# OFFICE COMMUNICATIONS TECHNOLOGY

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Hugh Collins

Communications Studies Group
Joint Unit for Planning Research (University College London)
172 Tottenham Court Road, London WIP OBS
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## Summary

This paper was conceived on a working visit to the New Rural Society project at Stamford, Connecticut, during July, 1972, by Alex Reid and Hugh Collins. It is based on initial work by Reid (P/71349/RD).

The paper describes a model of office activities, concentrated on communications activity, which may be used to predict the potential usefulness of communications facilities in and between offices, not only for person-person communication, but for person-machine and person-store interaction also.

The model involves sets of office roles, split up into separate activities, each of which requires information flow to and from the office worker which may be described by a set of 27 parameters. These same parameters may also be used to describe communication devices of all types, so particular activities may be matched to particular devices or sets of devices by this method. An example of how the method may be applied in the case of a single office worker is given, and the method of extending the process to an organizational unit is described.

Examples are also given of the way in which apparently dissimilar communication devices may be described using a common set of parameters, making it possible to isolate the important similarities and differences between devices. This method will also serve the important purpose of creating sets of design parameters for new devices based on an analysis of need rather than on technological feasibility.

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## Introduction

This paper describes a model of office activity which may be used to predict the potential usefulness of communications facilities in and between offices, not only for person-person communication, but for person-machine and person-store interaction.

The Telecommunications Impact Model, Stages 1 and 2, as described in P/71275/CL and P/72031/CL is a method for providing information about an important, from a communications standpoint, subset of office activities.

Many items in a typical office are communications devices, where communication is broadly defined. For instance, a pen and paper together constitute a device for creating a store of information which may be transferred to and read at other points, thus forming a communication event. A device for recording incoming telephone calls also performs the same function, in so far as it creates a store of information.
Our problem in considering devices as diverse as the two above is to provide a taxonomy which will enable us to indicate concisely both the similarities and differences between, for instance, a pen and paper and a call recorder. We shall consider devices serving, hopefully, all known office functions, including person-person, person-machine, and person-store communication.

We then have the problem of describing office activities in such a way that the need for various devices which arises in undertaking these activities can be predicted. The range of routine office activities is large, but when we consider non-routine activities, the problem of a useful classification with a reasonable number of classes becomes even more acute. However, the approach does not need to be comprehensive in extent before areas in which we have knowledge may be applied.

This approach of relating office workers to sets of activities to device parameters, and hence to actual devices with their associated costs, is one which we feel is useful, both as an aid to understanding office procedures, and in providing suggestions for new terminal configurations which would fulfil a recognizable need or set of needs.

## A formalization involving four matrices

The problem may be formalized by means of four matrices, as follows:

(a) A matrix relating office roles to sets of individual office activities.

(b) A matrix relating office activities to the required parameters (input and output rates, storage, etc.) of a device or devices to be used by particular activities.

(c) A matrix relating devices to the sets of device parameters which define those devices.

(d) A matrix relating particular devices to their costs, broken down into capital, depreciation, and running costs.

Each of these matrices will now be described in detail.

## a. The role-activity matrix

The entries in this matrix ($a_{ij}$) consist of the proportion of time spent by a person fulfilling a particular role $R_i$ in the activity $A_j$, although an alternative would be a binary entry, where $a_{ij} = 1$ indicates that a significant element of activity $A_j$ is involved, and $a_{ij} = 0$ indicates no significant element.

One dimension of this matrix is the unordered set of office roles (R), which would include such titles as typist, personnel manager, etc. This set may either be general, in which case each title is well defined and commonly understood, or it may be a set peculiar to a particular organization, if that organization either uses the titles in a different way, or has extra titles which are not normally included in the general set. The set is essentially unbounded, and could include job-types which do not yet exist.

The other dimension of this matrix is the unordered set of office activities (A). This could be defined at several levels of distinction, depending on the amount of effort available for constructing the matrix in a particular application. Ideally, the activities would be homogeneous with respect to the device parameters which they imply (see the activity-device parameter matrix), but this will often mean that we must use classifications which cannot be related easily to office roles. The implied pay-off between fine and coarse classification should be resolved when these classifications are put to practical use. Several partial classification schemes are already available, especially for business meetings. For instance the Communications Studies Group has identified several distinct dimensions of office meetings. From the Contact Record

Sheet; a questionnaire administered to 9 700 civil servants in Central London, the distribution of several basic variables such as length and number of participants for meetings held between blocks of work in the Civil Service has been determined. The Group has also developed a classification system which may be applied to the purposes of meetings, such as sales, control, liaison, and to the mode of occurrence of meetings, such as pre-arranged, regular or fortuitous. In a separate survey, the Group discovered the dimensions used by middle and senior managers to describe their own meetings. However, although meetings or telephone calls can take up to 80% of some managers' working time, the Group knows less about how to classify those activities which do not involve other people. Palmer and Beishon (1972) have developed one possible classification scheme from their observation of the managerial behaviour of various individuals in manufacturing plants. It involves such things as thinking, writing, reading, accessing information, etc., and is hence a fairly simple, though comprehensive, classification. Thus a valid classification can probably be extracted from these overlapping classifications which would include those variables which are necessary both to relate a particular activity to a role and to a set of device parameters.

The classification could also be applied at an aggregate level, in that just as an individual might spend some of his time reading, some conversing, and some writing, so would the members of an organizational unit. We may thus use the time budget of an individual or a unit.

## b. The activity-device parameter matrix

One dimension of this matrix is the unordered set of office activities (A), as described under 'The role-activity matrix'.

The other dimension is that of device parameters (P) such as input and output rates, storage capacities, etc. A possible set of these will be described in the section headed 'Device parameters' in this paper.

The entries in this matrix ($b_{ij}$) are data rates, or requirements, where $b_{ij}$ gives the rate or level required by activity $A_i$ for device parameter $P_j$. In some cases there may be interchangeable sets of parameters so that an activity $A_i$ may result in several rows of entries $b_{ij}$, each of which should be a sufficient set of parameter requirements. The entries $b_{ij}$ may depend on the personalities of the participants. Some preliminary research in this area by the Communications Studies Group indicates that performance may be affected not only by the device and system used, but by personality. Here we shall assume that device parameters are sufficient to allow satisfactory use by most potential users.

## c. The parameter-device matrix

One dimension of this matrix consists of the set of device parameters (P) as described under 'The activity-device parameter matrix'.

The other dimension consists of the unordered and unbounded set of devices (D), which are available or might become available for use in the office. These could range from a pen and paper to a conference TV system, and may include person-machine and person-store communication devices. Also, new devices may be entered into the set as they become available, and hypothetical devices may be evaluated by this means.

The entries in this matrix ($d_{ij}$) are the data rates or availabilities under each device parameter ($P_i$) which a particular device ($D_j$) provides. They are measured in the same way as the device parameter requirements measured under 'The activity-device parameter matrix' above.

It is thus possible with this formalization to relate a particular role to a percentage of time requirement for a particular device or devices, or to suggest what new device or set of devices might be suitable.

Likewise it is possible to relate a particular aggregate set of roles as found in an organizational unit to a percentage of time requirement for a particular device or set of devices. If uncertainty exists as to the size or scheduling of demand, as is likely, then conservative estimates may be obtained by raising the percentage requirements for activities (A) which roles (R) require, so that the total requirement exceeds 100% of the employee time available for the use of any device. An example of this procedure is given later in this paper in the section 'Example of an office worker'.

## d. The device-cost matrix

One dimension of this matrix consists of the set of devices (D) as described under 'The parameter-device matrix' above.

The other dimension consists of a set of cost parameters (C), such as fixed cost, cost per hour in use, cost per mile of suitable communication channel, etc.

The entries in this matrix ($c_{ij}$) are the actual costs associated with particular devices ($D_i$) under parameters ($C_j$). Together, they should enable the total cost of using a particular device to be determined.

Hence when alternative devices for particular activities have been identified, the alternatives may be evaluated in terms of total cost.

Users, devices and channels

In order to model the physical form of the communications universe, the following pictorial scheme is employed. The channels for information transfer, which are either electronic, or involve the physical transport of stored information, are seen as being separate from and unobserved by the users of the communications system (channels which consist of mechanical levers, rods, or wires are ignored, as being generally outdated, and light facilitated transmission systems are included under the electronic heading). The users may interact with the system only via terminals or devices, which may be conceived of as gates in a continuous wall which separates the channels from the users. The users are outside the wall, but interact with the communications channels (and so with other terminals and users) through the various gates or devices in the wall. If the users travel in order to meet face to face, then that process occurs outside the wall, and is hence independent of the communications universe. However, if they wish to pass messages to each other, the messages are created within a device (for a handwritten message the device would consist of a pen, paper and light), transported or transmitted through the channel system, and then read at another device (same paper, different light). The model is depicted in figure 1.

Th figure 1, no spatial relationship is implied. All channels are by definition 'behind' the devices, and all users are 'in front' of the devices, regardless of the actual physical configuration.

Telephone exchanges, switching centres, and even repeater equipment and test gear are seen as gates in the wall, because typically they have some information to give to users or operators, such as signals to indicate their status, billing information, etc.

It is true today, and will continue to be true in the future, that not all devices can be connected with all others, for two reasons. One is that most devices are highly specialized, so that the transmissions of one device are usually unintelligible to other types of device. The second reason is that the channels and switching centres are not fully interconnected. Some types of device are connected to one autonomous system, others to separate autonomous systems. In the future, with the widespread adoption of digital transmission and switching techniques, it should be easier to integrate systems. Such a unified system would seem

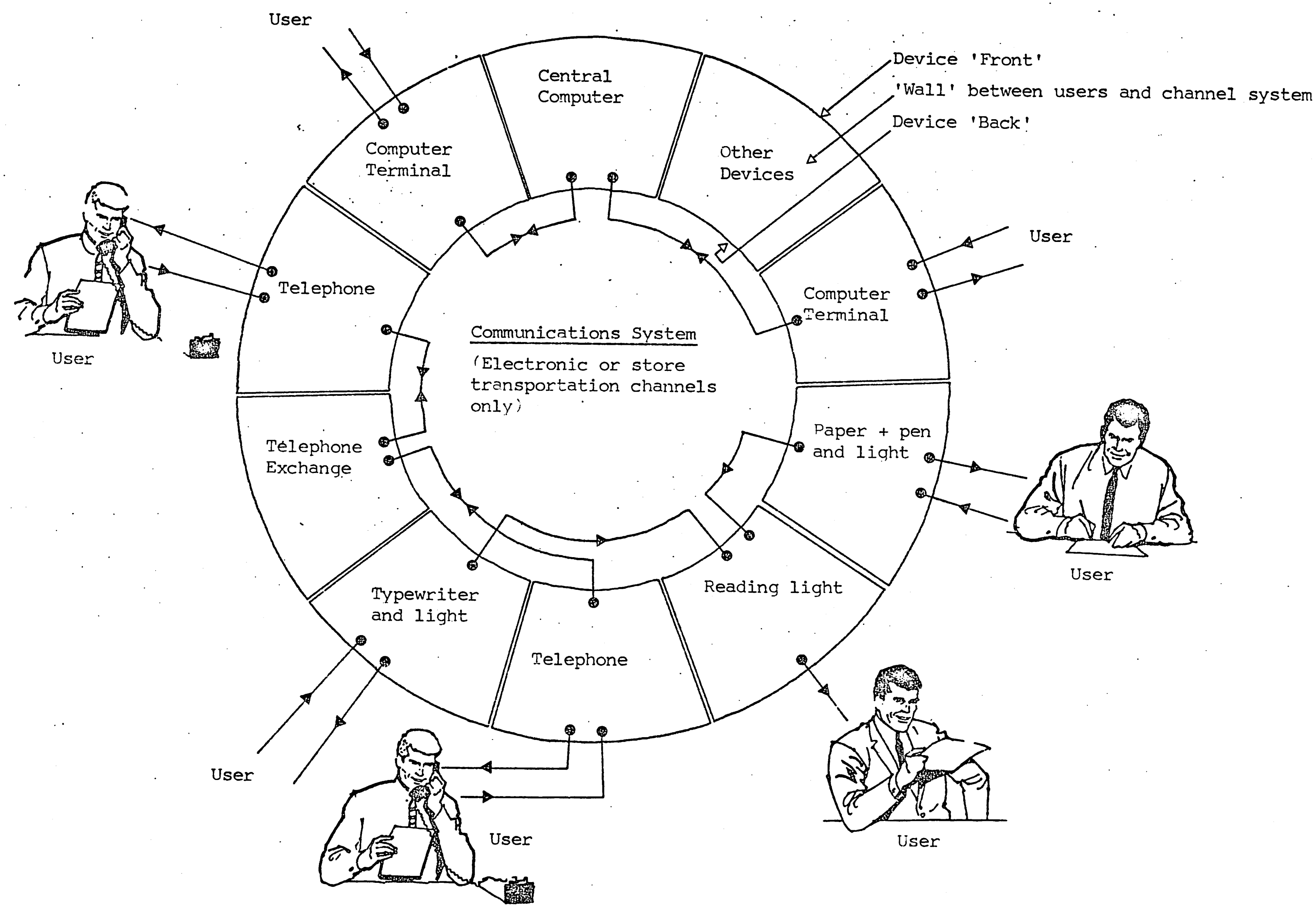


Figure 1: A model of the physical form of the communications universe.

to be ideal, as potentially any terminal could transmit to and receive from any other, thus maximizing the potential utility of the system.

Devices which could serve many office activities, behaving as a telephone one minute, and as a computer terminal the next, will also increase the utility of the communications universe. The standard model of a terminal device, described below, indicates how a terminal may be described in terms of a single set of parameters, whatever functions it performs. In this model, the interconnection potential will be regarded as one of the set of device parameters, as it is through the device that the user perceives the interconnection potential of the system to which the device is connected.

## Standard model of a terminal device

A terminal device is any piece of equipment which enables the user to encode information which he wishes to send to another user, or to decode information sent by another user.

The functions which such devices may incorporate are the receipt of information in an audio, video, or mechanical form; its transformation, processing or storage, and its output to a suitable communications channel. In the opposite direction, it may be required to receive information from a channel, to transform, process or store it, and to output it to the user in an audio, video or mechanical form which he can understand. Some devices, such as telephone exchanges or computers, may have little direct output to the individual user, but may perform further transmission, processing, or storage of users' messages.

Since we are only considering communication channels which are either electronic or involve the transport of stores, this simplifies the model as compared with that which would be necessary if mechanical channels were being considered. We define the standard model of a terminal device as follows: first, it may contain transducers from each of the three modes, audio (A), video (V), and mechanical (M), to the electronic mode (E). It may contain two types of store: video-mechanical and electronic, and one type of processing: electronic. The various parts will be connected to each other and with the surrounding world as depicted in figure 2.

This general terminal would allow a user to input information by talking (A), showing himself, objects, or documents (V), or by pushing keys, buttons, or levers (M). He would be able to receive information by voice (real-time or pre-recorded), visual signals (hard copy, CRT displays, etc.), or by mechanical signals (rare at present, but could be used for telecontrol of objects or people in medical applications, for [illegible]). [illegible] be [illegible] electronic.

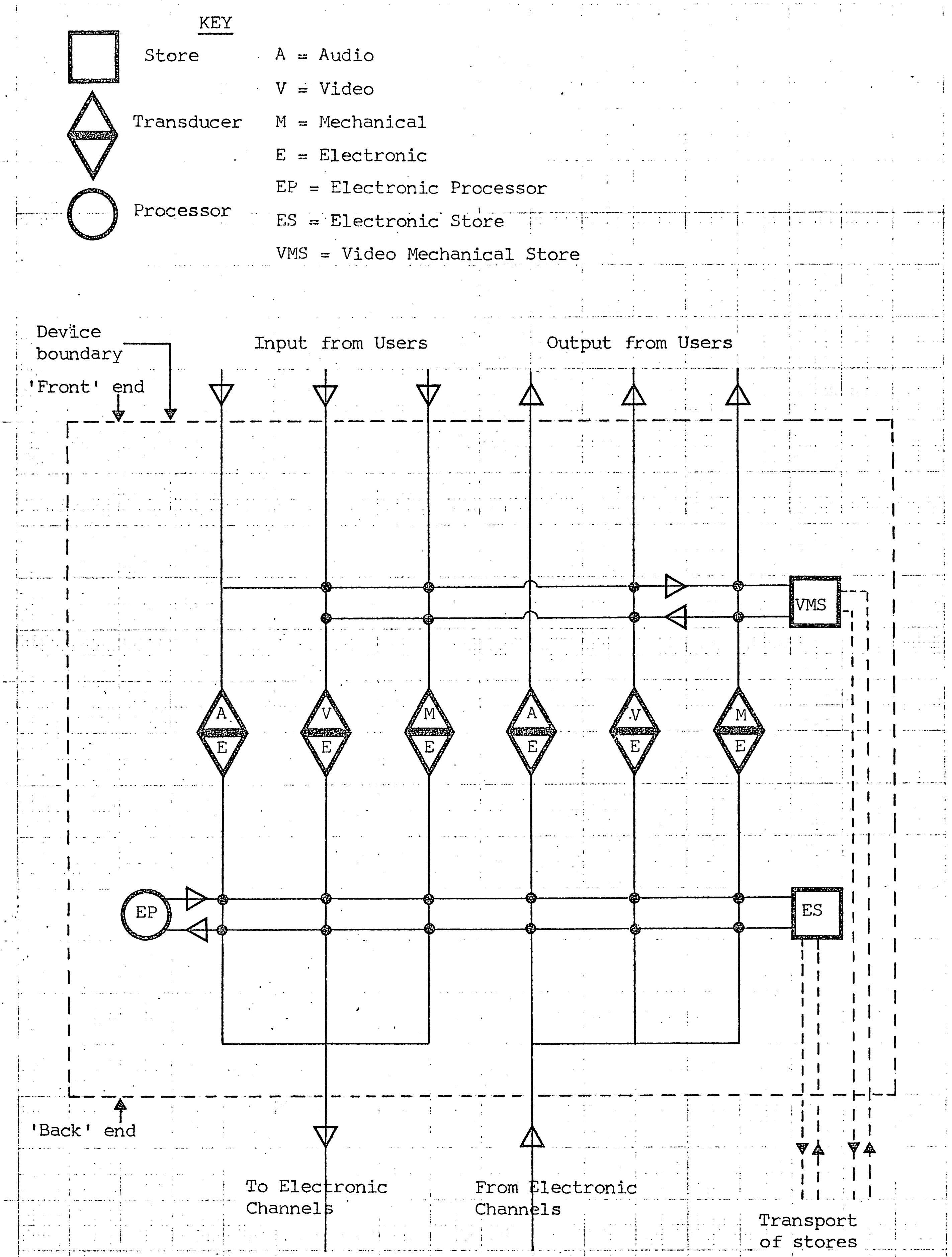


Figure 2 Standard Model of a Terminal Device.

instance). The output from the device to the channel or channels would be purely electronic, or in the form of a store ready for transportation, as would the input to the device from the channels. The information could be processed or stored before it leaves the device or as it arrives.

Obviously, a general terminal of this type can be very complex, especially if it incorporates great processing power or large storage capacity. So the input and output rates, storage capacities and processing power required or available in particular situations must be defined in order to describe a particular device accurately.

## Device parameters

Although it is useful to know the configuration of a device, a better understanding of its function may be obtained by specifying the data rates available in each channel, the size of the store, and the power of the processor, together with the values of relevant system variables. These system variables may include the terminal's interconnectability (one-to-one, one-to-many); its general availability (number of compatible terminals on the same system); the capability afforded to a user to initiate contact through the terminal with another user, and the need for training or experience before the user can make full use of the terminal.

Input and output rates are measured in bits per second at the terminal, for the purposes of this model. A possible shorthand method of specifying bit rates which covers the known range of bit rates in use to-day is to take $\log_{10}$ of the bit rate measured in bits per second. The values between 0.0 (1 bit per second) and 9.9 ($8 \times 10^9$ bits per second) will include information rates ranging from that produced by the standard telephone dial to the channel capacity which would be required by a large or multi-screen colour TV system.

The variables which are used to describe storage are its size, its erasability, its reusability, and its transportability. It is assumed that the natural decay rates of stores are low enough to be negligible, but if this factor is important, it may of course be included in the general model.

Processing power may be measured in many ways, such as speed of operation, number of registers, etc. Since these are positively correlated in most machines available to date a single composite measure may be feasible. In certain applications, such as the Bell Electronic Switching System, other characteristics such as reliability may become of overriding importance.

The suggested list of device parameters is as follows: (other parameters may be added to this list if they are important in particular applications)

Input rates from users and output rates to users:

| | | | | |
|---|---|---|---|---|
| 1. | Audio input rate | measured in bits per second | | |
| 2. | Video " " | " | " | " |
| 3. | Mechanical " | " | " | " |
| 4. | Audio output rate | " | " | " |
| 5. | Video " " | " | " | " |
| 6. | Mechanical " | " | " | " |

Storage potential within device:

| | | | | |
|---|---|---|---|---|
| 7. | Electronic store input rate | " | " | " |
| 8. | Electronic store output rate | " | " | " |

9. Electronic store volume in bits.
10. Erasability and reusability of electronic store
11. Video-mechanical store input rate in bits per second
12. Video-mechanical store output " " "
13. Video-mechanical store size in bits
14. Erasability and reusability of video-mechanical store

Output rates to channels, and input rates from channels:

15. Electronic output rate to channel in b.p.s.
16. Electronic input rate from channel in b.p.s.
17. Store transportation

Electronic processing power of device:

18. Cycle time in seconds
19. Number of registers

    (these measures are weak, and require closer analysis)

System factors:

20. Degree of interconnectability (one-to-one, one-to-many)
21. Availability of compatible devices
22. Exclusive or shared device
23. Degree of privacy or security
24. Feasibility of initiating contacts by using the device
25. Training requirements
26. Speed of feedback
27. Overall inter-user noise levels

It may be necessary to extend this list. However, these 27 parameters are sufficient to describe and differentiate between a range of currently available communications devices. Examples of this are given in the section 'Device examples' below.

When applied to a particular device, these parameters describe the performance of that device. When applied to a particular office activity, these parameters describe the necessary characteristics of a suitable device. Thus in the case of the activity, there may be alternative sets of parameters which would be equally satisfactory. For instance, the activity of obtaining airline flight information requires a terminal output rate of 240 b.p.s. for reading in video mode, or 64kb.p.s. for listening. Both of these would be satisfactory output modes and rates. Alternative sets of parameters may be shown in the matrix by creating several columns for each activity, one for each alternative set of device parameters.

Here are some examples of the bit rates which are necessary to transmit certain types of information, and of some of the channel capacities which exist. In this table the following key is used:

Audio = A

Video = V

Mechanical = M

To or from store = S

Input to terminal = I

Output from terminal = O

Also, a character is assumed to require 7.5 bits on average, and a word is assumed to require 45 bits.

| Device | Bit rate | Type of flow |
|---|---|---|
| Ordinary telephone dial | 2 bps | MI |
| Ordinary touch-tone pad | 8 bps | MI |
| Fast touch-tone pad | 24 bps | MI |
| Normal handwriting | 30 bps | MI or VSI |
| Experienced typing | 45 bps | MI or VSI or MSI |
| Slow facsimile (4 minutes per A4 sheet of alphanumerics) (Not defined for graphics, but the absolute maximum would be the channel rate, say 1200bps) | 75 bps | VSI or VSO |
| Paper tape teletype (150 words per min.) | 120 bps | MI and VSO |

| Device | Bit rate | Type of flow |
|---|---|---|
| Ordinary reading | 240 bps | VSO |
| Card punch at 100 cards per minute | 1 kbps | VMSI |
| Line printer (1000 lpm) | 15 kbps | VSI |
| Xerox (1 second per A4 sheet of alphanumerics) (for graphics much greater, depending on resolution) | 18 kbps | VSI or VSO |
| 48 kHz channel with average noise | 40 kbps | |
| Voice at 4kHz (talking or listening) | 64 kbps | AI or AO |
| Hi-fi sound | 200 kbps | AI or AO |
| Reading or writing magnetic tapes | 2.0 mbps | ESI or ESO |
| Picturephone | 6.0 mbps | VI or VO |
| Reading or writing magnetic disks | 6.0 mbps | ESI or ESO |
| Broadcast colour TV | 92.0 mbps | VI or VO |
| Bell T4 carrier | 281.0 mbps | VI or VO |
| Large screen or multi-channel TV | 700+ mbps | VI or VO |

It should be noted that the speed at which an individual can receive information is usually much less than the rate which the device must be capable of in order that the information is acceptable to him. For instance a TV monitor requires large amounts of information in order to present a fairly realistic picture to the viewer. This is because the system cannot predict where changes in the picture will occur, if at all. TV systems are therefore designed to regularly and rapidly recreate the whole picture, causing huge redundancy in the information transmitted. Another reason for disparity between the device rate and the rate at which the individual can receive information is that human communication in both audio and video mode is highly redundant in information theory terms.

No examples of telecontrol input or output are given above, but telecontrol applications could involve wide ranges of information transfer rates, from the low rate required by the remote door opener to the high rate required by the numerically controlled machine tool.

## Device examples

In this section, there are five examples of the use of the device description parameters described in the section 'Device parameters'. Before giving specific examples, it is necessary to describe the measures which will be used for each parameter.

Input and output rates (1-6). The audio, video, and mechanical input and output rates refer to the interface between the device and the user. Input rates refer to input to the device, and output rates refer to output from the device. They are all measured in bits per second across the interface. A value of zero indicates that the channel is not available.

Store input and output rates (7-8,11-12). The electronic and video-mechanical store input and output rates are measured in bits per second, and refer to the internal interface between the store and the device. Input rates refer to input to the store, and output rates refer to output from the store. A value of zero indicates that the device is not capable of reading or writing that type of store.

Store sizes (9,13). Store sizes are measured in bits. A value of zero indicates that no storage facility is provided. Virtually unlimited storage, such as paper tape in the case of a teletype machine, is recorded as unlimited (U).

Erasability and reusability of stores (10,14). If a store is erasable, it is assumed to be reusable. If it is erasable and reusable, the entry is 'yes', if it is not then the entry is 'no'. If the store does not exist, then the entry is not applicable (NA).

Electronic input and output rates (15,16). These are measured in bits per second, and give an indication of the channel capacity required both for transmission from the device, and for reception by the device. A value of zero indicates that the channel does not exist. No information about transmission quality is included here.

Store transportation (17). 'Yes' indicates that stores may be physically transported from one device to another; 'no' indicates that they may not, and not applicable (NA) is used when there are no stores.

Processor descriptors (18,19). Processors include electronic and electro-mechanical types, such as those found in telephone exchanges. Cycle time is measured in seconds, or not applicable (NA) is used if there is no processor. 'Registers' are measured by number, or by not applicable as appropriate.

Degree of interconnectability (20). The suggested measures are as follows:

| | |
|---|---|
| self-contained, no channel connection | = 0 |
| one-to-one dedicated link | = 1 |
| selection of single device from set of compatible units | = 2 |
| selection of one or more compatible units | = 3. |

Number of compatible devices (21). This factor is only important when the likelihood of potential correspondents having a compatible device is significantly less than unity. The measure used in this paper is low (L), medium (M), and high (H). This is a measure which may require reassessment in particular cases, such as that when a firm invests in a system which is internally compatible, but isolated from the rest of the communications universe.

Exclusive or shared (22). This describes the typical office use of the device. For instance a pen and paper is an exclusive device, in that office workers typically have one or more such devices for their personal use. However, conference TV facilities lie at the other end of the scale, in that the typical use of such facilities is by a large set of individuals, possibly taken from several different organizations. The measure used in this paper is simply exclusive (E), or shared (S).

Degree of privacy or security (23). The privacy or security offered by a device and channel system combined is an important factor in many communication situations, in both government and private enterprise. Various classification systems are used within government, and it may be appropriate to use such a system directly. However, in this paper security is simply classed as low (L), medium (M), or high (H), depending on both the physical configuration of the system, such as whether devices are located in public spaces or in private offices, and on the security devices used to discourage the illicit tapping of messages. An ordinary telephone is classed as having medium privacy and security, because the device is usually situated in such a way that the user is not overheard, but no security equipment is used. A telephone with scrambler attachment is classed as having high security.

Attitudes and training requirements (25). These are difficult to measure at this stage in relation to recently introduced or projected devices, but if a system is to come into widespread use, then one of the main requirements is that potential users should have positive attitudes towards its use, and that training requirements should be minimized. With other systems, designed for particular purposes, such as airline booking systems, the attitudes and training requirements of the general public become irrelevant. It is only the system operators who need be considered here, and greater training requirements can be tolerated. If attitudes towards the system are positive at the end of such training, then the system satisfies the constraints of attitude and training requirements. The measure of necessary training used in this paper is low (L), medium (M), or high (H). This measure should include all aspects of the training required to use the device. Thus although most office workers can read and write and use a phone before they arrive in an office, the training requirements are actually quite substantial, especially for reading and writing. The training required for reading and writing is rated as high, and that for the use of the phone as medium.

Ease of initiation of contact (24). The ability to initiate contact with another person using a particular device may be seen as a parameter of that device. It is a function of the skill of the initiator in using the particular device, of the availability of compatible devices, and of the speed of feedback. Thus a skilled user of the telephone has the ability to initiate contact with large numbers of previously unknown people in many countries, provided directory information is available. The measure used is low (L), medium (M), or high (H). Thus the telephone is rated high, but the facsimile machine is rated low.

Speed of feedback (26). This parameter may be measured as the minimum time between a user finishing the dispatch of a message at a device, and his starting to receive a reply at the same or at a different nearby device. In the case of the telephone the speed of feedback is fast by human standards. The postal system affords slow feedback. The measure used is low (L), medium (M), or high (H).

Overall inter-user noise (27). This parameter provides an estimate of the general noise which might be expected between a pair of users or a set of users using compatible devices of this type and a suitable connecting channel system. It is a measure of the overall intrusiveness of this general noise, which is different from a technical measure of the noise level. Systems such as the phone are fairly tolerant of line noise, because of the redundancy of the language and the intelligence of the users which may be used to confirm doubtful messages to the users' mutual satisfaction. A computer terminal, however, may require error-free message transmission for satisfactory operation. This may be achieved by using error-connection techniques involving either repetitive transmission or redundant coding. If this is done, then the overall noise can be dramatically reduced to a vanishingly low level. The measure used in this paper is low (L), medium (M), or high (H).

The measures used are in some cases crude and subjective, so it is clear that refinement may be necessary before the device parameters may be successfully used. Five examples using the above set of measures are shown below.

Devices described using the device parameters

a. Domestic telephone with dial.

b. Facsimile machine transmitting a typed A4 sheet in 4 minutes.

c. A videophone.

d. A 150 words per minute teletype computer terminal.

e. Pen, paper and light.

| | a. | b. | c. | d. | e. |
|---|---|---|---|---|---|
| 1. Audio input rate | 64k | 0 | 64k | 0 | 0 |
| 2. Video input rate | 0 | 0 | 6m | 0 | 0 |
| 3. Mechanical input rate | 2 | 2 | 8 | 45 | 30 |
| 4. Audio output rate | 64k | 0 | 64k | 0 | 0 |
| 5. Video output rate | 0 | 240 | 6m | 240 | 240 |
| 6. Mechanical output rate | 0 | 0 | 0 | 0 | 0 |
| 7. Electronic store input rate | 0 | 0 | 0 | 0 | 0 |
| 8. Electronic store output rate | 0 | 0 | 0 | 0 | 0 |
| 9. Electronic store size | 0 | 0 | 0 | 0 | 0 |
| 10. Erasability of elec. store | NA | NA | NA | NA | NA |
| 11. Video-mech store input rate | 0 | 75 | 0 | 120 | 30 |
| 12. Video-mech store output rate | 0 | 75 | 0 | 120 | 240 |
| 13. Video-mech store size | 0 | 18k | 0 | U | U |
| 14. Erasability of v-m store | NA | No | NA | No | Yes |
| 15. Electronic output rate | 64k | 1200 | 6.1m | 120 | 0 |
| 16. Electronic input rate | 64k | 1200 | 6.1m | 120 | 0 |
| 17. Store transportation | NA | Yes | NA | Yes | Yes |
| 18. Processor cycle time | NA | NA | NA | NA | NA |
| 19. Number of registers | NA | NA | NA | NA | NA |
| 20. Degree of interconnectability | 2 | 3 | 2 | 3 | 2 |
| 21. Number of compatible devices | H | L | L | M | H |
| 22. Exclusive or shared | E/S | E/S | E/S | E/S | E |
| 23. Degree of privacy/security | M | M | M | M | H |
| 24. Ease of initiation | H | L | H | L | H |
| 25. Training requirements | M | M | M | H | H |
| 26. Speed of feedback | H | M | H | M | L |
| 27. Overall inter-user noise | M | L | M | L | L |

In the above table, rates are measured in bits per second, and capacities in bits.

From the examples above the similarities and differences between, say, an ordinary telephone and a videophone may be [illegible]. Both existing and planned devices may be entered in the matrix, and sets of parameters obtained from the activity-device parameter matrix may be compared with those of particular devices to check whether the devices would be suitable for that activity. If no suitable device is available, then the parameter set may be used as design criteria for a new device.

Example of an office worker

This section shows how the matrix system may be used to determine the device requirements of a particular office worker. Consider a computer company's librarian, working in a branch sales office, whose job is to keep salesmen, systems engineers, and customers supplied with printed computer manuals and up-dates for those manuals, and to maintain a library of the same information.

She normally orders all requirements on standard order forms and mails them to the central printed material store. The material is batched up at the store, and sent by carrier to the branch office. She then supervises the unpacking and checking of the consignment, and distributes the material to the original orderers. Another form of consignment is the automatic up-date, which arrives from the central store without specific order. There is also a special delivery service, involving the telephoning or telexing of orders to the central store, and the special delivery or facsimile transmission of a particular document. Orders are created at the branch office by the salesmen, engineers, and customers, or initiated by the librarian herself in order to maintain the branch library. She is also in a position to answer enquiries about documentation in general. Invoicing is centralized, and is not her concern.

Her typical working week involves the following types of activity, in the proportions shown:

| | | |
|---|---|---|
| a. | Face-to-face meeting | 34% |
| b. | Telephoning | 19% |
| c. | Reading | 21% |
| d. | Writing | 15% |
| e. | Other | 21% |

These are generous estimates so that any calculation of device requirements based on these figures will tend to over-provide, allowing for day-to-day variations or minor changes in her working patterns. The total of the above five activities is 110%. The table below shows how these activities are made up:

| | a. | b. | c. | d. | e. | Total |
|---|---|---|---|---|---|---|
| Receiving orders from within office by phone, order form or face-to-face | 5% | 5% | 5% | - | - | 15% |
| Receiving orders from outside office by phone or letter | - | 2% | 3% | - | - | 5% |
| Dealing with enquiries by phone or face-to-face | 15% | 5% | - | - | - | 20% |
| Collating orders and sending them - reading and writing | - | - | 5% | 10% | - | 15% |
| Unpacking and distributing material | - | - | 5% | - | 20% | 25% |
| Maintaining library - chasing documents, etc. | 4% | 3% | 1% | 2% | - | 10% |
| Dealing with rush orders | 2% | 2% | - | 1% | - | 5% |
| Thinking about improvements to the system | - | - | 2% | 2% | 1% | 5% |
| Office meetings and other activities | 8% | 2% | - | - | - | 10% |
| Totals | 34% | 19% | 21% | 15% | 21% | 110% |

For entry into the role-activity matrix, neither of the above descriptive systems which form the axes of the table are really suitable. This is because the main requirement for such a system is that each class should be homogeneous with respect to its device parameter requirements (see section 'The role-activity matrix' above). A descriptive system, or set of activities, which is more useful is the one below. The proportions of time which she spends in each of these activities is shown.

| | |
|---|---|
| Face-to-face contact within office | 34% |
| Contact within office requiring fast feedback | 19% |
| Contact outside office " " " | 2% |
| Reading material (involves no interaction) | 20% |
| Writing material " " " | 14% |
| Other " " " | 21% |
| Total | 110% |

The values of the device parameters required for each of these activities must now be determined.

Face-to-face contact occurs outside the communication universe as presently conceived, so it is not included here. If results of experiments and field trials show that a particular telecommunication system would be equally viable, then requirements for such a two-way system could be entered. 'Other' activities are also excluded. Thinking is excluded because it does not involve the use of a device.

Activity-device parameter matrix for one office worker:

Activities are as follows:

a. Contact within office requiring fast feedback

b. Contact outside office " " "

c. Reading material (involves no interaction)

d. Writing material (involves no interaction)

| | | a. | b. | c. | d. |
|---|---|---|---|---|---|
| 1. | Audio input rate | 64k | 64k | 0 | 0 |
| 2. | Video input rate | 0 | 0 | 0 | 0 |
| 3. | Mechanical input rate | 8 | 8 | 0 | 45 |
| 4. | Audio output rate | 64k | 64k | 0 | 0 |
| 5. | Video output rate | 0 | 0 | 240 | 240 |
| 6. | Mechanical output rate | 0 | 0 | 0 | 0 |
| 7. | Electronic store input rate | 0 | 0 | 0 | 0 |
| 8. | Electronic store output rate | 0 | 0 | 0 | 0 |
| 9. | Electronic store size | 0 | 0 | 0 | 0 |
| 10. | Erasability of elec. store | NA | NA | NA | NA |
| 11. | Video-mech store input rate | 0 | 0 | 0 | 45 |
| 12. | Video-mech store output rate | 0 | 0 | 240 | 240 |
| 13. | Video-mech store size | 0 | 0 | U | U |
| 14. | Erasability of v-m store | NA | NA | No | Yes |
| 15. | Electronic output rate | 64k | 64k | 0 | 0 |
| 16. | Electronic input rate | 64k | 64k | 0 | 0 |
| 17. | Store transportation | NA | NA | Yes | Yes |
| 18. | Processor cycle time | NA | NA | NA | NA |
| 19. | Number of registers | NA | NA | NA | NA |
| 20. | Degree of interconnectability | 2 | 2 | 2 | 2 |
| 21. | Number of compatible devices | L | H | H | H |
| 22. | Exclusive or shared | E | E | E | E |
| 23. | Degree of privacy/security | M | M | M | M |
| 24. | Ease of initiation | M | M | L | L |
| 25. | Training requirements | H | H | L | L |
| 26. | Speed of feedback | H | H | L | L |
| 27. | Overall inter-user noise | M | M | L | L |

In the above table, rates are measured in bits per second, and capacities in bits.

By multiplying the amount of time spent in each of these activities by the above device parameter requirements, we may determine the total requirement for channel capacities and devices in a given time period.

From the example of the telephone in the section 'Device examples', we see that it will satisfy the demands of activities a and b, which are contact requiring fast feedback both within and outside the office. Two parameters are critical to its proper functioning in this case. The first is that the device should be connected to a system which includes all the required correspondents as the ordinary dialled telephone network probably would. The second is that the device should be exclusive, which in the case of the telephone it can easily be and usually is.

In the case of this librarian, the main area of uncertainty is over the type of terminal which could be used for reading and writing. At present, pen, paper and light, or typewriter, paper and light are used for writing, and paper stores and light are used for reading. However, the order-entry process is a programmed activity, and therefore highly suited to some kind of computerization, in which case some of the writing activity could be transferred to a computer terminal. If others in the office, or in customers' offices have access to compatible terminals which may be connected to the same system, then the same terminal could be used for sending or receiving unformatted messages such as memos. A substantial amount of this writing and reading activity requires the retention of messages in video-mechanical store.

It therefore seems that the hardcopy terminal would satisfy the requirements of most of the writing activity, with the added bonus of fast transmission and feedback. In the case of the library order system, the ability to enter orders immediately and directly could well have substantial advantages over the present manual system.

Reading of short items, such as order copies or lists of up-dates could also be facilitated by the same terminal, which could be used to produce the necessary video-mechanical stores. Bulkier items, such as the manuals themselves for customers, salesmen, or the library should be handled by store transportation as at present, because electronic transmission of large quantities of information is comparatively uneconomic at present, and likely to remain so in the future. The use of microfilm or fiche as an alternative to paper should be considered because of the potential savings in transportation, storage, and reproduction costs.

This example shows how the method may be used for assessing the device and system needs of an individual. Groups may be treated as if they consisted of separate independent individuals, or if they have common and describable characteristics, it may be possible to consider each group as a single entity, and assess its device and system needs accordingly.

## Summary

A method for assessing the usefulness of and needs for present and future communications devices and channel systems has been described. Need is analyzed according to the following rationale: the fulfilling of an office role requires a certain set of activities, each of which occupies a proportion of the role-player's time. Some of these activities are interactive with people, and others are interactive with information sources. Both these classes of activity may require the use of a device or devices, however simple. The specific nature of the need may be measured by use of a set of device and activity parameters, which may be used to describe both devices and activities, and therefore form a link between the two which may be used to rationally assign satisfactory devices to activities. Results of laboratory experiments and field trials may be used to alter the assessment of the parameter values which describe a particular activity, especially in the case of interpersonal activity. The method may be applied either to individuals, or to groups of office workers. It may also provide sets of design parameters for new devices, indicating at the same time the office roles which would require such devices.

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