Open, Heterogeneous Communications Network for the Operational Command and Control of the Crisis Reaction Forces

Communications functions were developed for the operational command and control of the crisis reaction forces stationed in Kosovo and Macedonia.

Task Description

For the newly produced equipment for the expansion of the existing command and control system network of the SFOR, KFOR and ISAF operating forces, the new FAUST E1 software which was generated from the GeFüSys programs and the Battlefield 2000 field test is to be used instead of the previously used FüU A3 command and control application. Therefore, on the one hand, a connection of the new command and control component to the "old" communications is required and, on the other hand, the communications should be supplemented with modern media (ISDN, modem, GSM).

Technical terms:

FAUST E1	Tactical command and control equipment, version E1
FüU A3	Command support, version A3
GeFüSys	Battlefield command system of the army
leKomDEG	Light data terminal with communications capability
MIP	Multilateral Interoperability Program
RFC	Request for Comment, name of an internet standard
RFC 821	Internet standard for the transmission protocol of an e-mail
RFC 822	Internet standard for the format of an e-mail
SMTP	Simple Mail Transfer Protocol (internet e-mail method)
WAN	Wide Area Network

Network Environment

The objective was to achieve an interconnected network environment according to Fig. 1:

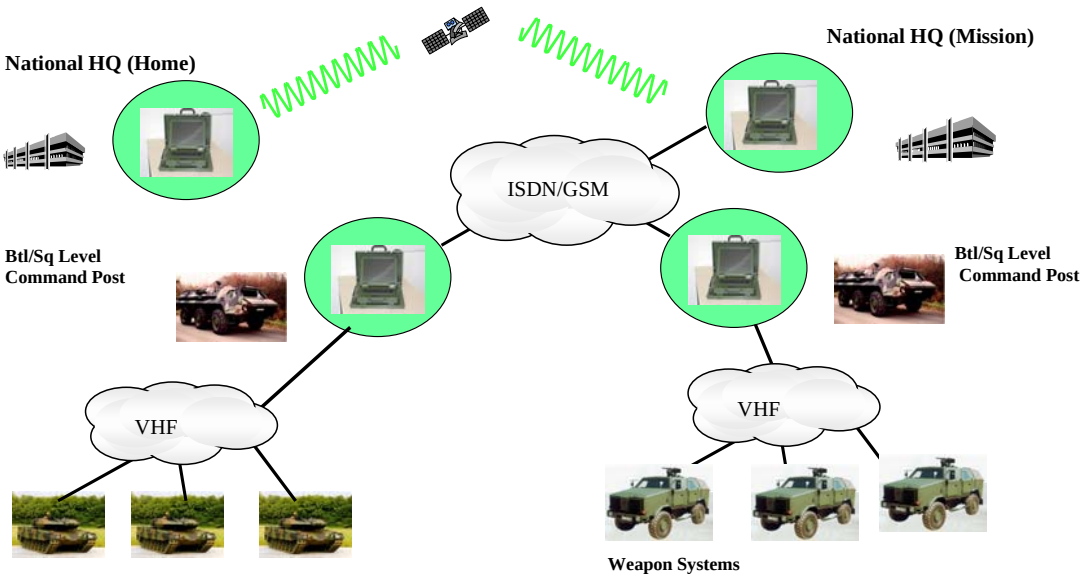

Fig. 1: Target Structure for an Interconnected Network Environment. The troop assignment shown is to be understood as an example and does not reflect a real mission.

The following components were present in the country of operation:

- SEM 52 and SEM 80/90 VHF radio equipment
- HF radio equipment 6181 and XK405
- Trimble Galaxy C/GPS Satcom transceiver

They had to be connected to the new hardware to be supplied.

Fig. 2: CHALLENGER with Extensions for the Network Configuration

Special Requirements for the Implementation

During implementation, some special requirements had to be taken into account in order to ensure efficiency and acceptance by the user.

- **Freedom of Configuration**

  In the country of operation, the systems had to be used in dynamic scenarios and connected with very different network topologies. The systems had to be **configurable** by the tactical user **himself**. Therefore, the communications portion was not allowed to have special management interfaces for its configuration.

  The only configuration option was to be the **address administration integrated** in the FüInfo application. All data for the underlying functions had to be capable of being extracted or derived from the available information.

- **Selection of the Network**

  The user required the ability to select the communications path himself, i.e. the network (VHF, ISDN, GSM; etc.) to be used for the transmission. The background of this requirement is that the user, on the basis of the available information, can best judge from the networks that are in principle available which are actually usable at the time of sending the messages.

  For the use of the telecommunications equipment, its specific technical address (e.g. ISDN or GSM call number) simply had to be transferable into the configuration.

- **Interoperability with the Existing Equipment**

  The new systems had to be interoperable and compatible with the previously used systems. Interoperable, on the one hand, to be able to create an old/new interconnected command and control system, if the previously used FüU A3 was installed on the new systems and compatible, on the other hand, to use the identical communications infrastructure on all systems. Therefore, only the WAN connection which was not available in the old systems was allowed to be newly connected.

- **Acknowledgments**

  The sender of a message has to be informed at all times about the status of the messages which he sent to the communications system.

Approach to a Solution

To keep the costs and development times low, commercially available products (COTS), if possible without license fees had to be used. Therefore, the solution that presented itself was the use of a standard e-mail procedure on the basis of ESMTP for the message transfer, i.e. the standards used in the internet. These standards have all the features required for fulfilling the military requirements in the special environment:

- Configurable acknowledgment mechanisms
- Free addressability for selection of the networks
- Extendibility of the formats by special military contents, such as classification, priority, etc.

Principle of Message Transfer

After the method of solution was defined in principle, the potential interfaces to be used in the system had to be defined. The underlying civil standards ("RFC") allow many degrees of freedom since they have experienced many extensions in the course of time.

Therefore, the definitions created in the MIP program were employed for the use of the e-mail standards for message transfer. These describe a specific version of the standards; characteristic for this are among others the defined acknowledgments which are based on the DSN (Delivery Status Notification) extension of the standard.

Fig. 3 shows the sequence of a message transfer as well as the generation of the associated acknowledgments.

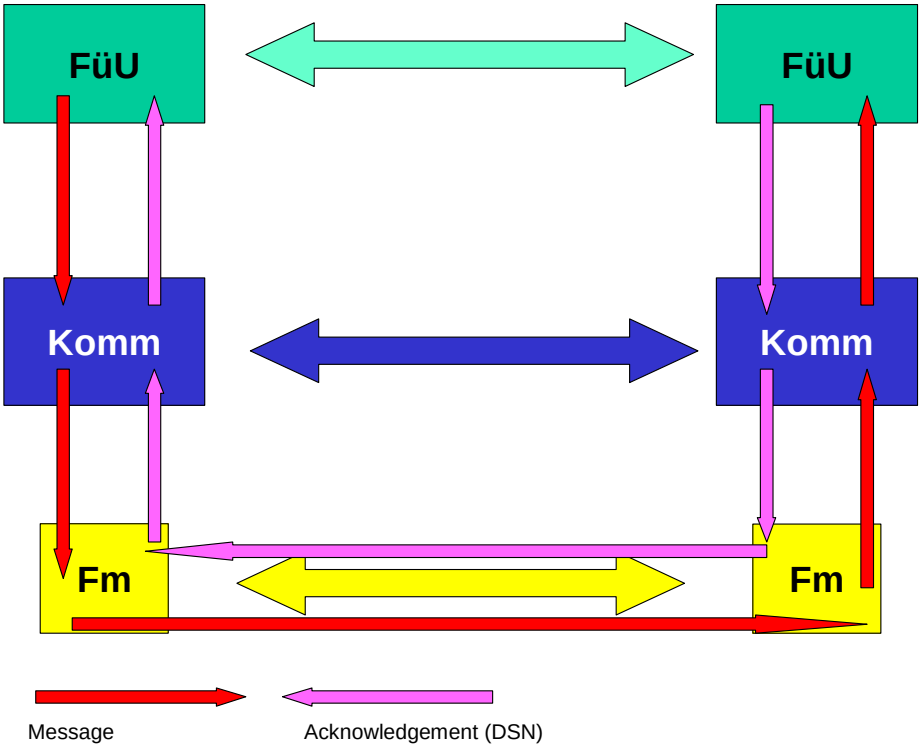

Fig. 3: Message Transfer with Acknowledgment.

By the - optional - request for a DSN, the sending system is at all times capable of following the flow of the sent messages and to describe it accordingly in message processing. If an error occurs in one of the involved nodes or an error of an underlying system is noticed, a DSN is generated directly at this position, an informative error code entered and sent to the sender.

Transmission Method and Network Protocols

When selecting the transmission processes to be used for the networks to be connected and the protocols for message exchange according to standard e-mail procedures, the military narrowband radio connections on the one hand and the civilian standard networks on the other hand had to be distinguished.

First, a TCP/IP protocol stack on ISO layers 1-4 is part of SMTP. However, due to the mechanisms included for flow and error control, it entails a considerable overhead concerning the length as well as the switch-over times between the transmission devices. This is also reinforced by the sequence of the Simple Mail Transfer Protocol with its relatively complicated transfers with many changes of direction.

Solution for Narrowband Radio Networks

For narrowband radio networks, the solution can therefore exist only in a procedure which is designed for the specific conditions. Because of the requirement of using introduced systems, the radio protocol to be used was already determined: The AX.25 protocol which was taken over from the amateur radio sector. On this basis, a **special message handling system** serves for connection to the ESMTP distributor as the interface to the application (see Fig. 4)

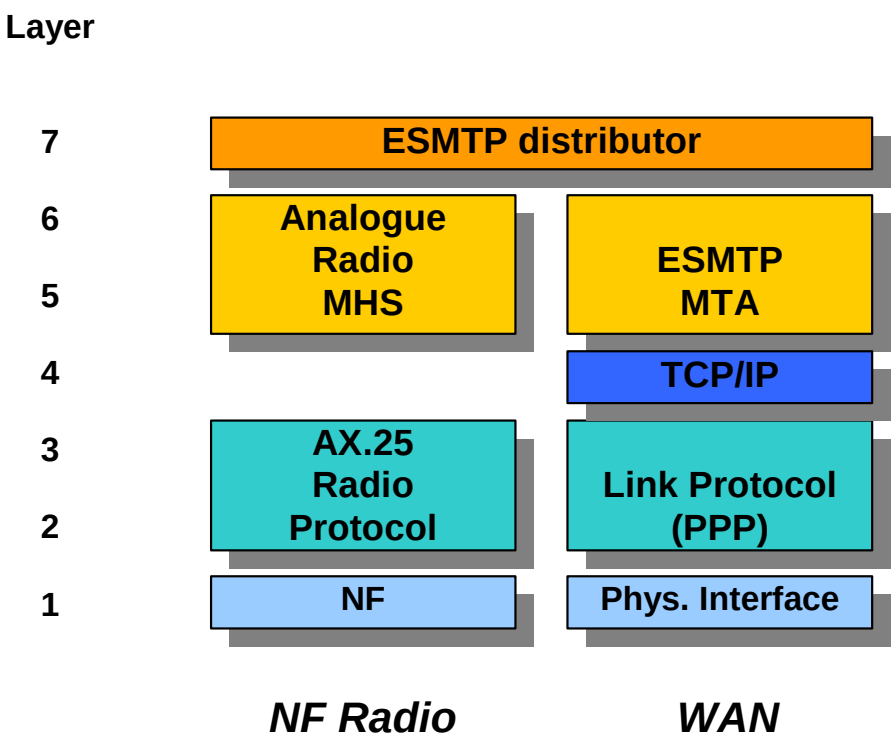

Fig. 4: Protocol Profiles for Radio (NF) and WAN Transfer.

Data Reduction

To keep the overhead low which is created by the SMTP function, the following measures were taken which, to some extent, make adaptation developments necessary.

- On the radio path, the SMTP protocol (RFC 821) was not handled, but instead the messages which were formatted according to the SMTP standard (RFC822) were transmitted by means of a narrow message handling procedure on the basis of AX.25.
- The "overloaded" SMTP syntax was routed through a specially developed reduction mechanism which removes language overhead from the SMTP header and transmits only pure information.
- Finally, the remaining, already length-reduced e-mail is subjected to a compression procedure.

Solution for WANs

For the WAN area, however, the TCP/IP protocol stack is the correct decision. On the one hand, because it was possible to use a worldwide proven transport and internet protocol and on the other hand, because it was possible to use special services for dial connections with network connections already existing at ATM ComputerSysteme.

Dial On Demand

With a normal remote data transmission connected which is made available by the operation system via modem or also ISDN, the target address is normally the same for every outgoing IP frame: The selected internet provider. It transmits the packets to other network nodes or directly to the recipient.

However here, since such a network infrastructure is not available, every recipient must be directly addressed. Such a method is also called "Dial On Demand".

Simultaneous Client/Server Operation

A further difference to standard systems as used, for example, in home PCs is the capability of a system to also accept connections at any time. Only with these functions is a network set-up similar to a radio network possible in which everyone can reach everyone.

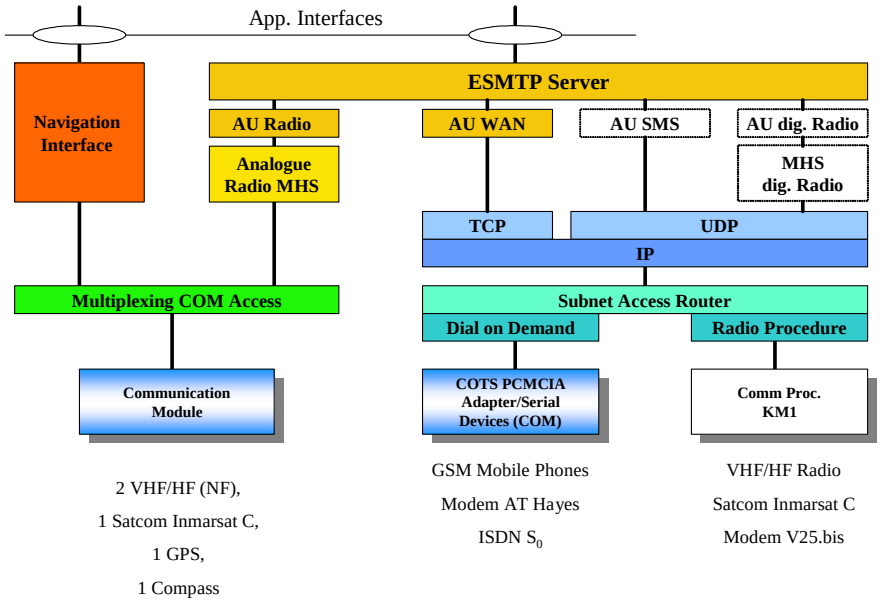

Fig. 5: Architecture of the Communications System.

Implementation

The Architecture

The ultimately selected architecture is shown by Fig. 5. This figure shows the communications string with the introduced telecommunications means connected via the communications module as well as the new portion of the WAN communications.

The core consists of COTS products from ATM ComputerSysteme which were available and thereby – with minor modifications – could be easily applied.

This is, first of all, the ESMTP server with the main function of message distribution. The second key function is the Subnet Access Router which is installed underneath IP. Here, the above mentioned "Dial On Demand" procedure as well as all specific network access routines are handled. This Subnet Access Router is embedded in the system as a software router via an internal virtual LAN.

In the figure, the possible extensions of the system are already shown in the direction of the digital radio connection (dashed, white).

The communications module in Fig. 6 is planned as an autonomous hardware module for versions with the COMMANDER Notebook. In the configuration with the CHALLENGER Notebook, its functions are installed in an "extension tray" underneath the PC.

Fig.6: Communications Module

The Address Concept

As described above, the configuration of the subscriber addresses had to be limited to the maintenance of this information within the FAUST E1 application.

However, for the use of IP technology for the WAN connection, the copying of the SMTP to the IP address is required. Therefore, a way had to be found to save the user the required IP configuring of the subnet access router.

The starting point was the format of an SMTP address defined together with the developer of FAUST (EADS Dornier) according to Fig. 7:

user@kreis_net.phys_addr.takt_addr.de

Fig. 7: Address Format

Address fields in detail:

user	The recipient of a message, shown with his role
kreis_net	Designation of either the command and control circuit or the network via which the addressee can be reached.
phys_addr	Physical address in the respective network, e.g. MAC radio address for the radio circuits, telephone number for ISDN
takt_addr	Tactical address of the user
de	Country code for Germany

All components required for addressing can be derived from this information which is contained in the complete SMTP address:

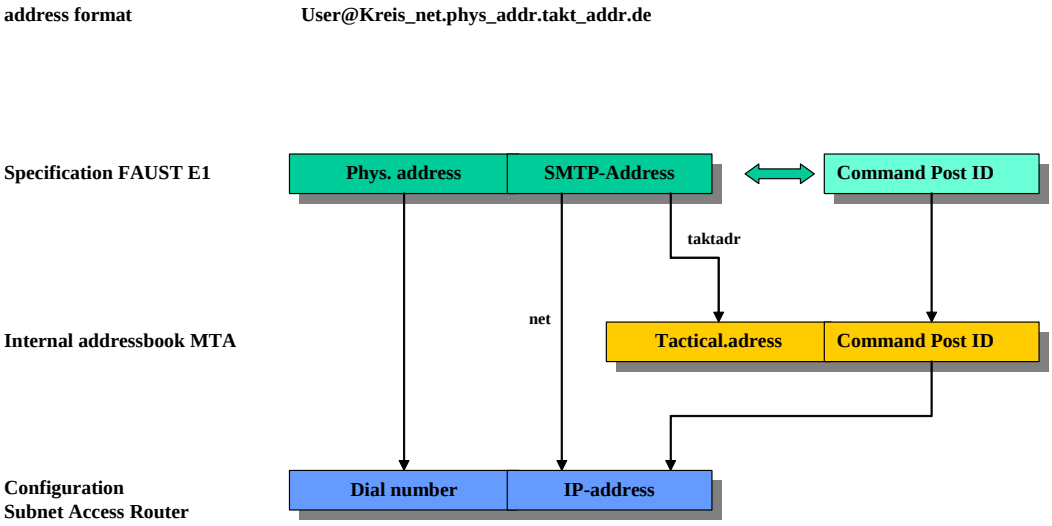

Fig.8: IP Addressing

For the radio area, the conversion of the addresses is simpler. Here it is sufficient to determine the radio connection port on the basis of the *Kreis_net* component and then to address the recipient in the radio circuit with *phys_addr*.

Resume

Short implementation times can be achieved by the utilization of the technical innovations and civilian standards. However, the correct selection as well as optimum adaptations and integration determine the overall function and acceptance by the user.

Therefore, it makes sense to use COTS modules and standards as much as possible. Dedicated modifications and extensions, however, ensure an optimized end product.

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