TOWARDS NEW TECHNIQUES IN TELECOMMUNICATIONS TO SERVE LARGE USER POPULATIONS

Facts and Views Concerning Industry Oriented Research at the Faculty of Electrical Engineering in This Field

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Summary

An account is given in this paper of the industry oriented research at the Faculty of Electrical Engineering in the past five years in the field of Public Telecommunications and Telematics.

Actual and realistically anticipated needs of the users are briefly surveyed at the outset. Facts and views, concerning specific projects and underlying methodologies, are considered.

The paper was presented at a symposium, held at the Faculty of Electrical Engineering, April 19 and 20, 1983 as part of the bicentennary events at the Technical University of Budapest.

Introduction

Means for serving economically and efficiently a large user population distributed over a certain area, plant or building by electronic communication and information services have been rapidly improving in the past decade. New activities are appearing in this respect also within the reach of Hungarian workers in Public Telecommunications as well as consumer oriented Informatics [3, 4]. All this is just one of the impacts of the growing functional possibilities of electronic devices on basic information technologies.

Progress in Public Telecommunications and related new data processing services is a matter of particular interest also in this country for at least two reasons: the vast and still increasing amount of unmet demands in Public Telephony and the more recent ambition to provide low cost personal computers with a flexible and cost saving access to remote central services and also to each other.

My purpose in this talk is to give an account of what has been done in this field specifically at this Faculty within the past five years and to draw some

conclusions. Let me start, in so doing, with a brief survey of the actual and anticipated needs of a population working or living within a certain investigated area. Besides I will also point out what has been actually achieved concerning specific projects and underlying methodologies.

While all this has certainly been influenced by my personal experience and interests, I still hope to give a fair picture of what has been pursued and achieved in this respect by the entire Faculty and full time Research Staff of Electrical Engineering, here at the Technical University of Budapest.

This paper was presented at a symposium held at the Faculty of Electrical Engineering on April 19 and 20, 1983, as a part of the bicentennary events at the Technical University of Budapest. Let me refer, at the outset, to the general information given at this event in the Opening Address [1] and in a survey lecture on the entire research done at this Faculty [2]. I am going to refer in the text to companion lectures, presented at this meeting, and also to papers previously published by my colleagues and myself on specific topics.

Growing Need for Communication and Information Services and Impacts of Microelectronics

People doing their work or living within some investigated area need means to communicate with distant parties by speech and text (i.e., via telephony and telegraphy), to use information services, execute transactions, leave messages, mail letters promptly and listen to or watch broadcasted programs. They may wish to do so when turning to parties and centers either within or outside of the considered area. Many of them may also want to be warned whenever anybody calls them, wherever they stay within the area, perhaps far from any access to the public network. (Services of this latter sort are frequently called paging.)

Needs, even for the more recent kind of these services, are apparently growing also under the economic and infrastructural conditions that exist at present here in Hungary.

In Table 1 a brief account is given of these services. (See columns.) The conventional telephone set, the personal computer, when communicating either with some other user set or with a service center, the conventional television and radio set are the most popular devices through which people can directly turn to these services. (See the rows in Table 1.)

By the thick and thin traced crosses in Table 1 the services are indicated which, for the time being, are either in widespread use or just under

experimentation, especially here in Hungary. (Thick traced crosses refer to the former.)

Comments at the arrows point out the present state of the art in this country a bit more thoroughly in four respects.

Professional users and homes of essentially different needs and behavior are interested in these services. However the amount of investment and service costs to be returned annually per user are the most crucial figures of assesment in all of these cases. They should be, in some reasonable sense, proportional to the specific economic and social advantages actually experienced by the final user and also to what he can actually afford. This strongly Economy and Society influenced attitude makes these kind of applications specific even when basic methodologies are concerned.

Microelectronics achieved a functional efficiency in the past decade, thus also data processing, viz., the *tele*-inform*atics* type of the aforementioned services became, for the first time, really appealing even for the general user (Fig. 1).

As a matter of fact, one could hardly have spoken about many of the items in Table 1 as really reasonable even, say, ten or fifteen years ago. However, efforts to make each of the aforementioned mass services uniformly available is becoming a widely accepted goal for any perspective communication and information service planning in any ambitious community.

Table 1

Meeting additional demands by existing networks

Speech conversation	Informatics services offered			Electronic		
		via				
(telephony)	by an autonomous use of personal devices	public or private networks	broad-casting	mass media	mail	paging
	many unmet demands					
	first home products					
				almost complete covering of the country		

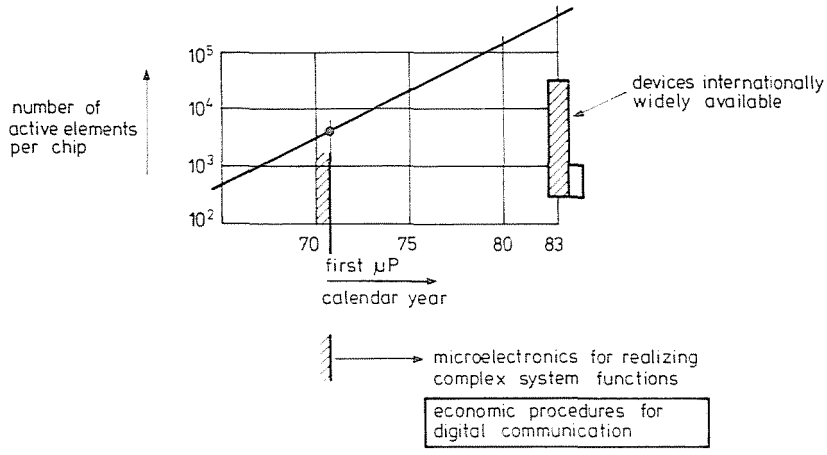


Fig. 1. Increase in functional capabilities

The above activities also appear as particularly appropriate for orienting both class- and project-work of students toward real-life topics in Communication Technology and Information Sciences. These facts also motivate our interest in teaching and research at this University.

Steps Toward Distributed Intelligence in PCM Networks

One of the most urgent actual tasks in Public Telecommunications also in Hungary is to meet the vast amount of unsolved and intensively arising new demands by means of existing telephone networks and relatively simple additional developments, as far as possible (Fig. 2).

Some features of the telephone network architecture, widely used at present, are summarized in Fig. 2.a. A multitude of trunk lines, each for serving just one of the actually busy telephone channels individually (1) and individual subscriber lines (2) are typical for this practice. It is quite obvious how infrequently most of the subscriber lines are really used, even during the busy hours. It is well known that most of the present routine in Public Telecommunications still relies upon analog techniques.

By digital transmission and switching, however, basically new possibilities are offered. Using either a single or several 34 Mbit/s digital channels for conveying many speech signals simultaneously, inter-exchange traffic can be essentially increased. On the other hand, access for up to 500 individual subscribers can be realized to a local exchange by means of an intelligent digital

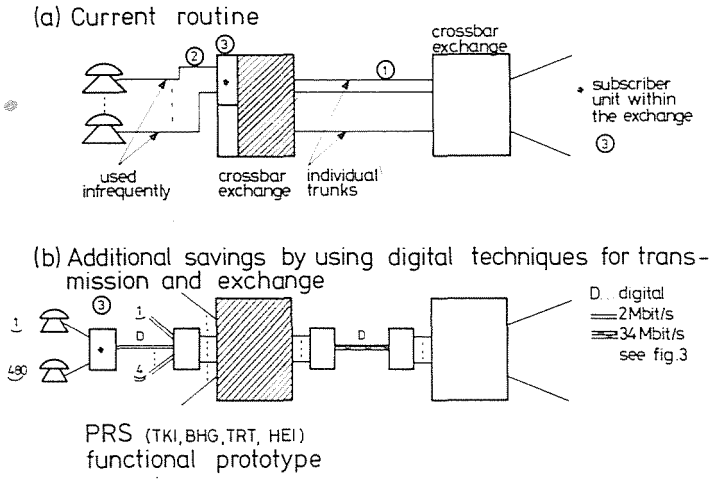


Fig. 2. Traffic concentration, and distributed exchange functions for digital suburban and rural networks

concentrator, including also the subscriber level switching functions of the local exchange, through a 2 Mbit/s digital channel. The extent of service may be easily multiplied by using several such channels.

A prefixed subdivision of the sampling period among the individual speech channels to be served simultaneously and coding each instantaneous speech sample individually (i.e. conventional PCM techniques) appear as the most appropriate basic means for Public Telephony for the time being and are also likely to maintain this status until present conditions will hold for electronic implementation and network planning.

Convincing examples are found in this respect for digitizing trunk systems also within the existing urban telephone network of Budapest. The most interesting is the star-network completed by the end of the seventies for linking, through the Széchenyi Hill Microwave Center, the most vital exchanges of the city. This network makes a particularly appropriate use of the specific geography of Budapest.

System PRS, a joint project of the Telecommunication Research Institute (TKI) and the Hungarian telecommunication companies BHG and TRT, is a current development in PCM techniques at a lower level. This system is specifically meant to economically serve suburban and rural areas by PCM principles and multiprocessor-stored program-control. The Institute for Communication Electronics (HEI) of this Faculty has been contributing to this venture in the past two years by basic studies in distributed control and

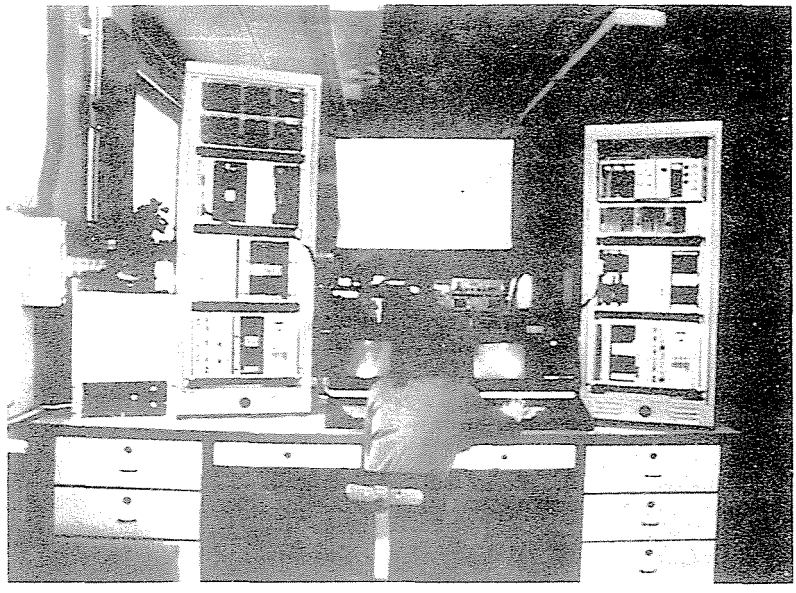


Fig. 3. Functional prototype of the terminal interface and central units for the System PRS

switching and also by developing the functional prototype of the terminal interface unit [5, 6]. (See asterisk in Fig. 2.b.) This prototype is, as yet, at the stage of overall performance tests at the TKI and the BHG (Fig. 3).

Techniques for Digital Radio Telephony and Speech Packet Communication

More recently, access to public networks through land radio channels is becoming an interesting option also here. VHF radio systems offer flexible means for telephony as well as data services even within a single frequency slot with a width of, say, 25 KHz, even between parties not strictly within line of sight. On the other hand, SHF systems can handle much broader bands, but are strictly confined to stations appropriately located with respect to each other.

For any significant progress in digitizing commercial land VHF systems more service and flexibility should be offered within the very same frequency band at about the same cost per speaker as do current analog systems.

One may also want to offer significantly more service even when conveying just a single telephone subscriber through a single 25 kHz wide

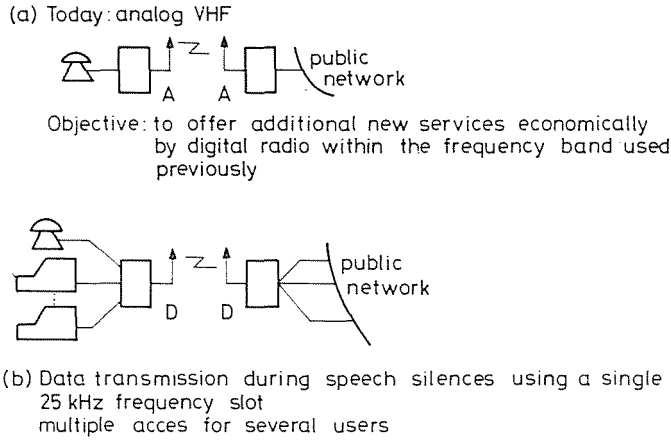


Fig. 4. Access to a public net via radio

frequency slot. A realistic goal may be to give simultaneous access to, e.g., two personal computers even while the speech source is actually busy. (Fig. 4.b. D stands for digital radio communication.)

Such a combined service makes sense when, e.g., the continuity of transactions or electronic mail from desks or windows, around some executive or dispatcher with a telephone set, should not be interrupted even during speech conversations.

While such "data between voice" procedures can be implemented also if the speech samples are coded individually (as in conventional PCM), and even in analog speech transmission, very low addditional investments are needed for this approach when, instead of individual samples, appropriately labelled speech segments (of, say, 10 ms duration) are coded and conveyed jointly. (Such labelled message segments are usually called packets.)

The way message fragments from two data sources, D1 and D2, are stored and then forwarded during speech silence periods is explained in Fig. 5, specifically for packet communication.

The sequence of speech packets and silence periods generated consecutively by speech source S, the way of inserting data packets from sources D1 and D2 into speech silence periods and, finally, the combined sequence of speech and data packets actually conveyed are shown in Fig. 5.

The conclusion that speech should have priority, follows directly from a comparison of the admissible values of the transmission loop delay for speech and man-machine conversations, respectively. This is less than 0.1 s for speech and more than 1 s for man-machine dialogues, for the specific application considered.

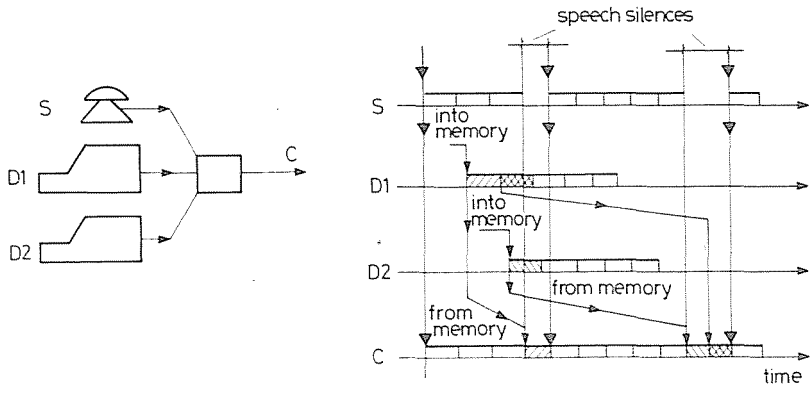


Fig. 5. Inserting packets of two data sources into the sequence of speech packets

Conventional VHF transmitter technology has got a preference for nonlinear techniques such as frequency modulation and also needs some suitable radio pulse shaping for the efficient use of the frequency spectrum.

A particularly appealing approach for solving the first of these problems is to adopt the partial response principle in some appropriate way to frequency shift keying, a solution known as tamed FM [7].

In order to convey binary coded speech through a 25 kHz wide frequency slot, a compression to 16 Kbit/s is needed.

A transceiver of such sort meeting CCIR compatibility recommendations [8] and a specific speech compression approach [9] particularly appropriate for low cost implementations have been developed for these purposes at the HEI, as part of a project of the Hungarian radiocommunication company BRG. VHF telephone extensions mainly for rural areas are the goals of this work. Speech transmission with communication quality (of appropriate articulation but definitely below the CCITT recommendations for toll quality) has been demonstrated by a transceiver pair, specifically developed at the HEI for this purpose.

Basic techniques for speech packet communication have been investigated recently, also at the HEI, concerning such topics as the impact of loosing 10 ms duration speech packets on the articulation and the subjective quality of speech [10]. Transmission delay in store and forward procedures have been analyzed, also at the HEI, under conditions specific to speech packet communication [11, 12, 13].

Offering Free Access

As personal computers become widely accepted also as intelligent typewriters, demands to turn from these to central information services occasionally and to deliver also electronic mail, are likely to become widespread. Presumably only a randomly selected very small part of a very large (seemingly infinite) population of potential users are to use the network at a certain time, much the same, almost unrestricted, way as these people enter supermarkets. Active users may show up practically at any point within the considered area. And they may want to be served by the network even if they do not possess user sets previously accepted by the network.

Any of the users, even when busy, use the network just for a small fraction of time. E.g., even a busy user turns to the network only twice in a minute, each time just for a fraction of a milisecond.

It is well known that random access communication offers particularly simple and flexible techniques to serve users. Indeed, these techniques proved to be particularly practical for such purposes within the past decade abroad [14...21] and more recently also in this country [22...25].

By random access communication we mean, at least in the current context, a specific procedure by which a common medium (viz., a bus or a radio channel) can be completely seized, at any instant by one user entirely. The time interval, during which this happens depends, however, on the actual entrance and processing times of the rivalizing users. Thus access is given randomly (Fig. 6).

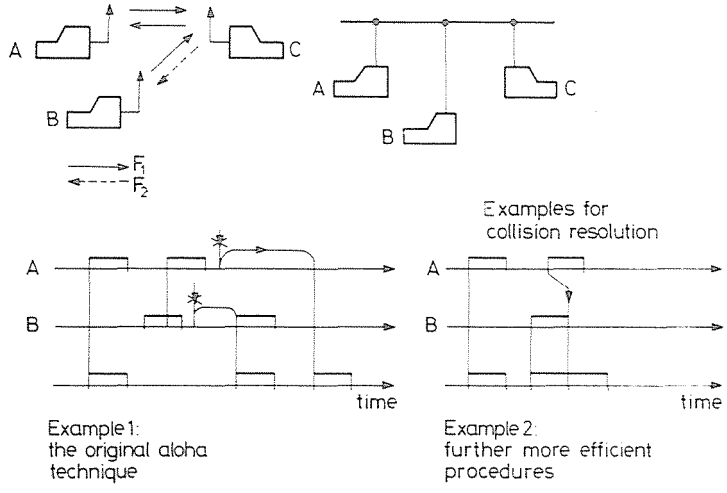


Fig. 6. Random access communication for data sources via a broadband channel

The main task here, is to devise some collision resolution algorithm, by which the rivalizing packets can be conveyed with a tolerable delay, provided the intensity of the incoming calls is below a certain threshold.

By Examples 1 and 2 we merely point out two conditions, by which essentially different algorithms can be arrived at.

Thus, in Example 1 the packets from source A, meant for C, are automatically retransmitted, provided no positive acknowledgment arrives from C through the return channel within some previously determined response time. Sources A and B retransmit of course in this case their packets only next to some waiting time, drawn in both cases, independently, according to an appropriate probability distribution. This is the classic ALOHA procedure [14].

One obviously arrives at algorithms different from Example 1, if any new packet is automatically excluded from the competition until all of the actually processed demands are not met (Example 2, Fig. 6).

Efficient algorithms of various properties can be devised by adopting various ways of collison resolution. This can be done either with or without keeping away newcomers from the actually proceeding race.

Any packet has, of course, to carry the specific identifier of the called party as well as that of the sender, and also some code structure for error detection. While the simplest options of random access procedures use the information carrying packets also for searching, this can obviously be done also by much shorter packets, carrying identifiers and some error-detecting structure only. One can arrive in this way, at a time utilisation (called also throughput) of, e.g., 70%, i.e. not much below PCM, within an admissible packet delay.

Besides data conversations also some telephone service can be offered. In addition to giving priority to speech packets, the very fact may also be utilized in this case that, e.g., 1% of the speech packets can be lost without any essential deterioration of speech quality.

Let me refer at this place to the contributions by the HEI [26...35] to algorithmic ideas, analysis, computer and electronic simulation techniques in this field.

First an experimental set-up was developed, implementing the simple ALOHA procedure at a rate of 1200 bit/s for radio terminals within the display terminal system of the IBM 4331 center at the HEI. It is used as an experimental extension of this system by mobile terminals and also as a facility to investigate various algorithms under more or less real life conditions.

Carrier frequencies F_1 and F_2 around 160 MHz, are conveying packets from the users A and B to the center C and in the reversed direction,

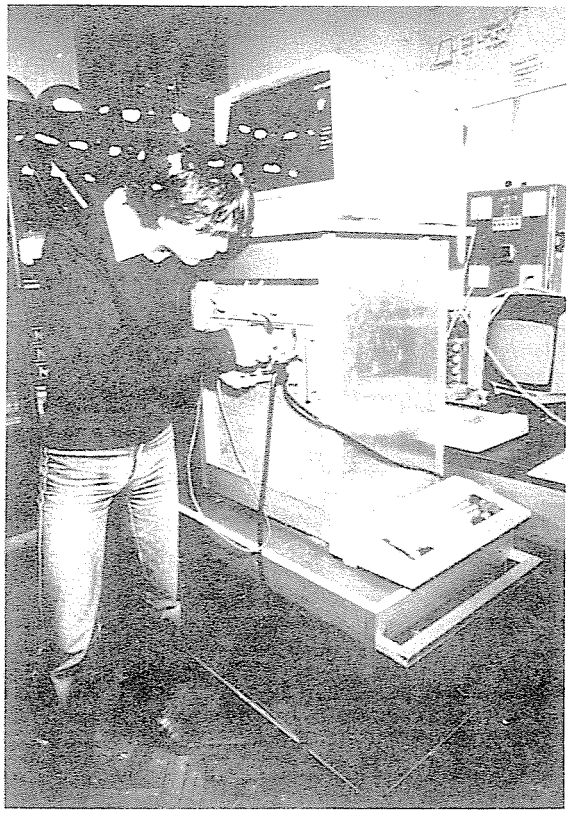


Fig. 7. Central unit of a development system for random access communication

respectively (Fig. 6). The central control unit of this set-up, interfacing the mentioned IBM 4331 center, is shown in Fig. 7.

By means of a computer based electronic simulator, a Poisson-flow of packets was generated at an intensity $(n-1)$ times the intensity actually experienced for a single user, realizing interactive programming (n stands for the number of the display terminals supposed to be simultaneously busy). Experimental evidence was obtained in this way that 10 intensively working interactive programmers can be simultaneously served by such a service within an average transmission loop delay of 2 s, even at a rate as low as 1200 bit/s [36]. The user acting at a display terminal in this way did not experience, even under such load, any remarkable slow down.

A radio terminal, equipped with a whip antenna, proved to work, for a long while, without any error in most of the typical classrooms, on the campus

of the Technical University of Budapest [37]. Similarly affirmative experience was obtained when operating one such radio terminal in a classroom, in the building of the Computer Educational Center, Hungarian computer applications company SZÁMALK, Szakasits Árpád út. This is 2.5 km apart from the HEI computer center, still within the busy urban area of Budapest.

Activities at the HEI in this field are associated with a number of specific projects. One of these is a VHF random access extension of a packet-switched open network system, being developed by the Computer and Automation Research Institute (SzTAKI) of the Hungarian Academy of Sciences. Random access radio terminal extensions are envisaged also for three regional centers of the Hungarian Ministry of Education in Szeged, Pécs and Budapest. This is also of interest to further the possibilities of serving personal computers and telephone sets through buses and VHF land radio channels, flexibly and economically, in this way.

Random access communication is, however, by far not the only approach by which at most one user is served at a time by the common channel. Conventional polling is the other extremity which needs, however, previous configuration. Much time can be vasted in this case, if many of the registered users are actually silent. Various techniques may, of course, be found in between, each with advantages under specific conditions [38]. Let me, however, confine myself just to random access procedures in this paper, as these are the "one-user-at-a-time" systems, which really need almost no "a priori" organisation.

But the policy of serving at most one user at a time is also not the only way to offer free access to a population.

Free access procedures, permitting at any instant a strictly simultaneous use of the common channel by several users, are of growing interest also for Public Telecommunications. It is a question of great interest above what geographic traffic density are such procedures superior in economy, flexibility and privacy to other free access options. Perspective tasks considered in this respect are:

— mobile Public Telephony extensions by cellular networks

— offering free access through buses also for a high ratio of telephone users.

For such procedures either the term code division or the term spread spectrum multiple access is used. The actual usage depends on whether one wants to emphasize the very fact that the simultaneously received signals are distinguished by the way they are encoded, or the very property that each individual signal makes use of the entire common frequency band.

Appropriately fast synchronisation techniques, reliable reception at low cost even between parties communicating under temporarily unfavourable conditions, are two crucial topics in this respect. (The latter is only of interest for VHF communications but not when a bus is used as the common medium. Unfavourable is meant, in this context, with respect to the joint interference due to all other simultaneously received stations.)

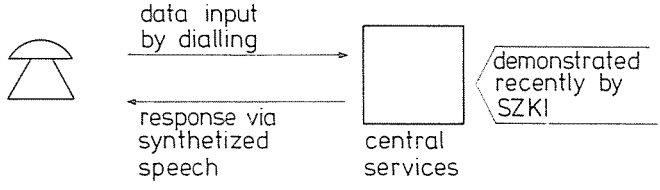
It is therefore not surprising that the actual significance of spread spectrum techniques, specifically in Public Telecommunications is more or less still an open question at least for the time being.

Let me just refer to basic studies and experiments done in this respect at the HEI in the past couple of years and also to an experimental set up developed at this place for such purposes [39...48].

Topics within Telematics

A seemingly modest but actually significant option offered since a while at some international banking centers abroad is to give people access to data centers also through conventional telephone sets. These sets are assumed to have no auxiliary device at the place of the user for supporting specifically this option (Fig. 8).

Some basic features of such services were demonstrated in Hungary by the Institute for Computer Coordination (SzKI) this spring [49]. While this Faculty undertook no activity on any such project until now, procedures and a many sided experimental set up, recently developed at the HEI for speech synthesis, are of immediate interest also in this respect.



Remarks

synthetizer at the service center
user identification and encyphering
for public networks

One of the relevant applications of speech synthesis (see VT-HEI)

Fig. 8. Providing information services via the telephone set

This synthesis project was initiated by the Hungarian computer company, VIDEOTON, specifically for feasibility studies and industrial purposes.

Some insight into the activities within speech synthesis and into some other basic speech processing techniques at the HEI, is given by one of the companion lectures at this meeting [50], by a previously published paper, a monography in print and a recent preprint [51, 52, 53].

The significance of using a television set as a port for either one- or two-way data services is already fairly well known, in Hungary too. (These one- and two-way services are more recently called by the CII, broadcasting and interactive videotex, respectively.)

Workers in Television at the HEI have adopted and investigated the basic procedures, created a development set-up, thoughtful test procedures and test sets, two kinds of receiver prototypes, and have also undertaken feasibility studies and field experiments in this respect. The fact that the Hungarian Television is regularly broadcasting videotex pages for experimental purposes, that commercial projects are under development for interactive videotex services, e.g., by the SzKI, that much field experience is available for both kind of the videotex services, are fairly due to this activity.

A photograph of the aforementioned videotex development set up at the HEI is shown in Fig. 9. Let me refer for further information in this respect to a companion lecture on this project given at this meeting [54] and also to two reports [55, 56].

One may also wants to transmit high resolution pictures, such as photographs, from one office or laboratory to another, with a high fidelity, from any spot where a telephone set is available. This may happen either occasionally, just within some fraction of a telephone conversation, or for longer periods, e.g., outside busy hours. The requirement may be either to convey a single picture through the channel within some time, tolerable for human transactions, or not vasting time or money unduly even when long runs of pictures are to be conveyed, e.g., at night. Efficient picture compression is obviously a topic of particular interest in any of these cases.

The photograph of a coder developed specifically for such purposes at the Department of Microwave Communication (MHT) at this Faculty, is shown in Fig. 10 [57].

A specific sort of nearly universal coding is adopted for slow scan television in this device. This project is an example of the efficient joint activity of the MHT and the Institute for Computer Coordination (SzKI) [49, 57].

Another project pursued within Telematics also at the MHT, is paging through radio broadcasting. Progress, in extending Public Telephony by VHF

Fig. 9. Development system for interactive and broadcasting videotex procedures

radio and the improvement in low cost pocket transceivers, will gradually make access to the Public Network also practical from many of the places excluded as yet from such services. Nevertheless, much investment is still needed for any really essential progress in this respect. An option for warning people by concise addressed messages any time they are called by others is therefore also of lasting interest. This option is, of course, meant only for those who previously checked into the service.

Broadcasting radio programs and paging messages simultaneously is possible by using conventional frequency multiplex techniques.

Medical doctors, dispatchers and executives of various commissions may be warned in this way even if they are at any arbitrary place within some very large geographic area. Broadcasting calls in a similar way may also be of interest within public telecommunication networks, provided appropriate VHF extensions are available.

A photograph of the central unit of a radio paging service, developed also by the MHT is shown in Fig. 11.

This unit is part of a radio paging system, meant for feasibility studies within the Hungarian broadcasting system [58, 59].

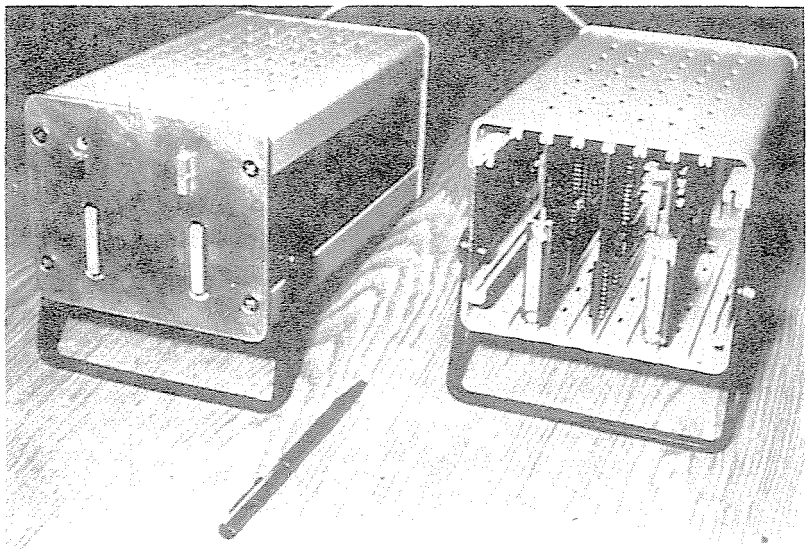


Fig. 10. Source coding for slow-scan picture transmission

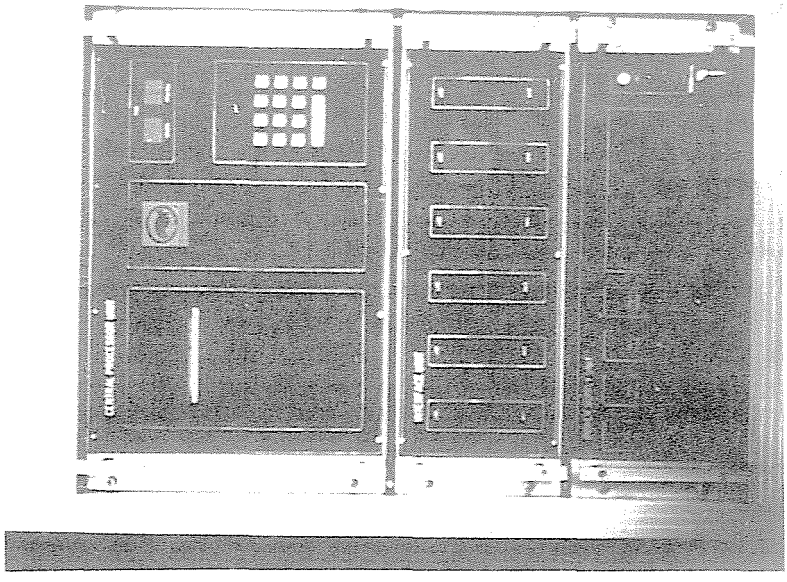


Fig. 11. An experimental paging unit for radio broadcasting

The Underlying Methodologies

I have intentionally confined the previous survey to tasks of common interest within Public Telephony and Telematics only.

Such activities are certainly of interest to anybody actually using, operating or implementing such kind of services. On the other hand, fairly much machine intelligence can be embedded into such systems by means of electronic devices, operating at relatively low rates and using mostly widely available technologies. Projects of this type are therefore likely to be of interest and also within the reach of organizations working under economic and infrastructural conditions which exist, e.g., here in Hungary.

Ambitious students, or anybody approaching this field, may of course ask, what methodologies are underlying current projects and what is really instructive from a more general aspect in this area.

Relevant information is summarized in Table 2. In the previous sections reference was given to each of the first six items in Table 2. As a matter of fact, these are the methodologies within each of which work has been actually done at this Faculty in the past five years.

I included the seventh item, viz., USER IDENTIFICATION AND CRYPTOGRAPHY FOR PUBLIC NETWORKS, into Table 2, just because there is a rapidly growing interest, also within Public Telecommunications and Telematics in this respect [60]. Until now, however, there has been no specific activity in this field at this Faculty.

Let me, therefore, confine the following comments just to the first six items in Table 2.

Table 2

Some of the underlying methodologies

- ☐ Specific queuing techniques
- ☐ Control techniques for stored program exchanges
- ☐ Principles, procedures and theoretical possibilities of multiple access communication
- ☐ Speech processing (silence detection, compression, synthesis)
- ☐ Picture processing (enhancement, compression)
- ☐ Codes for error detection and correction
- ☐ User identification and cryptography for public networks

Obviously, Queueing Theory is the key discipline in random access communication. Many of the queueing tasks within this field are specific, with respect to conventional topics, because of the specific models and rules of interest in collision resolution [61].

Such cases are of particular interest under conditions when the queueing process tends to some stationary behaviour, even if the call flow is drawn from an infinite population of users. (Usually only Poisson input flows are considered in this respect.) In any case this actually happens, the random access procedure is said to be stable.

At any occasion when data and speech sources are handled jointly, priority has to be given to speech. Conditions when temporary dependence within the individual speech call flow is eliminated is a question of interest. As a matter of fact, there are several interesting new aspects thrown up by random access communication in addition to the standard menu of Queueing Theory.

Priority and also dependence within the call flow are topics of interest when store and forward techniques are considered, provided that also speech packets have to be conveyed besides data.

Queueing studies are gaining importance also within Consumer Electronics, previously a field of application very far from traffic studies. This is the case, e.g., when we are interested in restricting user behavior or in introducing appropriate tariff policy specifically for interactive videotex, operated in heavily loaded public networks.

Distributed control, handling real time tasks efficiently and reliably, devising multiprocessor architectures, real time operational systems, automatic diagnostics and routing algorithms particularly for such purposes outline the key methodologies for any stored program control for switching systems.

Spread spectrum multiple access techniques raise a set of specific theoretical topics concerning quasi-orthogonal pseudo-random sequences, fast recursive estimation, the statistical analysis of various channel models and transmitting schemes and devising suitable code structures. This area appears, since a while, the most active field of publications, as far as theoretical subjects of the present survey are considered.

Information theoretic studies specifically concerning performance limits, attainable within various classes of either random or spread spectrum multiple access procedures, are also topics of fundamental interest. This is in part because of the insight actually gained from such results and also because of the real need for assessing the efficiency of various, more or less occasionally invented, specific procedures.

While work at this Faculty has been mainly concerned with devising and analysing multiple access procedures in the past five years, we also had a good chance to be in touch with schools pursuing these strictly information theoretic aspects, both in Hungary [63, 64] and abroad [61, 62].

Speech processing, silence detection, source coding (i.e., data compression) and speech synthesis were the main research subjects here, in the past

five years. Specific topics investigated were speech process modeling and characterization and inference in stochastic processes under specific contraints of source coding.

Picture processing for slow-scan television may seem easy at first sight because of low data rates and long processing times. However, this is by far not so, if tolerable transmission times are wanted. The special feature of the joint work done by the SzKI and the MHT in this respect is an original sort of closely universal coding, efficient for very different kinds of pictures.

I have already pointed out some uses of code structures. While even error detection poses some special problems in random access communication with feedback (e.g., with acknowledgements), coding for spread spectrum techniques raises a number of really specific questions, concerning the dephts of code construction [65].

It is well known that error control in conventional data transmission is usually an additional option to increase reliability. Nevertheless transmission is functionally possible in most of these cases also without any coding. However, random access with feedback relies existentially upon error control: without this the collision resolution procedure can not proceed.

Error control was entirely unknown in Consumer Electronics, e.g., a decade ago. But, at present, videotex units of conventional TV sets use a Hamming code for error correction as a commonplace.

Conclusions

Academic work on low cost mass services, for Public Telecommunications and Telematics, was considered in the present paper.

The reader may still wonder, whether methodology can make sense in such an everyday topic under the severe pragmatic conditions, well known in these cases.

It turned out, however, that the pragmatic constraints imposed on cost, flexibility, ease of use, etc. do not necessarily make commonplace the design task itself. As a matter of fact, a number of very specific methodological problems are posed in this way.

I hope that even the readers previously unaware of the specific problems arising in this field, were given at least some insight into the extent methodologies could be utilized in this respect, especially at the Faculty of Electrical Engineering, here at the Technical University of Budapest in the past five years.

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