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COMMUNICATIONS CONTROLLER PROTOTYPE

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ABSTRACT

A United States military battle simulation center, consisting of a number of rooms containing computer equipment, functions as a training facility for force commanders. The computer equipment is used to conduct simulated air/land battle engagements, and each room is designed to simulate a representative Air Force or Army operations center. Because communication within the facility are current state of the art, they have been designed deliberately to be nearly error-free.

The communications controller prototype simulates wartime communication failures by confronting the participants with an information exchange capability approximating that which would be experienced in wartime with regard to both the availability and the quality of the communications. The prototype intercepts a message about to be transmitted between two users over the LAN, loses, garbles, and/or delays the message, and then sends it to the receiver if it is not lost.

This paper describes the following:

a. Need for a communications controller

b. Prototype communications controller used for demonstration purposes

c. Ideas for an upgraded communications controller

INTRODUCTION

The communications controller prototype described herein was designed for use at a United States military battle simulation center. It consists of a number of electrically interconnected operations rooms used to conduct simulated air/ land battle engagements for the purposes of operator training and procedural development. Each room is equipped with an assortment of graphic displays, alphanumeric displays, printers, and telephones and is set up to simulate a representative Air Force or Army operations center. Participants are provided with graphic and alphanumeric inputs characteristic of air/land command and control battle operations. These inputs are produced by programs within the center's computer complex. The simulation programs adjust the progress of the air/land battle situation in response to actions taken in the operations rooms.

Communications within the complex include a local area network (LAN) connecting the central simulation facility with the displays. Because communications within the facility are current state of the art, they have been designed deliberately to be nearly error-free.

The communications controller is a program designed to degrade the quality of the communications within the battle simulation center in a manner representative of wartime conditions. The objective of the communications controller is to ensure that training and lessons learned during exercises held at the center are based on a realistic, rather than an idealistic (relatively problem-free), communications environment.

The MITRE Corporation has designed, coded, tested, and demonstrated a communications controller prototype for analysis purposes. The prototype intercepts a message about to be transmitted between two users over the LAN; it loses, garbles, and/or delays the message, and then sends it to the receiver, via the LAN, if it is not lost. In providing this capability, the prototype allows the user to tailor the communications controller to the specific needs of the battle simulation center.

The communications controller prototype described in this paper was designed for a United States military battle simulation center which deliberately remains unnamed because the center has changed its direction concerning the communications controller since its introduction. The purpose of this paper is to describe the simulation developed for the center. Although work has continued on evolving the communications controller to their needs, the author is currently not involved in the project and cannot fairly represent the center's current ideas about the communications controller.

THE BATTLE SIMULATION CENTER

The battle simulation center consists of a computer complex designed to train its operators to utilize an information-exchange capability under control of simulation programs which approximate characteristic air/land battle operations in a wartime communications scenario. Each room is equipped with displays that accept graphic and alphanumeric inputs, characteristic of air/land battle operations, under the control of simulation programs contained in the center's computer complex. The simulation programs adjust the progress of air/land battle in response to actions taken in the operations rooms.

Exercises are conducted at the center for force commanders who participate in the battle simulations for a period of one to three weeks. These exercises are designed to actively involve participants in

battle simulations where they can respond as if they were participating in an actual wartime communications scenario. Progress is made in approaching the goal of more closely modeling a wartime environment, as inadequacies are indicated from previous exercises and the simulations are perfected.

The simulation programs interact with red (enemy) response, blue (friendly) response, and white (neutral) control. One of the battle simulations supports ground operations, close air support, battlefield air interdiction, and some air reconnaissance. Another simulation supports air defense operations and some air reconnaissance. The programs are each resident in a VAX 11/780 computer and form the core of the center's simulations. Some interaction between the programs is provided via data tables accessible from either computer.

Recently, a text message transmission system was developed and installed using additional, dedicated alphanumeric terminals in selected operations rooms. Exercise participants use the capability to exchange text messages between terminals in separate operations rooms. These terminals are dedicated to message traffic and are independent of the battle simulation terminals. In addition, messages received at these terminals can be diverted to printers in the same room to produce hard copies. A record of all messages sent using the utility is kept for post exercise analysis.

Communications within the center take several forms. These include a local area network (LAN), connecting the central simulation facility with the displays and printers. The LAN provides graphic and/or alphanumeric data from the battle simulation programs to the display terminals, from the terminal operators to the battle simulations, and from terminal operator to terminal operator.

Current and anticipated future facilities and equipments at the center supporting the exercises are listed in table 1.

Table 1: Assets Directly Supporting the Exercises

Unit	Present	Future
Buildings	1	4+
Rooms	17	30+
Battle Simulations Programs	2	3+
VAX 11/780	2	3
LAN (coaxial)	1	Expanded
Alphanumeric Terminals (battle simulations)	42	80+
Alphanumeric Terminals (text message system)	4	?
Printers (battle simulations)	7	15+
Printers (text message system)	0	?
Graphic Terminals	12	40+

COMMUNICATIONS CONTROLLER CONCEPT

Electrical communications within the facility are hardwired and as such are relatively error-free. The communications controller is a proposed system to aid central monitoring and control of voice and data communications, including a capability to degrade or impair the quality of the communications in a manner representative of wartime conditions. The communications controller confronts the participants with an information exchange capability approximating that anticipated in wartime with regard to both the availability and the quality of the communications. During an exercise, this could be done by introducing delays and impairments into voice and data communications typical of a wartime communications scenario.

The communication circuits exchange text between alphanumeric display terminals via the LAN. This emulates teletype/message traffic and is provided by a text message transmission system. Impairment of this traffic was explored in developmental prototype work done at The MITRE Corporation. In this prototype, the emphasis was on a feasibility demonstration of text impairments using computer-based software routines (random errors, garbles, delayed, and lost messages) generated in response to random number functions.

COMMUNICATIONS CONTROLLER PROTOTYPE

The WPC communications controller prototype simulates wartime communication failures by introducing delays, impairments, and lost messages into the text message system over the LAN. The prototype software resides in a Cromemco computer connected to the LAN via a two-port Sytek bus interface unit (BIU), as depicted in figure 1.

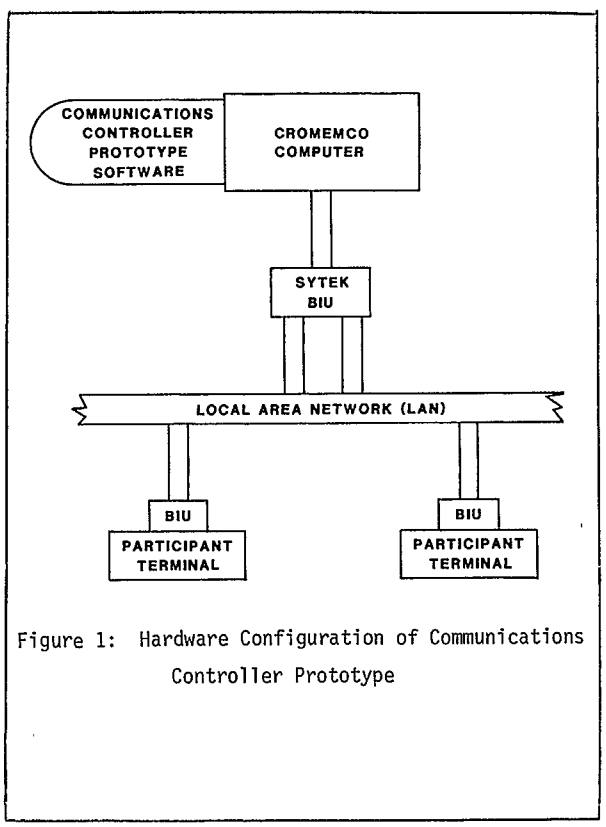

Figure 1: Hardware Configuration of Communications Controller Prototype

The Cromemco used for the prototype runs the CROMIX operating system, and the C-programming language is used for program implementation. An example of an exemplary message transmittal is provided in table 2.

Table 2: Message Handling

ATAF

```
CALL ATOC

MESSAGE: (terminate with <CR> @)

THIS ORDER IS EFFECTIVE FROM 140300Z TO 150300Z
SECTION ONE OF PART THREE
1.  PART ONE:  GENERAL INSTRUCTIONS
1.  A.  GENERAL:  DIRECTION IS TO INCREASE THE
WEIGHT OF EFFORT ON COUNTER AIR AND
INTERDICTION OPERATIONS.  CONCENTRATE
DEFENSE ON PROTECTION OF FORCES.
B.  INTELLIGENCE REPORTS INDICATE OPPOSING
FORCES MAKING ADVANCED PREPARATIONS FOR
OFFENSIVE ACTIVITY.  ALL UNITS TAKE
PRECAUTIONS.
C.  OVERTASKING MAY OCCUR.  PRIORITY
ONE IS TO COUNTER AIR.
@

END OF SESSION
```

(LOSE, GARBLE, AND/OR DELAY)

ATOC

```
MESSAGE FROM ATAF

THIS ORDE IS EFFECI&VE FROM 140300Z TO 15 00Z
SECION ONE OF PAR THREE
1.  PART ON:  GEERAL INSTRUTIONS
1.  A.  GERERAL:  DIRECTION IS TO NCREASE TH
WEIGHTOF EFORT ON COUNTER AIR AND
ITERDICTION OPERATIONS. COCENTRATE
DEFNSE ON PRATECTION OF F%ORCES.
B.  ITELLIGENCE REPORTS INDICTE OP#POSING
FORCES MAKING AVANCED PREPQRATIONS FR
OFFENSIVE ACTVTY.  AL UNITS TAKE
PRECAUTIONS
C.  OVERTAKING MY O3CUR.  PRIORITY
IS TO OUTER AIR!

END OF MESSAGE
```

MESSAGE DEGRADATION

The communications controller makes some internal decisions as to whether or not to lose or garble/delay a message before sending it to the receiver. A random number is used to decide whether to lose the message. If the message is lost, then the message is not transmitted and program control returns to start. If the message is not lost, then a random number is used to decide whether to garble the message. If not, the program control goes to the delay routine. If the message will be garbled, then the following three garble routines are randomly selected:

a. Replace: Replace random characters in the message with other characters

b. Insert: Randomly insert extraneous characters into the message

c. Drop: Randomly drop characters from the message

The communications controller prototype delays all messages which have not been lost. Delays are short and fixed for demonstration purposes to show the user the capability without boring him with long delays.

Table 3 sums up the lose, garble, replace, insert, and drop routines.

Table 3: Lose, Garble, Replace, Insert, and Drop Routines

```
LOSE = rand * 200

if LOSE >= 190
   then lose message
        return to beginning
```

else

```
GARBLE = rand * 200

if GARBLE >= 175
   then do NOT garble
        goto delay
```

else

```
REPLACE = round ( rand * 3 )

if REPLACE = 3
   then replace as follows
        x = rand * total-in-message
          every x char replaced by char ( rand *
          42 )
```

```
INSERT = round ( rand * 3 )

if INSERT = 2
   then drop as follows
        z = rand * total-in-message
           drop every z character
```

NOTE: A rand is a positive random number between 0 and 1.

The random method was chosen for use in the prototype for the purpose of demonstration and ease of design. The routine used to return a random number in the C-programming language is as follows:

```
double rand()

    extern long rno;
    double fl;

    rno = ( ( 25173 * rno ) + 13849 ) % 65536;
    fl = rno / 65536.0;

    return ( fl );
```

MESSAGE RECEIPT

After the message is garbled and delayed, it is transmitted to the receiver. The receiver is not warned of the message being sent and is interrupted by transmittal of the message.

A basic flowchart of the program is provided in figure 2.

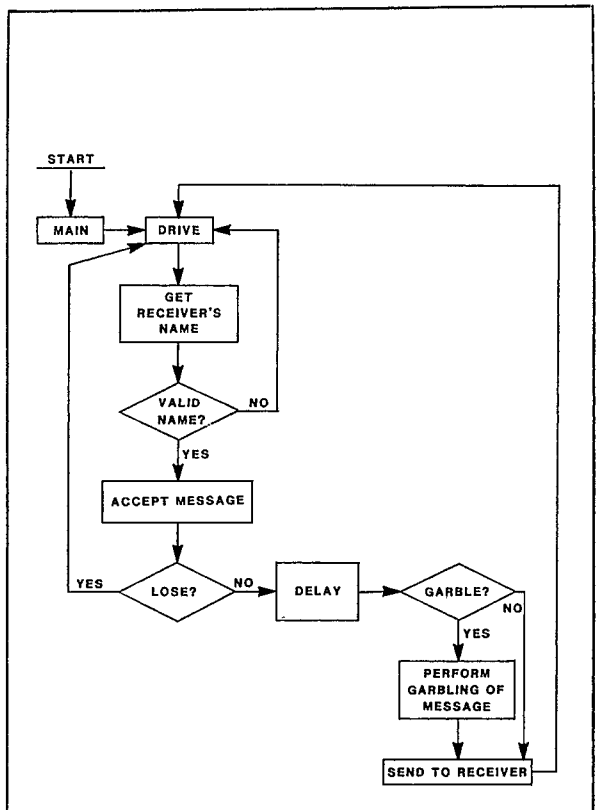

Figure 2: Communications Controller Prototype Flowchart

COMMUNICATIONS CONTROLLER UPGRADE

Results of training exercises indicate the need to more closely simulate a wartime environment by degrading the quality of the communications. Continued effort is being devoted to developing an upgraded communications controller to be used by all participants sending alphanumeric messages via the terminal during an exercise. As the author is currently not involved in the project and cannot fairly represent the center's ideas about the communications controller, what follows are the authors initial ideas for upgrading the prototype. The upgrade described is based on the assumption that it can be developed as an extension of the existing text message transmission software resident in the VAX 11/780.

MESSAGE DEGRADATION

Whereas the prototype performed message impairments by a totally random process, the upgrade would utilize a route selection to perform its impairments of messages. Each sender/receiver pair would have a certain route assigned to it corresponding to the physical attributes of that particular communications circuit. Although participants at the battle simulation center are rooms apart physically, they are simulating an actual wartime scenario where they may be many kilometers apart and, therefore, may be more vulnerable to message degradation. The impairment algorithm would still use a random number generator to calculate when a given message would be impaired, depending upon the probability of its particular route.

LOST/DELAYED MESSAGES

Messages would be delayed and lost according to the probability assigned to their route. Whereas the prototype messages are all delayed a fixed, short period of time, the upgrade delays would vary from 0 seconds to as long as the exercise continues. In this case, a lost message is defined to be a message which is delayed for a longer period of time than the exercise lasts. Delays would be decided by the probability assigned to the sender/receiver route and a random number generator.

MONITORING CONTROL

The capability would exist for a monitoring function to control the impairments of alphanumeric messages being transmitted via the communications controller. Two terminals, a monitor and controller, would be dedicated for these purposes. The monitor terminal would display the following information for each message transmitted:

a. Sender
b. Receiver
c. Time message transmittal was initiated
d. Time for transmission (with delay)
e. Route number (sender/receiver pair)

The controller terminal would display the route matrix where a certain route number is assigned to each sender/receiver pair. The designated operator could change the route selection of any sender/receiver pair at any time during the exercise, while the communications controller is in operation simply by entering the correct sequence of commands at the control terminal. This would enable the monitor to alter the intensity of impairments depending upon specific need.

In order of importance, the proposed forms of impairment would include delayed message delivery, lost message, and random character errors. Longer term issues include the following:

a. Whether to integrate the message system with the battle simulation system (e.g., so that canned messages could be triggered by simulation events)

b. Whether a standalone add-on communications controller is desirable/possible for a LAN that already supports a message system

c. Possible addition of dedicated printers in each operations room to provide hard copy of messages to the participants

CONCLUSION

There is no doubt that the battle simulation center provides an important function in preparing Air Force and Army personnel to operate in a wartime communications environment. However, its success is contingent on the implementation of effective battle simulations. To further enhance these simulations, personnel constantly revise and model real-world wartime scenarios. They record results of the various exercises and try to compensate for existing insufficiencies when structuring the following exercise. Because of the apparent lack of random impairments and delays in the communications, a desire was expressed in attaining this capability.

A successful feasibility demonstration has been performed at the center using the prototype designed and developed by the MITRE Corporation. This initial step has ensured momentum for alternative growth to an unlimited terminal delay/loss/impairment capability and was achieved successfully at the low cost of designing, producing, and demonstrating the prototype.

ACKNOWLEDGMENT

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