from the Kyung Pook National University in South Korea. She is currently a professor of Electronic & Information Communication Engineering Department at Daegu Cyber University in South Korea. Her research interests include NGN, open interface, and network control and management.