Jong-Hyeon Henry Lee <jhlee@acm.org>

Project: CDMA Digital Cellular System-Home Location Register
Employer: Electronics and Telecommunications Research Institute, Korea
Term: February 1991-December 1995

1) Application of theory
   a) Analysis of requirements

This project was designed to implement a complete set of digital cellular networks that complies with a standard IS-95A/narrowband CDMA (code-division multiple access)-based 2nd generation digital cellular system. Since the standard IS-95A was an interim stage, there had been many revisions to finalise the standard, and we also contributed to its standardisation process. This project involved various telecommunication entities including switching systems, location registers, radio base stations, and cellular terminals (mobile phones). This project was funded by the Ministry of Information and Communication, Korea, and it had lasted for five years since 1990. The outcome of this project became a base infrastructure for the current mobile communication network in Korea. The part that I had been involved was the implementation of a home location register.

   b) Design and construction

The home location register is a location database in the cellular network and stores cellular subscribers' information for call setup and charging. Since this project was designed on the concept of the Intelligent Network, the whole network works like an information system, quite differently from conventional telecommunication systems. It requires several databases in the network; the home location register is one of them.

The basic principle of the system design was simple: we follow as many standards as possible to make the system as compatible as possible with future standards. Since this system is a part of a large-scale telecommunication system, it would work with various systems and the only way to maximise compatibility is to follow standards defined by market leaders or international standard bodies. We also participated in the standardisation process of the standards that we adopted.

The IS-95A standards were officially released in the middle of the 1990's; we had been implementing a home location register based on the ITU-T Q.1000-series recommendations of the International Telecommunication Union and interim versions of IS-95A.

We implemented the register by following the Signalling System 7 (SS#7) specification, and it consists of a functional layers Message Transfer Part (OSI layer 1), Signalling Connection and Control Part (layer 2), Transaction Capabilities Application Part (layer 3), Application Service Elements (layer 7), and Application Processes (layer 7). The lower layers (1-3) handle message transactions with communication peers, and the business logic is defined and processed in application service elements and application processes.

Since the location register is a stand-alone system, it needs a subsystem for operation and administration that shows the current status of the system, sets up configuration, and controls the access to the system. I used the X Window system (X11R4) with Motif for the presentation of the system status and followed ITU-T Z.300-series Man-Machine Language (MML) for command line operator interface of the register.

We followed common practice of the information systems industry rather than that of the telecommunication industry, since we took the approach of the intelligent network. For example, CHILL is a standard language for telecom entities, defined by ITU-T, but we decided to use the C language for implementing this system. We then found that many other communication system builders had also adopted C instead of telecom-specific languages.

Our implementation used many *de facto* standards in the computer industry like X Window, TCP/IP socket, etc.; this was not a common approach in the telecommunication industry in early 1990's.

   c) Process engineering

There were committees to assess product results and performance of development process, and we had produced reports for our performance with results every month in addition to the annual report of the project.

d) Quality control

We applied the white box and black box tests to entities in the system. Those tests were performed internally by our team.

Since the home location register is a part of the digital cellular network, we need a comprehensive integration and interworking test between other communicating entities like visitor location registers and cellular phone switches. We set up all communication entities in a building and tested every item based on its integration requirements.

Since this system was developed for commercial services to the general public, the performance was also important and load tests were crucial. We made a full system configuration in the same way used in a commercial service and tested our system for a year. In the meantime, we fixed reported bugs and enhanced system performance.

e) Asset management

Since ETRI is a government-sponsored research firm, all the source codes, patents, and documents for design, implementation, and testing should be registered in the ETRI library or in the government intellectual property office. Each revision of a document is also registered in the library.

f) Project management

Since I was not the manager, but a software engineer, of this project, I did not plan the whole project, but every software engineer defined the project life cycle of his or her part according to the life cycle of the whole project. I produced the documents and source codes based on the life cycle. Since this project was a long-term project which ran for five years, we had made an annual plan for project progress, expenditure, and quality control of the result every year and had needed to get yearly approval from the project management committee.

2) Practical experience

The system we implemented was adopted as a national standard. We transferred our implementation to telecommunication system vendors including Samsung, LG, and Hyundai, so that they could commercialise and manufacture it. We also transferred the administration techniques to telecom service providers including SK Telecom and DACOM, so that they could learn how to maintain the system.

3) Communication skills

Since this was a part of a huge project and many developers might move around during the project, clear communication with other teams and departments was crucial. To achieve this, we had a weekly meeting and produced weekly work report. Without clear communication skills, we could not complete the project.

Another way to achieve clear communication is to make documents clear. We define our system at four levels: a system, subsystems, modules, and units. In each level, we produced a specification of requirements, a design document, and implementation memorandums, so that any newcomers could understand how the system works.

4) Social implications of engineering

The value of the implementation of the 2nd generation CDMA digital cellular system is enormous. When we started the development of the system, there was no commercially used CDMA system in the world, and this technology had been used only in the military. Most commercial digital cellular systems used TDMA (time-division multiple access) systems like Europe's GSM and the US's digital cellular system. However, we saw the benefit of a CDMA system, which can enormously increase the capacity for handling mobile subscribers at the same bandwidth, and we proved that CDMA systems could work well commercially and save the bandwidth. Nowadays, CDMA systems have become quite common for Personal Communication Systems (PCS), which is now the standard form of mobile communication systems in many places. The estimated overall economic effect of this development project to the Korean industry so far is $56.7 billion while the total cost of the project was $185 million.