THE BRITISH TELECOM SWITCHED STAR SYSTEM IN WESTMINSTER
PART 2: INSTALLING THE SYSTEM

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ABSTRACT

Westminster was one of the first eleven pilot franchises advertised in August 1983. The franchise was awarded to Westminster Cable Company who named British Telecom as the cable provider. The system was to be a switched star network, with potential for a comprehensive range of interactive services. The licence to run the system was awarded jointly to Westminster Cable Company and Broadband Ventures Limited (a wholly owned subsidiary of BT) in April 1985 and contruction commenced immediately. Service to trial customers was started in June, and commercial operation began in October.

INTRODUCTION

In part 1 of this paper Kevin Shergold has briefly described the switched star network, and you will see that its basic design has not changed since I gave a paper on the subject at this Convention some two years ago. The system uses brand new technology without equal on a commercial scale anywhere in the world. The main build has been underway now for six months so this paper describes early operating experience and gives some of the features of the administration system.

THE FRANCHISE AREA

Westminster was established as a unit of local government for the area in 1963 by the London Government Act. The Act effected a merger of the former London Boroughs of Westminster, Marylebone and Paddington into a single administrative and representative local government unit. According to the 1981 census returns the resident population is 163,892 with 73,132 private households, of which about 40% are housed in apartment blocks. Additionally there are some 22,000 commercial premises (offices, shops, banks, etc.) and over 500 hotels providing around 60,000 bed spaces. During the day Westminster accommodates half of Central London's workforce (half a million workers) yet two thirds of the resident working population work within the Borough. Westminster also contains 60% of Central London's shopping floor space.

The franchised area follows exactly the boundary of Westminster Borough, stretching from our seat of government, the Houses of Parliament, in the south to the residential suburbs of St John's Wood and Maida Vale in the north.

THE CABLE PROVIDER AND CABLE OPERATOR

Within the UK a distinction is drawn between the cable operator and cable provider, although there is no legal obstacle to these being the same organisation. In the case of Westminster, British Telecom, through its wholly owned subsidiary, Broadband Ventures Limited, is responsible for planning, installing and maintaining the system. BT also finances the network. Westminster Cable Company (in which BT has a 20% stake) is the licenced cable operator, and as such is responsible for negotiations with programme and other service providers, and marketing the cable service to potential customers. The system is owned by BT and capacity on the network is leased by BVL to the operator. It is important to remember this split in responsibilities when the facilities of the System Administration Centre are described later.

NETWORK PLANNING

Over 90% of the existing telephony plant in the franchise area is underground, and additionally a large part of the franchise has been designated a Conservation Area, to which special rules concerning the siting of external plant

apply. There was no way that the local authority would agree to the siting of overhead wires for the delivery of cable tv, so the network was planned in the same way as the telephony plant, only going overhead where the existing plant was so arranged. Consequently the network mimics that which is in use for telephony, with the head end feeding out to hubsites and thence to the wideband switches. A total of eight hubsites will be established within the area, all co-located with existing telephony central offices. Existing tunnels and surface duct routes are used for the head end to hubsite links, as the space taken by these optical super primary cables could be found. An 80 fibre cable is about 5/8 of an inch in diameter. A small amount of new duct has had to be laid for the primary network, mainly from the switch position to the nearest main duct route. Here again the small diameter of the optical fibre cable helps. However, from switch to subscriber, where small bore coaxial cables are used, almost all new duct has had to be provided.

Ten 30-tube coaxial cables run away from each switch, occupying four 4 inch duct bores, and these are split down to 20 and 10 tube cables. Each 10 tube cable terminates in a distribution point housed in a footway joint box. These cables are installed before a switch is released for marketing so when a customer agrees to subscribe his "drop cable" is installed and connected. Unfortunately many of these "drop" cables require new service pipes (a one inch diameter duct running from footway to house) to be run, and this inevitably means on site discussions with the home owner. Consequently we can only offer a 21 day installation from the time that the subscriber agrees to take the service.

At the present time all the cabling plans are drawn by hand, but it is intended in the near future to change to a computer based system. Large scale digitised maps of the franchise area have been recently made available, and the interactive graphics terminals and software are already installed. This facility will ease the time consuming job of drawing up plans and producing works estimates and parts lists. Another planning aid has been developed for areas where digitised maps do not exist. Large scale maps are photographed and laid down onto video disc. A personal computer controls access to the disc, and holds the plant information as a computer generated overlay. Both systems have the planning rules built in, and can generate works estimates and a list of parts.

CABLING AND JOINTING

Both the optical fibre and copper coaxial cables have been designed and specially made for this network. New jointing techniques and joint closures have been devised. The multimode optical cables are of loose tube construction with ten fibres in each tube. The tubes are layered round a polyethylene insulated central steel strength member and the outer polyethylene sheath has an aluminium moisture barrier. At a joint each tube of ten fibres is split down into individual fibres, each sleeved with small bore PTFE tubing. The transition between the hard arnite of the loose tube and the individual PTFE sheathed fibres is achieved by a small flexible moulded manifold. Although this may seem to be an awkward job, experience has shown that the task is easily achieved, but it does call for good eyesight and a steady hand. Individual fibres are fusion spliced, and the bare fibre and completed splice are enclosed in a splice protector, consisting of a metal bar and a meltable adhesive liner inside a heat shrinkable sleeve. Splices and excess fibre (to allow for rejointing) are assembled into metal trays, which are in turn put in a chassis, and the whole enclosed in the joint closure. When optical tapping is needed, the splitters are also mounted on the trays within the joint.

The primary and super primary cables are pressurised with dry air, and pressure monitors are mounted on each joint. The status of these monitors is continually checked using a microprocessor based system at the head end, communicating with each monitor over the metallic strength member and aluminium moisture barrier in the cable.

Optical fibre tail cables are used to connect equipment to the route cable. These are tight jacketed fibre, and where they are run internally, for instance at the hub sites, can have up to 80 fibres. Air blocks are incorporated in the joint where this cable is connected to the loose tube route cable. Pre-connectered ruggedised tail cables are also used to interface to the optical equipment either at the switches or the hubsites. Installation experience so far has been most encouraging. Where circumstances permit lengths of over one kilometer can be pulled in. The average joint loss is under 1/2dB, although there have been some instances of losses over 1dB which have defied all attempts to lower them by remaking the joint. These seem to occur in areas of high humidity, for example in cable tunnels. The increase in loss is not significant, as the fibre loss of the

cable is below its design specification, to which the network was planned. Cables are tested before the joints are finally closed, and this has revealed that a number of the optical splitters have been faulty. Once these have been replaced, and the joints closed, there have, to date been no optical cable faults. The coaxial cables used in the secondary network are, like the fibre cables, available in two main types. The route cable, in 10, 20, or 30 tube sizes which has a tape outer conductor, and the terminating or tail cable which is of braided construction. This is more flexible than the tape cable, and each tube is separately covered with a thin polyethylene layer, allowing direct termination on an F type connector. Pre-terminated 30 tube tails are available to connect to the switch. Special tools are used to strip back the inner and outer conductors, and splices are made using an infra red heat gun and pre-formed solder filled parts, one to join the inner conductor, and the other, contained in heat shrinkable tubing, to join the outers.

The splices are tested before the joint is closed, and the percentage of bad joints has been small, and mainly due to operator error, for example poor stripping of the outer insulation (paper) on route cables.

There is, under development, a crimp splice, which will offer time savings. The development has been hampered by a particular cable which was manufactured with an overall diameter just over the specification, such that the crimp would not perform correctly.

This secondary network, once commissioned, has also been fault free. There have been a very small number of faults on the customer drop, all due to badly fitted F type connectors. It is a feature of the customer signalling system that a direct current path must exist between customer unit and switch, so a faulty connector usually results in the customer not being able to change channels. This has the advantage that the fault is immediately reported and repaired, so preserving the integrity of the screening on the secondary network.

SYSTEM ADMINISTRATION AND MANAGEMENT

The system is controlled by a suite of computers at the head end. These communicate with the switches by data links carried on the optical network, and to terminals at the cable operators and providers premises. There are two main subsystems, and a number of secondary subsystems dependant on the amount of interactive facilities required. The subsystems communicate via an Ethernet bus.

The main subsystems are:
-- Administration, providing facilities for
- Homes passed database
- Secondary network plant and DP records
- Customer account maintenance
- Billing for subscription tv, pay per view, videotex, video library
- Sales ledger accounting
- Automatic payment methods
- Works order processing
- Master control of distributed databases
- Special features

--Management subsystem
- Network configuration
- System initialisation
- Fault and error control
- Data collection from customers
- Real time control of switch (class of service records etc.)
- Pay per view programme control
- Primary network plant database

The secondary subsystems installed in Westminster are:

Information server, providing 1000 pages of rapidly accessable videotex information, and carrying at the moment a programme guide to all channels, a local news service, community information from Westminster council, and a guide to the use of the system. Additionally this server can be used to customise the first videotex page as seen by a customer on a particular switch, and direct him to particular areas of the database. A large hotel is using this facility at the moment.

Videotex server, providing many thousands of information pages, and may be likened to the public Prestel videotex service. Unlike the information server, the customer can be charged for the use of this server. It is important to remember that the subscriber needs no extra equipment in his home to receive these services. The text information is sent as a data stream to the switch, where text generators turn it into video information for reception on a standard tv set.

Traffic subsystem, keeping a record of processor occupancy and traffic levels on the system. An invaluable tool for the design and dimensioning of future networks, and predicting when to relieve

the current network. (The design is such that processor overload can be relieved by connecting additional processors to the Ethernet)

Video library subsystem, providing on demand access to material held on video disc. As this is a one to one service the customer can, from his keypad, control the functions of the player. Examples are stop, start, slow, search to a frame etc.

Photovideotex subsystem, produces video output of photographic images stored the processor. This can be used in conjunction with the videotex and library subsystems to insert photographic quality images into videotex pages.

Gateway subsystem, providing interfaces to other databases,such as Prestel, electronic mail, etc.

These last three subsystems, although installed, have not yet been commissioned. Their functions have been demonstrated on the experimental switched star system installed in the Research Laboratories at Martlesham Heath.

CONNECTING CUSTOMERS

To illustrate the use of the management system it will be useful to describe the stages passed through in connecting a customer. The basic data loaded into the system at start up was an address file, obtained from the postal authority and containing all known tenancies with postcode, but without names. The network planners then defined switch areas, and associated switch numbers to groups of tenancies. Detailed planning of each switch area was then done, and the network details entered into the database. Consequently the network manager knows, and can identify, which tube runs from the switch to a particular distribution point, and which addresses are served from that point. This data entry is manual at present, but the link between the graphical planning aid mentioned earlier has been tested and is about to be commissioned. The switch is then installed along with the cabling, and then that area is "ready to connect customers".

At this time the operator can begin marketing and creates in the administration machine an account file of signed customers. At the same time programme options for each customer are entered. Having created an account the system checks to see that there is a network resource available, and if so, allocates this to the customer. The class of service information is downloaded to the local processor in the switch and the system then asks for an appointment date. This is entered, and provided that manpower is available, the appointment can be confirmed. The manpower diary has been previously populated with available manhours by the providers installation control. The system then creates a work order, showing all information needed to connect the customer, including any special comments made by the operator. This work order is not issued until just before the installation date, but summaries of all pending orders are continually available, and these are checked by the installation planners for availability of service pipe etc. If for any reason a network resource cannot be allocated, then a planning work order is issued immediately for remedial action to be taken, and the operator is prevented from making an appointment. This may occur, for example, where difficulty has been found in obtaining wayleaves, or the switch needs upgrading to serve more customers.(The switch is not fully populated to start with). When the planning work has been cleared the operator is free to make an appointment. The work order is issued to the fitter who completes the installation by patching the switch outlet to the customers tube in accordance with the instructions on the order, drawing in and connecting the drop cable, installing the customer unit, tuning the tv to the cable output channels, and demonstrating the facilities to the customer. He also checks that the right tube has been connected by entering a test sequence from the customer's keypad, which returns the customer account number from the switch, and this is cross checked with the account number on the work order. The fitter can write any comments on the order, and the customer is asked to sign to the effect that the work was carried out to his satisfaction. On return to installation control any further comments on the order are entered into the system, as is the time taken for the job, and any additional chargeable items. At this point the order is closed as far as the provider is concerned, and it is from this time that the provider starts to charge the operator the lease charge for that particular customer. The completed order is placed in a history file for subsequent analysis, and reports are available to the installation manager regarding proportion of jobs completed within standard hours etc.

The system passes details of closed works orders to the provider, who in turn has to log them off the system, it is from this time that the customer billing cycle begins.

CUSTOMER BILLING

The billing system has to collate not only the monthly subscription charges, but also session charges. The system can allow the subscriber to authorise himself, from his keypad, to watch pay per view programmes, or to change his service tiers (self spin). Videotex and library access can also be charged on a per session basis, and if these services are available to hotels the charges must be immediately available. Consequently the billing system works in real time, with session charges being added as they occur.

On receipt of payment the system allocates the cash, monitors payment performance and performs credit control on delinquent customers. The operator can, of course, switch off or reduce the service to bad payers from his terminals. The final stage is to issue a recovery work order to the provider. It is possible using the facilities of the information server for a customer to call up and view his current charges, and it is an extension of this facility which allows hotel management to charge their guests for session based services. The billing system also records credit due to programme providers.

Many of the more advanced facilities, self authorisation etc., although implemented have not yet been activated. The average subscriber has not been exposed to cable before, so he will not be able to understand all the sophisticated facilities available to him. Furthermore, the addition of these facilities will have ramifications on the marketing strategy of the operator.

FAULT MONOTORING AND REPORTING

The system includes comprehensive monitoring facilities. At the switch the incoming optical power is continuosly checked, as is the temperature and humidity within the cabinet. Cabinet door openings are also logged. At the head end and hubsites the laser current is monitored, as a rise here is indicative of a failing laser. All these alarms are collated by the system manager and displayed on a terminal screen. The trigger points on the optical components are set such that an alarm is given before service is affected. By analysing the pattern of these alarms, in conjunction with the output from the air pressurisation monitoring system, serious cable breaks can be rapidly detected. Each switch has, as well as fibres feeding signals to it, one fibre which is used for signals in the reverse direction. Part of the capacity is used for control and data traffic, but there remains capacity for four upstream tv channels. It is intended that one of these channels is used for monitoring purposes, so that outputs from sub switch units can be fed back to the head end and checked.

The one part of the network that is not monitored is the subscriber feed. A pilot does exist on this link, it is used by the customer unit for automatic gain control and equalisation, and serious consideration was given to monitoring the level of this pilot over the secondary link data connection. This was abandoned on the grounds that the system would not know whether a fault existed, or whether the customer had just switched his box off.

When a customer experiences a fault, his interface is with the cable operator, who is aware off any major network faults. If this is an isolated incident, the operator takes the customer through a simple question and answer routine to try an pinpoint the problem. Questions such as "Does the red light on the set top box flash when you press a key on your keypad?" check whether the customer signalling system is working, and "Have you got a picture on your other cable channel?" check whether the transmission link is in order. (Each subscriber can have two simultaneous switched channels, as well as FM radio). If the fault cannot be cleared in this way, then a fault work order is produced by the system and immediately printed in the provider's maintenance control. Records of these works orders are kept for analysis. The software system itself incorporates many checks for errors. It reports failed attempts at sending messages amongst its subsystems. It is continually monitoring the state of the processors in all switches and causes immediate alarms should it detect anything amiss. It also checks the database in each switch against its own master copy. Facilities are provided so that the maintenance control engineer can manually look at the switch database either from the central maintenance control position, or by means of a small hand held terminal which plugs into the maintenance port at each switch site.

An important consideration in the design of the software was that it should allow the system to fail gracefully, and attempt to preserve at least some service

to subscribers. Thus a fault in any of the secondary servers only causes the loss of that service, and a fault in either the administration or manager subsystems, although serious, does not cause catastrophic failure of the total system. Instead the switches go into isolation mode, with their local processor carrying out all normal functions. During this time no changes can be made to individual customer"s class of service records, and the services provided by the head end are unavailable (information, videotex etc.) but accounting information is stored until the head end comes back. This philosophy is taken further in that if the switch processor fails, channel switching of "free" and "subscription" services is done by the microprocessor on each sub switch. Only if this micro fails is service lost to thirty subscribers, and provided that the rest of the system is in good health, this will be reported immediately to the maintenance control.

RELIABILITY

The customer base and network size is as yet too small to get any meaningful figures on reliability, however some observations can be made. As has already been mentioned the number of cable faults when commissioned is zero. The same can not be said of the optical transmitters, where in the early days there was an almost 25% failure in lasers. This is still the subject of intensive investigation, but has been isolated to an early batch by one particular manufacturer. During system development lasers from the same manufacturer showed excellent life test results. Happily, later laser cards do not exhibit such a failure rate, as of some 150 cards on pre-commissioning soak test only two have failed. It is also gratifying to know that of the early failures all were trapped by the rising laser current monitor before they became service affecting.

Early difficulty was experienced with connectors on the launch module cards.(The launch module takes the signals from the sub switch unit and sends them down the subscriber coaxial cable). A faulty batch had been supplied by a manufacturer, such that when the patch cord was tightened it destroyed the connector. Measurements proved that the connector was not meeting its specified tightening torque.

Trouble was experienced with the low noise amplifiers on the satellite antennas. They exhibited a peculiar oscillation mode when the temperature fell below freezing. This has been confirmed by the manufacturer and a different design of l.n.a. has been installed. Generally the satellite receivers have been a source of annoyance, as they seem to need almost constant fine tuning to preserve picture quality. Unfortunateley the uplinked signal cannot always be relied on to be perfect, nor can the signals being broadcast from terrestial transmitters. The switches have so far proved very reliable, as have the customer units. The worst record is that of the hand held keypad and associated infra red receiver, this is being investigated. A large proportion of the reported faults can be shown to be customer error, often detuning of their television receiver or experiencing difficulty in using a video recorder. This has pointed to short comings in the user guide supplied to the customer, and this is being revised. It must also be said that in the early days the cable operator's staff were not totally familiar with the system and this led to a higher proportion of perceived faults being reported to the provider, instead of being cleared by talking to the customer.

There have been annoying bugs in the software, but none which have caused a complete shutdown. The software has been amended as a result of discussions between operator and provider to fit in with procedures designed to ensure trouble free installation and operation. It has, at times, been difficult to persuade people to use the system as intended, as it as seen as reducing their freedom for manoeuvre. Training both parties in the use of the system had been underestimated.

The worth of the "gracefull fail" has been amply demonstrated on a number of occasions when the computers have stopped due to a small glitch in the mains power supply. These normally result in no complaints from customer's, but one from the operator who cannot use his terminals. It was mistakenly assumed from records of the reliability of the mains supply that no standby power need be provided. However the machines are very sensitive to even a half cycle interruption, so steps are being taken to provide an uninterruptable supply with a 15 minute backup capacity.

CONCLUSION

The system commenced its trial phase in June of 1985 with 200 customers connected to two switches. By October confidence in the system design and fault rate was such

that the operator commenced commercial operation and the provider began installing more switches. At the end of 1985 16 switches were operational. Experience shows that this switched system works, and works reliably.

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