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Implementation Experience of a Mobile Workstation

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Abstract - This paper describes a practical experiment on building a radio mobile workstation in Taiwan. The mobile workstation consists of a mobile radio telephone, a portable computer, and some connected interfaces. Because of the noise interference, the coding scheme used in this project provides error-detection, error-correction, and data secrecy. The remote file server can communicate with the mobile workstation wherever it is, and gives immediate response.

I. Introduction.
In 1989 the Taiwan Telephone and Telegraph Office established the business in the Mobile Radio Telephone (MRT). Only 2 types of MRT were permitted at that time: they are the 4W MRT for automobile and the 1.6W for portable. This business not only opens up its service scope but also provides unlimited application of the computer radio communication. This permits a mobile computer to communicate with a remote host without any physical connection. Hence, policemen can use it to inquire any information in a remote host and obtain an immediate response. Managers can also handle the latest condition in his or her company by using a mobile workstation. The technique presented in this paper can be applied also to other radio data communication for navigation and to military operations. Since Taiwan is an island with relatively high mountains and there is practically no FCC regulation, this project supported by Industrial Technology Research Institute (ITRI), was to test the radio data communication feasibility using the newly available MRT facility.

Some average sky noises such as the atmospheric noise, the galactic noise, and the water vapor described in [1] exist everywhere. In addition to the white noise, the thermal noise and shot noise also affect the communication error rate of a mobile workstation. In order to overcome the interference from these noises, a transmission protocol and a mixed coding system are developed in our project. After several modifications, the mobile workstation was successfully built and tested in the summer of 1990.

Section II of this paper describes the system architecture and the communication protocol. The operation and coding scheme of the mobile workstation is presented in section III. Some implementation experiences are discussed in section IV. Finally, section V gives a conclusion.

II. System architecture
The system architecture is shown in Figure 1. A remote host is served as a file server that provides abundant information to users. The inquiry of mobile workstation is modulated by a modem and transmitted by the MRT. The modulated signal will be delivered by Taiwan telephone network system to the file server. There are many cellular sections in the network system, and each section has various re-locatable and reusable channels. Hence, a communication may be connected several times by the network system when the automobile runs across many cellular sections. A mobile base station consists of a radio receiver, a transmitter, an antenna, and a monitor equipment. They are used to transform the radio signal to the signal compatible to the telephone system and vice versa. The mobile base station is controlled by the mobile control station. The another end of cellular mobile telephone system is a mobile telephone exchanger which comprises an interface to the long-distance call network. The inquired information is sent back using the same path.

![Figure 1. The communication system for the mobile workstation.](image1.png)

![Figure 2. The system model.](image2.png)
The model for this communication system is illustrated in Figure 2. We break the model into four layers. The physical layer deals with the mechanical, electrical and procedural interfaces. The main task of the data-link layer is to take a raw transmission facility and transform it into a line that appears free of transmission errors to the coding layer [6]. Hence, the flow control and the error handling are provided by this layer. During the test phase, a noise generator is inserted between the physical layer and the data-link layer in the file server. The objective for this noise generator is to simulate the noise interference in the communication medium. In addition, the coding layer is used as a guard for detecting and correcting errors of the received data, and for defending the secrecy of transmitted data. The upper layer involves all functions in the transport layer, session layer, presentation layer, and application layer of the ISO Open Systems Interconnection (OSI) reference model.

- Preamble
- Frame type
- Number
- End
- Sym
- Ip No
- Data
- End

Figure 4. Data frame format.

In our project, the data frame format is defined as in Figure 4. There are five fields. The first field is the preamble field which is used to mark the frame boundary. The second field is the type field which is used to distinguish the data frames from the control frames. The third field is a sequence number. A sequence number is attached to each data frame at the transmitter; and the receiver will acknowledge or non-acknowledge each frame according to their sequence number. The fourth field is the data field. The last field is the end delimiter. Because of the noise interference, both the maximum frame length and the time-out period are defined during system startup time. This permits us to fine tune our system according to the working environment.

III. Software operations

In this section, both the protocol specification and the coding scheme for the mobile workstation system will be presented as follows.

• Program in Estelle

A protocol specification language Estelle (Extended State Transition Language) recommended by ISO is used to specify these operations of our mobile workstation. Figure 5 shows the module relationship of the system model. Three modules and two interconnecting links between them are depicted in this figure. The form of a transition specification in Estelle is shown as follows.

Mobile_phone:

1. MOD1: Upper N
2. MOD2: Mobile N
3. MOD3: Physical P

Figure 5. The module relation of workstation described by ESTELLE.

Specification Mobile_workstation:
default individual queue;
/** Default-option **)
timescale seconds;
/** Time-option **)
Const Lastbit = ...;
(determines packet size)
MaxSeq = 1;
RT_Time = ...;
(Re-transmission time)
Retry = ...;
type Bit = 0; 1;
SequenceNr = 0.MaxSeq;
packet = packet array [0..Lastbit] of Bit;
FrameKind = (Header, Data, Ack, Nak, Err);
Frame = packed record
   Kind: FrameKind;
   Seq: sequenceNr;
   Info: Packet;
end;

Link NAP(User, Provider);
/**Channel definition**)
   by User: DATA_CONFIRM(N_Data: Packet);
   by Provider: DATA_INDICATION(N_Data: Packet);
end;

Link PAP(User, Provider);
   by User:
      S_REQUEST(P_Data: Frame);
   by Provider:
      R_REQUEST(P_Data: Frame);
end;

module UpperLayer process;
/**Module definition**)
ip N: NAP(User) common queue;
end;

module Mobile process;
ip N: NAP(Provider) common queue;
P: PAP(User) individual queue;
end;

module PhysicalLayer process;
ip P: PAP(Provider) individual queue;
end;

/** Body definition for modules **)
body UpperBody for UpperLayer, external;
body PhysicalBody for PhysicalLayer, external;
body MobileBody for Mobile;
var R: Packet;
   S1, S2: Frame;
NextFrameToSend, FrameReceived, RT:
sequenceNr;
state Idle, Active;
/**state of physical layer**)
procedure Exit(0), external;
procedure IncVar k: sequenceNr;
begin
   if k < MaxSeq
      then k := k + 1
   else k := 0

end:
initialize;
to Idle
   NextFrameToSend := 0;
   FrameReceived := 0;
end;

/**transition declaration of the par process**)
repeat
/** packet from upper layer is made to frames**)
/** then sent to the physical layer when window is not empty**)
from Idle to Active
   when N.DATA_INDICATION
      begin
         S1.Kind := Data;
         S1.Seq := extFrameToSend;
         S1.Info := N_Data;
         Rt := 0;
         output P.S_REQUEST(S1);
      end;

   from Active to Active
   when P.R_RESPONSE
      /**Acknowledgement is received**)
      if P_Data.Kind = Ack then
         begin
            Inc(NextFrameToSend);
         end;

   (**frames incorrectly receive then sent a Nack back**)
   if P_Data.Kind = Err or P_Data.Seq <>
      FrameReceived
      begin
         S2.Kind := Nak;
         S2.Ack := FrameReceived;
         output P.S_REQUEST(S2);
         Inc(Rt);
         if Rt = Retry then Exit();
      end;

   /**response using the received header and a Ack**)
   if P_Data.Kind = Header then
      begin
         S1.Kind := Ack;
         S1.Seq := NextFrameToSend;
         S1.Info := P_Data.Info;
         Rt := 0;
         output P.S_REQUEST(S1);
      end;

   /**asking the upper layer to retransmit the damaged frame**)
   if P_Data.Kind = Nack then
      begin

SI.Kind := Data;
SI.Seq := P_Data.Seq;
SI.Info := buffer;
Rt := 0;
output P.S_REQUEST(SI);
end:

from Active to Idle
when F-R_RESPONSE
{ **Data frames correctly receive, then pass
them to upper layer**}
{ **response a acknowledgement to the
physical layer**}
if P_Data.Kind = Data and P_Data.Seq =
FrameReceived then
begin
S2.Kind := Ack;
S2.Ack := P_Data.Seq
output P.S_REQUEST(S2);
R := P_Data.Info;
output DATA_CONFIRM(R);
Inc(FrameReceived)
end:
until doomsday
end: (** of the ParBody **)}

modvar Mod1: NetworkLayer;
Mod2: Par;
Mod3: PhysicalLayer;
initialize
begin
init Mod1 with NetworkLayer;
init Mod2 with Par;
init Mod3 with PhysicalLayer;
connect Mod1 to Mod2;
connect Mod2 to Mod3;
end:
/** End of specification ***)

- Secret Error Correcting Codes using Block Chaining (SECC-BCC)

In the past, the algebraic-code is widely used to correct
the random errors and the burst errors in communication.
However, it does not provide the function of encrypting and
authentication. In 1978, McEliece develops a public key
crypto-system by using the Goppa code to provide the data
security and the error correction [2]. In 1988, Hwang proposes
a SECC-BCC system that offers the data security, the error
correction and the authentication in a one-step process [3].
The block diagram of SECC-BCC system is shown in Figure 6.
The definition of each component in the SECC-BCC system is as
follows:

\[
\begin{align*}
C_i &= f(M_i) \oplus Z_i \\
C_i &= f(M_i + X_i) \oplus Z_i & \text{where } X_i = f(M_i), Z_i = g(X_i) \\
C_i &= f(M_i + X_i) \oplus Z_i & \text{where } X_i = f(M_i + X_i), Z_i = g(X_i) \\
\hdots \\
C_n &= f(M_n + X_{n-1}) \oplus Z_n & \text{where } X_n = f(M_{n-1}), Z_n = g(X_n)
\end{align*}
\]

The sequence of decoding in the SECC-BCC is:

\[
\begin{align*}
D(C_1) &= X_1 = f(M_1), f^{-1}(X_1) = M_1 \\
D(C_n + g(X_n)) &= X_n = f(M_n + X_{n-1}), f^{-1}(X_n) + X_{n-1} = M_n
\end{align*}
\]

The error pattern in MRT can be generally divided into
two categories: random error and burst error. The Bose,
Chaudhuri, and Hocquenghem (BCH) codes form a large class
of powerful random error-correcting cyclic codes [4]. With the
interleaving technique, it can be also used to correct the burst
errors. The error rate in MRT is between \(10^{-2}\) and \(10^{-3}\).
Moreover the majority of error pattern in MRT is the burst
error. Hence, the (31,16,3) BCH code with interleaving
technique is used to design the generator matrix \(G\). As for the
inverse-able nonlinear function, it can be constructed by
modifying the LUCIFER system designed by Feistel in 1973
[5].

IV. Implementation.

Before this project, we do not have any experience in the
MRT. Moreover, the information provided by Taiwan
telephone and telegraph office is limited. Therefore, what will
happen in the mobile workstation is difficult to estimate and
predict at its beginning. For example, the experiments for
measuring error rate and error pattern can not be done as
scheduled, because the monthly charge for MRT is much

![Figure 6. The SECC-BCC system.](image-url)
higher than our budget. This causes many unnecessary modifications later on.

At the beginning of implementation, we select the random error as the major error pattern of the MRT communication system, and use the error rate data published overseas to design our system. After the prototype is completed, we do some experiments to evaluate the characteristics of each communication segment. The wire segment is evaluated first, and our experiment shows that there is almost error free in the wire communication segment. In order to evaluate the error correcting capability of our prototype, a noise generator with the random error pattern is inserted between the data-link layer and the physical layer in the file server, and the system works correctly. When we test our system with the MRT, the result doesn’t show as expected, because most errors are burst errors in the communication medium.

In April of 1990, a functional MRT was finally setup. We found the bigger file could not be sent successfully, and the retransmitting procedure was not robust enough to tolerate burst type error. Several modifications on the protocol and on the coding scheme were made. There is a tradeoff between performance and the robustness that we have to deal with. In addition, modern reliability was also one of the issues we had to take into consideration. Finally after we adjust our protocol and error correcting scheme to handle the encountered error pattern, we made our mobile workstation working successfully along the highway. Yet at some spots in the ITRI communication lab, it could not handle large file. Only after having moved the workstation a little farther from the lab, it functioned properly.

We believed that the Electromagnetic Interference (EMI) in the lab caused problem. In this experiment, the mobile workstation consists of a Motorola 4W MRT, an Intel 80286 laptop computer, and a 2400 bps baud rate modem. The occurrence of re-transmission was also measured; it was 1/60 with the frame size set to 128 bytes.

V. Conclusion.

In the sprout of MRT business in Taiwan, we implement a mobile workstation to provide the real-time inquiry service wherever the workstation is. During the implementation, many interference sources are found in our surrounding. It suggests us that the management for radio interference should be strengthened. The mobile workstation presented in this paper provides the capability of error-detection, correction for few error bits, and of data secrecy. Since the price of a mobile workstation is decreasing, we believe their usage will be more universal in the future.

Reference