RECOMMENDATION ITU-R M.539-3*

TECHNICAL AND OPERATIONAL CHARACTERISTICS OF INTERNATIONAL RADIO-PAGING SYSTEMS

(Question ITU-R 12/8)

(1978-1982-1986-1994)

The ITU Radiocommunication Assembly,

considering

a) that agreed technical and operational characteristics for systems and equipment could facilitate the introduction of international paging;

b) that certain technical characteristics of equipment and stations used in paging systems are of importance in connection with the grade of service offered and in respect of the radio interference between the stations of different countries;

c) that the use of agreed frequency bands and technical characteristics could reduce the risk of mutual interference between radio-paging systems and interference with other radio systems;

d) that the public radio-paging systems making use of the national and international telecommunications networks should be designed as extensions of those networks;

e) that additional messages of different types are operationally required by subscribers to such paging services thus increasing the number of paging codes required or complicating the structure of a single message code;

f) that the ultimate paging address capacity of a system is generally decided early in the planning process;

g) that the most economical way of providing international radio-paging services may be as an extension of national systems;

h) that the requirements for international radio paging can usually be anticipated in the planning of national systems,

recommends

that the following technical and operational characteristics of the systems, stations and equipment for land mobile radio-paging should be adopted for systems intended for international use.

1. Operational and system characteristics

1.1 Design principles

The radio-paging system should be designed as an extension of the telecommunications networks taking into account the limitations due to one-way transmission on the radio path.

1.2 Receiver operation when changing paging zones

The procedure by which a user can obtain service when moving from one paging zone or system to another (even internationally), should be as simple as possible. Manual adjustment of the receiver should not be required.

1.3 Messages

The system should enable the transmission and reception of additional messages of different types, such as the telephone number of the caller or longer numeric or alpha-numeric messages. It should be possible to use different types of receivers for different types of messages.

* This Recommendation should be brought to the attention of the Telecommunication Standardization Sector.

A large variety of messages should be possible, including pre-defined messages, (e.g. tone-only messages), long alphanumeric messages or any other type of coded messages using full transparent data capability. For numeric messages the length is typically some tens of numeric characters. For alphanumeric messages the typical length could be between some tens of characters up to several thousands of characters. The type of the application and the size of the display associated with the receiver may limit the possible length of the messages. As far as transparent data messages are concerned, the same limitation may apply. This limitation is also tied to the transmission capacity on the radio path of such a paging system.

1.4 Priority calls

Although it may be possible to have users that are given priority (higher or lower) according to the chosen subscription, this facility may not be available outside the home network (the operator network with which a subscriber has signed a subscription).

1.5 Authorization codes

It should be possible for subscribers who so wish, to have authorization codes that have to be used by the caller when calling such a subscriber.

Authorization codes may be required by the network operator for a customer to access some supplementary services, e.g. priority call.

1.6 Group calls

It should be possible to call several subscribers as a group.

1.7 Receiver identification

Each receiver should be identified uniquely in the system in which it is to operate. Where administrations combine national systems to give international service, they should ensure that no two receivers used for this purpose have the same identity, except when required for group calling.

1.8 Battery saving techniques

As low power consumption is essential for the receiver, the system should include methods for battery saving.

2. Control centre characteristics

2.1 Function

The control centre should perform the store and forward functions for paging calls for national and international service.

The control centre is linked with other control centres of paging operator networks through a standardized interface in order to provide international service (see § 7). The control centre is connected also with the access networks through interfaces from which it receives paging messages. These interfaces should follow the appropriate ITU-T Recommendations according to the type of access network.

2.2 Access network signals

The control centre is connected to different telecommunication networks which allow originators to access the paging system. These telecom networks are called access networks and are chosen by each network operator according to the type of access offered to the customer. The control centre therefore has to accept and generate telecommunication networks signals agreed for national and international networks.

3. Access networks requirements

3.1 Dialling codes

The dialling codes and their format used to gain access to the paging system should conform to those agreed for national and international use.

3.2 Group call codes

The ability to page groups of subscribers according to § 1.6 should be included in the dialling codes.

4. Transmitters and distribution of paging signals

4.1 Frequency of operation

For international service, at least one common international frequency channel or band should be assigned.

4.2 Multiple transmitter zones

In multiple transmitter zones, multi-channel operation of the receiver is to be avoided as much as possible in order to save the battery of the receiver. The transmitters can operate either sequentially or simultaneously.

4.3 Rate and type of data modulation

For international service these parameters must be agreed between the corresponding administrations. For Radio Paging Code No. 1, the preferred parameters are currently:

– data transmission rate: 512 bit/s or 1 200 bit/s (with an accuracy of $\pm 1 \times 10^{-5}$);

– modulation type: direct FSK in a non-return-to-zero manner, with a positive frequency shift representing binary 0, a negative frequency shift for binary 1, and a frequency deviation appropriate for the assigned channel, e.g. ± 4.5 kHz for a 25 kHz channel.

512 bit/s was selected as a compromise between the needs of various multi-transmitter situations. It has been demonstrated that 1 200 bit/s works correctly in various radio-network configurations. As far as enhanced capacity systems are concerned, the parameters given in Annex 2 should be considered.

4.4 Phase equalization

In systems where some or all transmitters operate simultaneously, the modulating signals should be equalized so as to be compatible with the data transmission rate and the modulation type. For the preferred values in § 4.3, the modulation time delay between adjacent transmitters should not exceed 488 μs for 512 bit/s and 250 μs for 1 200 bit/s.

4.5 Frequency offset

The radio-frequency offset for transmitters operating simultaneously on a common radio-frequency channel should be maintained within limits compatible with the data transmission rate and the modulation type. Further studies are needed to enable values to be recommended.

4.6 Transmitter frequency tolerance

The transmitter frequency tolerance should be, at least, in accordance with Recommendation ITU-R M.478. For the preferred values in § 4.3, the tolerance should be less than 5×10^{-6}. Where simultaneous transmitter operation with frequency offset is used, tighter tolerances may be needed.

4.7 Other transmitter characteristics

For the other transmitter characteristics, the values should be in accordance with Recommendation ITU-R M.478.

5. Receivers

5.1 Size, weight and cost should be as small as possible.

5.2 Power consumption

Power consumption should be kept as low as possible. Battery saving methods as offered by the system should be implemented in the receiver.

5.3 Sensitivity

The calling sensitivity should be less than 10 μV/m, for reference calling probability (see IEC Publication 489 – Part 6).

5.4 Selectivity

The adjacent channel selectivity should not be less than 60 dB in the VHF band. A lower figure may be appropriate for the UHF band.

5.5 Spurious emissions

The value of 10 nW should not be exceeded at any frequency up to 70 MHz. Above 70 MHz, spurious emissions should not exceed 10 nW by more than 6 dB/octave at frequencies up to 1 000 MHz. However, lower values are preferable (e.g. 2 nW or less) in view of the possible large number of receivers in certain areas.

6. Signalling code and format

Refer to Recommendation ITU-R M.584.

Further study is needed on this topic. The following factors, among others, should be studied and taken into account:

– address and message capacity requirements,

– expected calling rate,

– error detecting requirements,

– error correcting requirements,

– implementation possibilities.

7. International roaming

7.1 Architecture

Any wide area or local paging system should have at least three well-defined interfaces:

– the radio interface between the base station transmitter and the paging receivers;

– the interface between the control centre and the access networks;

– the inter-working interface between control centres.

In addition, other internal interfaces may also be defined.

As far as the inter-working interface is concerned Annex 2 should be considered.

7.2 Services and facilities

The networks should be capable of supporting a minimum set of services to ensure full compatibility with the basic version receiver.

The main services and facilities may be summarized as follows:

– international roaming;
– choice of call destination;
– temporary barring of incoming traffic;
– constitution of closed users' groups (the possibility of mobile and fixed subscribers to establish a group with only internal communication possibility; the mobile or fixed subscribers can be members of more than one closed users' group);
– protection against messages lost;
– establishment of priority levels;
– diversion of traffic to other receivers;
– security facilities;
– charging facilities;
– out-of-range indication;
– deferred delivery.

Regarding the paging categories, they may be summarized as follows:

– tone only;
– numeric;
– alphanumeric.

The type of message will be:

– individual calls;
– group calls (using common or multiple radio identity codes).

7.3 Radio coverage

As far as the radio coverage is concerned, the system should have the possibility to guarantee the continuous coverage of a given territory (e.g. a whole country).

A paging area is defined as the area served by a single transmitter or set of transmitters which send the same information. It is possible to foresee that the system area may be divided into several paging areas, overlapping or not. Messages may be transmitted in a limited number of paging areas and a dedicated procedure will enable roaming subscribers to temporarily re-route the calls to one or more alternative areas where appropriate.

7.4 Radio network structure

The radio network structure needs to be defined in such a way as to permit maximum flexibility for national implementation and efficient spectrum utilization (specifically in border areas), whilst retaining essential common characteristics.

7.5 Network aspects

The main principle of a wide area system is to keep the access to the system as easy as possible. Access to the system could be given through telephone or data networks, either private or public.

In case of an international call within the paging system, access to the national control centre should be preferred, instead of establishing an international call through the access network.

8. Transmission characteristics

Transmission characteristics of a radio-paging system as described in Annex 1 should be taken into account.

9. Existing systems and systems under development

The various existing domestic and international systems may soon be followed by new systems. Some administrations have an urgent need for a standard for their future systems and have made new studies in order to permit easy implementation of cross-border systems, sharing of users between various system providers, and to give good guidance to providers of paging services. The studies necessary to define the requirements for international radio-paging systems are not complete and should be continued. Annex 2 provides an example of a particular system design, suitable for international paging services.

ANNEX 1

Transmission characteristics of radio-paging systems

1. Introduction

1.1 The radio-paging systems referred to in this Annex are described as one-way selective signalling systems with message facilities and designed as extensions of telecommunications networks.

1.2 Some principal modes of operation are:

1.2.1 Dialled call to a control centre, where a telephone number dialled into the telephone network is routed to a control centre for processing into a radio-paging call.

1.2.2 Dialled call, with audio-frequency secondary end-to-end signalling, to a control centre, where the control centre accepts directly dialled digits and then accepts second stage audio-frequency digits to complete the information for processing into a radio-paging call.

1.2.3 Operator-handled calls.

1.3 False calls and messages should be eliminated so far as practicable, e.g. not more than one incident per user per year.

In the case of multiple-area paging systems, the user should be able to choose the area or areas within which he desires to be paged (see § 7).

The radio signal strength should be as uniform as practicable within the service area but restricted outside it. Special system considerations may be necessary to operate an aircraft paging receiver.

Radio paging could also be used to enhance other mobile services, e.g. paging aircraft in the ground-to-air direction or telepoint.

2. Control centre design concepts

For a high-capacity system, the use of a stored programme device seems to be desirable to perform the storing and forwarding functions of the paging calls.

It would be desirable for the control centre to make a validity check of all calls entering the system.

The control centre should return the necessary supervisory signals to the access network.

The control centre should generate directly or indirectly the transmitter modulating signals.

The number of control centres needs to be limited to ease the access and switching problems. For access to the control terminal, the dialling codes used over the telecommunications network should conform to agreed national and international standards.

As the control centre will be connected to a telecommunication network it should conform to the normal requirements for equipment connected to that network. The capacity of each control centre should vary from some 1 000s to several 100 000s paging addresses, i.e. discrete subscriber dialling codes. To obtain greater user capacity in any system, a number of such terminals could be used.

3. Radio-frequency conditions

3.1 The following factors need to be taken into account in the choice of a suitable radio frequency channel(s):

– economics of the system for a given area;

– availability of frequencies;

– propagation considerations and operational requirements;

– environmental noise levels;

– practical limits of receiver sensitivity;

– permitted limits of emitted power levels and antenna heights according to local regulations;

– levels of paging traffic.

3.2 Possible frequency bands

All three ITU Regions have some or all of the following frequency bands allocated to mobile services:

26.1-50 MHz

68-88 MHz

146-174 MHz

450-470 MHz

806-960 MHz

In the future, it is possible that higher frequencies may be allocated to the mobile service in all three Regions and consequently be available for radio paging, but the utility of such frequencies is not yet proven.

In addition, documents submitted by Sweden illustrate the possible use of the VHF-FM sound broadcasting transmitter network in the frequency band 87.5 to 104 MHz for a wide-area paging system over the coverage area of the broadcast transmission.

3.3 The cost of coverage

The costs and ease of providing base station antenna gain at 150 MHz and 450 MHz to overcome increased propagation losses at these frequencies, compared with the lower bands such as 26.1 to 50 MHz (in North America) and 68 to 88 MHz (in Europe), are of the same order as those for the basic unity gain antenna systems for the lower frequencies.

3.4 Effect of man-made noise

For receivers with identical gain, which is the current situation with paging receivers designed to operate in the various frequency bands, the receiver noise factor increases with frequency.

The level of man-made noise, which is particularly high in inner city areas and on busy highways, where paging systems find most of their subscribers, is inversely proportional to frequency.

In the category of man-made noise we can also include on-frequency interference. 150, 450 and 900 MHz provide relative freedom from long-distance transmission and thus from interference, which is a major disadvantage of the bands around 50 MHz and below.

3.5 Radio propagation into buildings

Measurements results submitted by a number of administrations have indicated that frequencies in the range of 80-460 MHz are suitable for personal radio paging in urban areas with high building densities. It is possible that frequencies in the bands allocated around 900 MHz may also be suitable.

From measurements made in Japan, the following median values of the propagation loss suffered by signals in penetrating buildings (building penetration loss) have been derived. These are shown in Table 1 below:

TABLE 1

Frequency (MHz)	150	250	400	800
Building penetration loss(1) (dB)	23	18	18	17(2)

(1) The loss is given as the ratio between the median value of the field strengths measured over the lower floors of buildings and the median value of the field strengths measured on the street outside.

(2) Somewhat less accurate than the other results.

Similar measurements made in other countries confirm the general trend but the values of building penetration loss vary about those shown. For instance, measurements made in the United Kingdom indicate that building penetration loss at 160 MHz is about 14 dB and about 12 dB at 460 MHz.

Frequencies of about 80 MHz suffer losses similar to those at 150 MHz, but still lower frequencies, e.g. 35 MHz and 26 MHz have been shown to be less suitable for use in urban areas but have some slight advantage over higher frequencies in suburban fringe areas.

For radio-paging systems which are intended to cover large areas with little urban development, the frequency bands around 80 MHz and 160 MHz seem to be most suitable.

3.6 Techniques applicable to multiple transmitter zones

To cover a service area effectively, it will usually be necessary to use a number of transmitters. When the coverage from a single transmitter is small, a single radio-frequency channel should be used so as to avoid the need for multi-channel receivers. In these circumstances, the separate transmitters may operate sequentially or simultaneously. In the latter case, the technique of offsetting carrier frequencies, by an amount appropriate to the coding system employed, is often used. It is also necessary to compensate for the differences in delay to the modulating signals arising from the characteristics of the individual landlines to the transmitters. One way to do this is to carry out the synchronization of the code bits via the radio paging channel. Information is required about the bit rates which this synchronization method would permit.

It is preferable that the frequency offset of the transmitter carrier frequencies in a binary digital radio-paging system be at least twice the signal fundamental frequency.

It is also preferable that delay differences between the modulations of the transmitters in a binary digital paging system should be less than a quarter of the duration of a bit if direct FSK, non-return to zero modulation is used. For sub-carrier systems the corresponding limit should be less than 1/8 of the cycle of a sub-carrier frequency.

Studies are required to determine optimum methods for the transmission of signals over landlines and for simultaneous operation of a number of transmitters.

3.7 Receiver design

Built-in antennas can be designed for 150 MHz with reasonable efficiency. A typical radio-paging receiver antenna using a small ferrite rod exhibits a loss factor of about 16 dB relative to a half-wave dipole.

The feasibility of large scale integration of circuits (LSI) seems now to be realized. Component costs for a receiver using these techniques are low.

The majority of wide-area systems which have been established have employed some form of angle modulation.

Repeated transmission of calls can be used to improve the paging success rate of tone alert pagers. If p is the probability of receiving a single call, then $1 - (1 - p)^n$ is the probability of receiving a call transmitted n times, provided the calls are uncorrelated. Correlation under Rayleigh fading conditions can be largely removed by spacing the call more than 1 s apart. Longer delays between subsequent transmission (≈ 20 s) are required to improve the success rate under shadowing conditions.

Receivers with numeric or alphanumeric message display can take advantage of call repetitions to detect and correct errors, in addition to the possibilities offered by the FEC Codes which are used in the paging system.

4. Signalling format

The signalling format should be standardized. The choice of the appropriate coding techniques should take into account the required capacity of code combinations, speed of transmission, call success rate, and lowest practicable false calling rate. The code should be designed to allow for transmission of various types of messages. Recommendation ITU-R M.584 provides details of a recommended code and format.

Cyclic block codes such as the Bose, Chaudhuri and Hocquenghem codes, permit the reliability of signalling to be improved and the probability of false calling to be much reduced, because of their distance and their inherent error detection and correction capability.

It is desirable that the standardized code can easily share a channel with other codes.

Message repetition is one possible way of increasing the successful call probability.

For the measurement of the signalling reliability of equipment, it is understood that the International Electrotechnical Commission (IEC) is working on this subject. Results from field tests are also desirable.

5. System capacity

The number of users to be catered for still has to be determined.

It was estimated that the available overall capacity at a national level should be at least 10 per 100 inhabitants.

The capacity of any system is affected by at least the following:

– the number and the characteristics of the radio channels used;

– the number of times each channel is re-used within the system;

– the actual paging location requirements of the individual users;

– the peak information (address and message) requirement in any location(s);

– tolerable paging delay;

– data transmission rate;

– code efficiency;

– method of using the total code capacity throughout the system (this may also affect the system's capabilities for "roaming");

– any inefficiency introduced by battery saving provisions.

In addition to the above, there may also be access system input restrictions.

6. Compatibility between international and national radio-paging systems

It was recognized that a high degree of compatibility would be necessary between the national and international radio-paging systems. However, this does not preclude the establishment of radio-paging systems in factories, buildings etc., using different standards.

On an international basis, between systems that are technically compatible, the international user should be able to move to another country, and the service provided in his home service area be extended to him in remote service areas of another nation.

One method of providing service between systems which are technically incompatible, would be to exchange the subscriber's paging receiver, and to use an agreed method to transfer the subscription data between national systems.

ANNEX 2

Technical and operational characteristics of ERMES

1. Introduction

The European Telecommunications Standards Institute (ETSI) developed a new international radio messaging system named ERMES capable of offering enhanced paging services both to national subscribers and to those roaming outside their home country where a corresponding network is implemented.

The standard ETS 300 133 was published by ETSI [1992] and the introduction of ERMES started in Europe in 1993.

This Annex contains a general description of possible services in ERMES, the system architecture and the network aspects, the radio sub-system structure including the transmission protocol over the air interface.

2. Services

ERMES provides the basic services as follows:

– tone only paging (eight different alerts per radio identity code (RIC));

– numeric paging (up to at least 20 characters; the maximum message length is 16 000 numeric characters);

– alphanumeric paging (up to at least 400 characters; the maximum message length is 9 000 alphanumeric characters);

– transparent data paging (in the form of an arbitrary bit data stream up to a maximum message length of 64 000 bits) for several applications such as graphics, telecommands, coded voice, etc.

Messages longer than the maximum message length that a specific receiver can accept, should not be delivered and the calling party should be informed that the message is too long. Users who wish to send such a message can split it into shorter parts and define a method of linking the parts of the messages together, transparently to the ERMES system.

In addition to these basic services, a great number of supplementary services will be provided (some of which might be offered locally by individual operators), such as:

- international and national roaming (enables the mobile subscriber to choose, for a specific period, in which country(ies) and area(s) he wants his calls transmitted);
- establishment of priority levels (urgent, normal or non-critical time related messages);
- protection against messages loss (repetition, numbering, storing and retrieval, etc.);
- temporary barring of incoming traffic;
- deferred delivery;
- constitution of closed user groups (CUG, the possibility of mobile and fixed subscribers establishing a group with only internal communication possible; the mobile or fixed subscribers can be members of more than one CUG);
- facilities related to the destination of calls (diversion of traffic to other receivers, choice of destination);
- security facilities (encryption, legitimization code, verification for access);
- charging facilities (standard rate, reverse charge, charging information; these may be subject to limitations depending on the access network);
- out-of-range indication.

The paging categories can be summarized as follows:

The types of calls will be:

- individual; or
- group (using common or multiple RICs).

Basic and supplementary services should be provided with a certain level of quality of service defined by some criteria such as:

- message delivery time (may vary according to the priority level);
- system response delay;
- call accepted acknowledgement delay;
- call success rate;
- false call rate.

3. General description

3.1 System architecture

To cater for the ERMES services, mainly regarding the roaming capability and the international traffic handling, the different national networks should be connected to provide extended coverage. The general structure of the ERMES system and of the different interfaces is shown in Fig. 1. The ERMES system is divided into two main parts, the telecommunication part and the operation and maintenance part. This architecture follows the ITU-T M Series Recommendations.

As far as the telecommunication part is concerned, each network is under the control of a paging network controller (PNC) (see Note 1) which is detailed in the following paragraph. Paging area controllers (PAC) and base stations (BS) ensure the radio coverage into one or several paging areas and together form the radio sub-system.

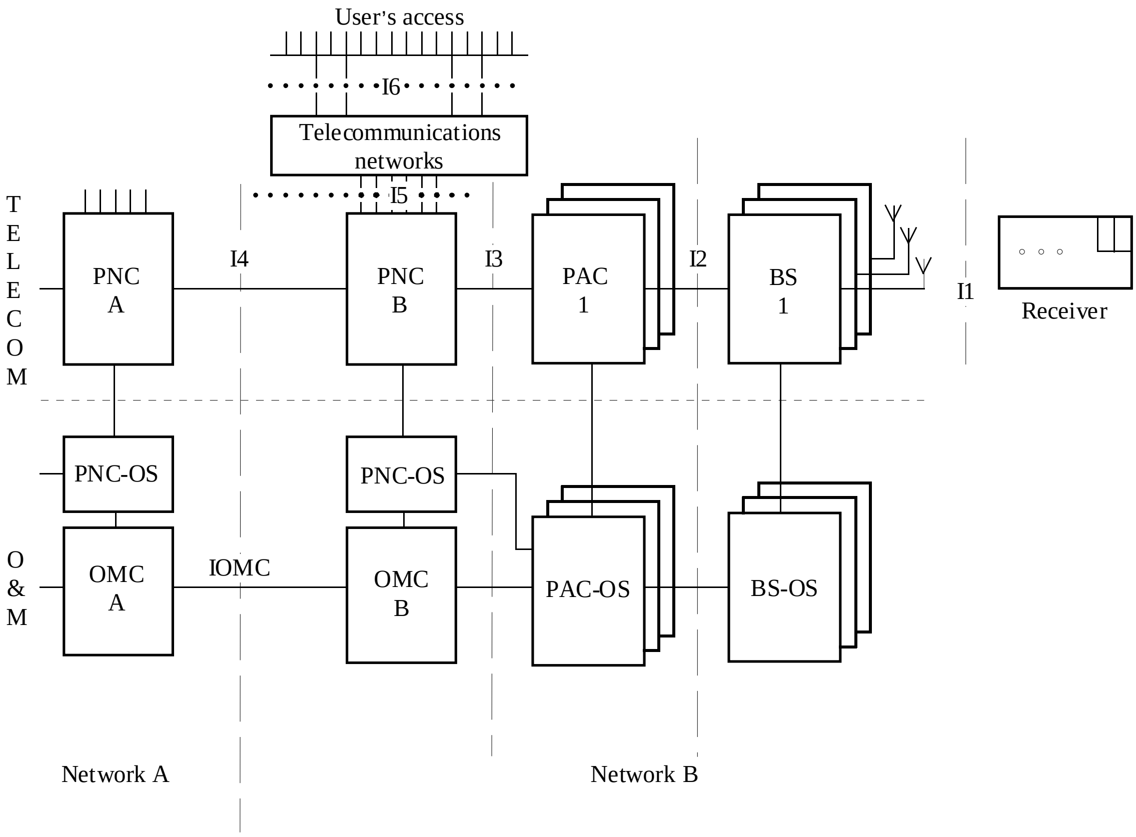
Note 1 – PNC is denoted control centre in the main part of the Recommendation.

The PAC, which controls one paging area, organizes the message queuing and batching according to the level of priority and the format of the transmission within the paging area under its responsibility.

The BS consists of one or more transmitters and the associated control and timing equipment. The transmission should be one of the 16 radio channels and organized according to the description given in § 6.

FIGURE 1

ERMES architecture



TELECOM: telecommunication part of the network
O&M: operation and maintenance part of the network
User's access: set of possibilities offered to users to gain access to the system (telephone, data terminal, telex, ISDN, etc.)
PNC: paging network controller
PAC: paging area controller
OMC: operation and maintenance centre
BS: base station
-OS: operation system
I1, I2, I3, I4, I5 and I6: functional interfaces between entities

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Interfaces between PNC/PAC and PAC/BS are respectively called I3 and I2. They are internal to the operator's network. External interfaces are I1 (air interface), I4/IOMC (inter-network inter-working) and I6 (user interface). I5 is considered external to the paging operator's network but it need not be harmonized with other paging operators.

I1, the radio interface, is based on the following characteristics:

– frequency band: 169.4-169.8 MHz;

Note 1 – Error correction capabilities of the transmission protocol have been designed for this frequency band. However, the transmission protocol is not tied to this frequency band and may operate in other frequency bands as indicated in Annex 1. It should be necessary that at least 1 of the 16 channels is common in the network which offers the roaming service. The common channel(s) is not necessarily the same in every network.

– 25 kHz channel spacing;

– modulation method = 4P AM/FM;

– symbol rate = 3.125 kBd (6.25 kbit/s bit rate);

– transmission protocol as described in Fig. 2;

– frequency agile receiver (16 channels).

FIGURE 2

Transmission protocol

PR: bit synchronization word
SYN: frame synchronization word
SI: system information
SSI: supplementary system information
AI: initial addresses
APT: address partition terminator
MC: message codewords

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3.2 Functional description of the paging network controller (PNC)

The PNC is the central call processing unit of the network. One PNC is normally in charge of one network and is linked to every other PNC of the ERMES system using the I4 interface in order to provide international paging calls and the roaming facility.

The PNC is responsible for the call processing which is described in § 4.3. In the case of international calls or roaming it cooperates with the other PNCs and exchanges appropriate information through the I4 interface. This interface should bear a standardized protocol stack using the ACSE and ROSE (ITU-T X.200 Series Recommendations) inter-working protocol and should conform to the ETSI specification ETS 300 133.

The PNC will proceed with a call acceptance mechanism for each call attempt in order to guarantee the offered quality of service. For this purpose, the PNC cooperates with the OMC which delivers status information.

Access to the service is gained through the I6 interface of the PNC which handles the user's dialogue. Access methods are summarized in § 4.2. When the connection between the user's terminal and the PNC is made through a telecommunication network, I5 is the interface between the network and the PNC.

4. Network aspects

The main principle of ERMES is to keep access to the system as easy as possible, so the user will access locally. Addressing, numbering and access methods are described below. Principles of call processing are also given.

4.1 Addressing and numbering

In the ERMES networks two different procedures are available to access services: one-stage and two-stage selection. In the one-stage selection, the call information input to the telecommunication access network is used for establishing connection to the PNC and also identifying the address code (AdC). In the two-stage selection the calling party firstly accesses the PNC using a service number (SN) and then, after the connection has been established, sends the AdC to the PNC followed by message or subscriber feature dialogue (see also Annex 1, § 1.2).

Every receiver should be allocated at least one AdC.

In the one-stage selection the AdC should follow the numbering plan of the access network. In the two-stage selection the AdC can be selected independently of the access network, for this reason the same AdC may be used throughout the ERMES access methods offered by the network. The AdC for this type of procedure should consist of the following three parts:

– country number, consisting of up to three digits (the same digits used as the country code for the PSTN in the ITU-T Recommendation E.163);
– network identification number, consisting of several digits which identify the network operator within the country;
– subscriber identification.

The AdC should not have more than fifteen digits.

A prefix should be used to allow the accessed PNC to differentiate between calls directed to receivers belonging to its own network or to other networks. These prefixes should be (according to ITU-T Recommendation):

– 00 if the called receiver belongs to a foreign network;
– 0 if the called receiver belongs to a network in the same country.

For this reason neither network nor subscriber identification numbers begin with 0.

All the receivers belonging to a group have at least one GAdC (group address code) following the same address structure of an AdC.

4.2 Access methods

The access methods fall into two categories:

– telephonic, when the system is accessed using a telephone set;
– non-telephonic, using any other type of terminal to access the system. Non-telephonic access methods are described for the following access networks: TELEX, MHS, ISDN (using user-to-user signalling).

For the two categories there are two modes of operation: one interactive and the other non-interactive. It is recommended to provide an interactive mode where the experienced user is allowed to bypass some parts of the dialogue.

4.2.1 Generic protocol for non-interactive access mode

The access procedure is non-interactive when prompt signals from the PNC are not required. The operation for each call may be divided as follows:

– preparation of the call in the local mode;
– automatic transmission:
  – call establishments;
  – information transfer;
  – ACK/NACK and call clearing.

4.2.2 Generic protocol for interactive access mode (two-stage selection)

The calling party can access the system via one of the two service numbers:

– Service number 1 (SN1) intended for call input and access to call input related supplementary services;

– Service number 2 (SN2) intended for accessing to control the subscriber features.

After every input prompt the system starts a timer waiting for input from the calling party.

All systems responses and acknowledgements are presented within a period of time specified by the quality of service limits. All the accesses are opened by a “greeting message” and closed with a “closing message”.

4.3 Call processing

Regarding the call processing the PNC performs one of several of the following roles:

– PNC-I (input): user’s access to the telecommunication access network and handling user’s dialogues;

– PNC-H (home): management and control of the subscriber database, checking the validity of the input AdC;

– PNC-T (transmission): sending the message to the appropriate PACs.

For a basic call input the call processing follows these general principles:

– A calling party establishes a connection to a PNC. This PNC plays the role of PNC-I.

– From the AdC given by the calling party, the PNC-I determines the PNC of the called mobile subscriber. This PNC plays the role of PNC-H.

– Receiving the AdC from PNC-I, the PNC-H sends back a response including all the elements in the database useful for the call processing and the result of the call acceptance calculation.

– With these elements the PNC-I informs the calling party if his attempt is successful or not. The PNC-I controls the validity of the message (accordance with the ERMES character set, consistency between the type of the message and the paging category of the receiver).

– The PNC-I sends an acknowledgement to the calling party and a page request demand to the PNC-H which is responsible for the call.

– According to the elements included in the database the PNC-H sends a transmit demand to the PNC-T(s) which are in charge of the requested paging area(s).

– The PNC-T transmits the message to the receiver on the corresponding paging area(s).

Supplementary services are taken into account in this processing. The call processing is also described for each subscriber features.

In any case the responsibility of the overall call processing is ensured by PNC-H.

5. Receiver operation

The receiver is the physical equipment which enables a mobile subscriber to receive a paging message. There are four types of receivers according to the different paging services, designed to provide:

– tone-only messages;

– numeric messages;

– alphanumeric messages;

– transparent data messages.

There is an upward compatibility between these types of receiver; e.g. an alphanumeric receiver should be able to receive also numeric and tone-only messages.

A receiver is able to operate in a frequency agile mode over 16 channels, according to the transmission protocol described in Fig. 2. As the transmission is coordinated through the 16 channels as indicated in Fig. 3 and a receiver is assigned to one batch, no information will be lost by the receiver even when it is scanning.

FIGURE 3

Coordination of batch transmission through the 16 channels

Channel																												
01	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L
03	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K
05	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J
07	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I
09	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H
11	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G
13	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F
15	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E
16	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D
14	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C
12	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B
10	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*
08	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
06	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N	O
04	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M	N
02	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*	B	C	D	E	F	G	H	I	J	K	L	M

12 s

*: Type A batch

D03

Each receiver should have at least one basic radio identity code (RIC) that is the number used by the system on the radio path to identify the receiver(s) for which the paging message is intended. The RIC consists of five parts:

– zone code (3 bits);

– country code (7 bits);

– operator code (3 bits);

– initial address (18 bits);

– batch number (4 bits).

Several battery saving techniques which could be combined are proposed:

– *Batch level:* battery saving at the batch level can be achieved by assigning a RIC at the end of the addressable RIC population, since addressing is always performed in descending order. A receiver may switch off if it detects an initial address higher than its own in its batch type.

– *Sub-sequence level:* battery saving on this level is an inherent capability of the air interface protocol achieved by initially addressing the receiver in only one of the sixteen batches of the sub-sequence.

– *Cycle level:* battery saving on the cycle level can be offered by getting the pager to receive signals for only a sub-set of the five sub-sequences in a cycle. The active sub-sequence for a particular pager is set by the sub-sequence mask SM (5 bits) stored in the pager.

6. Radio sub-system

The ERMES radio network structure is based on time divided and/or frequency divided network operation and it is up to network operators in each country to decide the mode of operation. Figure 4 shows the three modes of operation viable in the system.

6.1 Time divided operation

In a time divided network paging coverage is provided transmitting different sub-sequences (from the same cycle) in each paging area. Transmission on the same frequency for each batch type occurs at least once per minute in areas where coverage is offered. Adjacent paging areas may transmit on different sub-sequences to avoid interference between neighbouring areas using the same frequency.

6.2 Frequency divided operation

Frequency divided network operation implies that adjacent paging areas use different frequencies at a certain time. No time sharing between paging areas should be used. Within its home network a receiver should use different frequencies in different paging areas.

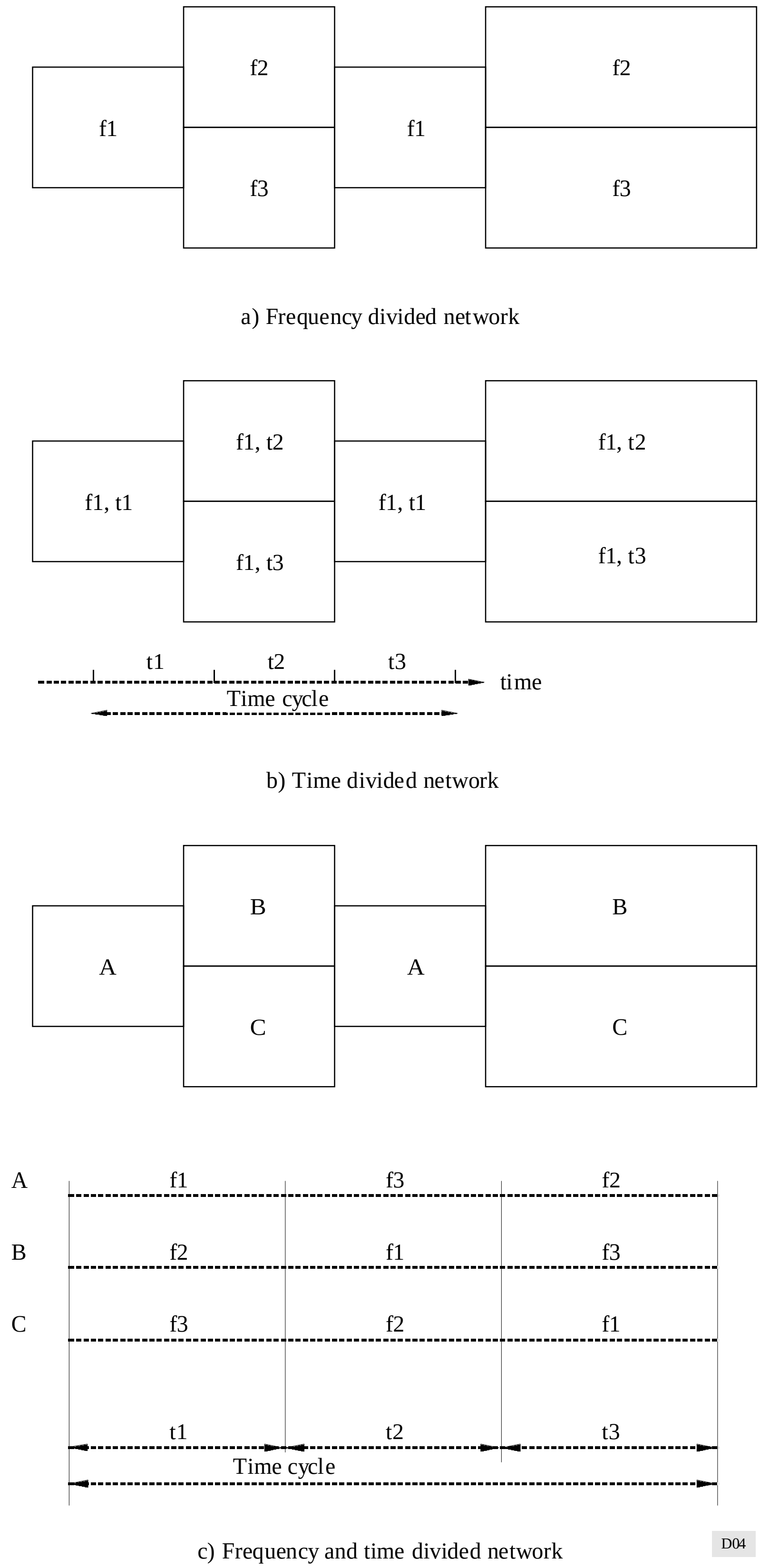
6.3 Combined time and frequency divided operation

This is a common mode of operation in large wide area paging networks. It is a combination of both modes previously described as shown in Fig. 4.

When a paging area is adjacent to a network operator boundary, the border area indicator is set to one in the system information partition. This means that a receiver associated with that network may expect to receive calls from an alternative network and should then take the appropriate action.

FIGURE 4

Possible configurations of ERMES radio structure



a) Frequency divided network

b) Time divided network

c) Frequency and time divided network

The external traffic indicator is set to one in the system information partition to indicate to receivers who cannot find their home network, that there may be a message for them in this batch.

REFERENCES

ETSI [July, 1992] European Telecommunication Standard ETS 300 133 – Paging Systems; ERMES ETSI. European Telecommunications Standards Institute, Sophia Antipolis, F-06291 Valbonne Cedex, France.