

Marine Archaeological Information Centers through Optical Fiber Communication Network

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In this paper an attempt has been made to interlink the various marine archaeological centres/sites through optical communication networks. The existing communication networks do not meet the growing needs of the system. The Integrated Broadband communication network (IBCN) based on optical fiber links are presumed to be the best possible structure. As a matter of fact it will enhance the communicative and distributive services throughout the world with optical fibers providing cost-effective distribution networks (local and toll).

INTRODUCTION

The entire history of past maritime trade of the world may be reconstructed if proper linkage is established in between the archives, marine archaeological information centres of Indian and rest of the countries throughout the world. This will facilitate the free flow and exchange of information between the marine archaeologists in different parts of the world.

So far the individual marine archaeologists are concentrating their work only locally. But many interesting and fascinating facts may be revealed if proper linkage is established between the important ports and marine archaeological centres. Information collected from different archives gives more than 200 shipwrecks in Indian waters. Information on 500 or more shipwrecks can be collected from several thousand records yet to be examined (Rao, 1987: 22-30). Work on shipwrecks may throw some light on the oceanographic conditions prevalent during that time. If this information is properly correlated with the sunken ships of the same time at another place it may reveal astonishing facts. Many such important marine archaeological records are documented in the India Office Library, Bibliotheque Nationale, Paris and in the Archives of Lisbon and Amsterdam.

In this paper a suitable Fiber optic local area and trunk network is proposed to interlink various marine archaeological centres, archives and museums in India and abroad. The limitations of the conventional information services are briefly reviewed, moreover the possible typologies of fiber optic local area and trunk network are discussed in detail. The component av-

ailability, system economics and other considerations related to design are also discussed.

INTRODUCTION TO FIBER OPTICS

The principal motivations behind each new communication system were either to improve the transmission fidelity or to increase the data rate so that more information could be sent, or to increase the transmission distance between relay stations. At the destination the information is removed from the carrier wave (because while transmitting information signal is superimposed with the carrier wave) and processed as desired (Fig. 1) since the amount of information that can be transmitted is directly related to the frequency range over which the carrier wave operates, increasing carrier frequency increases the available transmission bandwidth and consequently, provides a larger information carrying capacity.

The structure of an optical fiber (Fig. 2) consists of a central part called core of refractive index n_1 , surrounded by the material called cladding, of refractive index n_2 . Thus electromagnetic waves can be confined in the core region and transmitted by total internal reflections at the core/cladding boundary. Such an optical fiber is a form of dielectric waveguide in which silica-type glass and multicomponent glasses are usually used as the dielectric materials. The core diameter of optical fiber usually ranges from 10-20 μm , and outer cladding diameter from 100-200 μm . At present fused silica doped with group III & V compounds materials have the lowest transmission loss, with large bandwidth

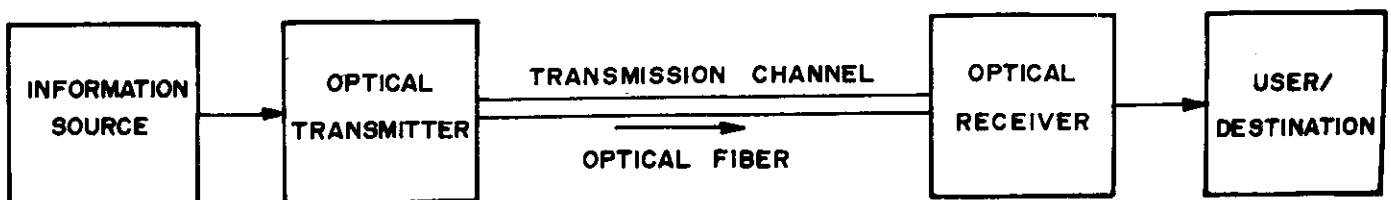


Fig. 1 An optical fiber communication link

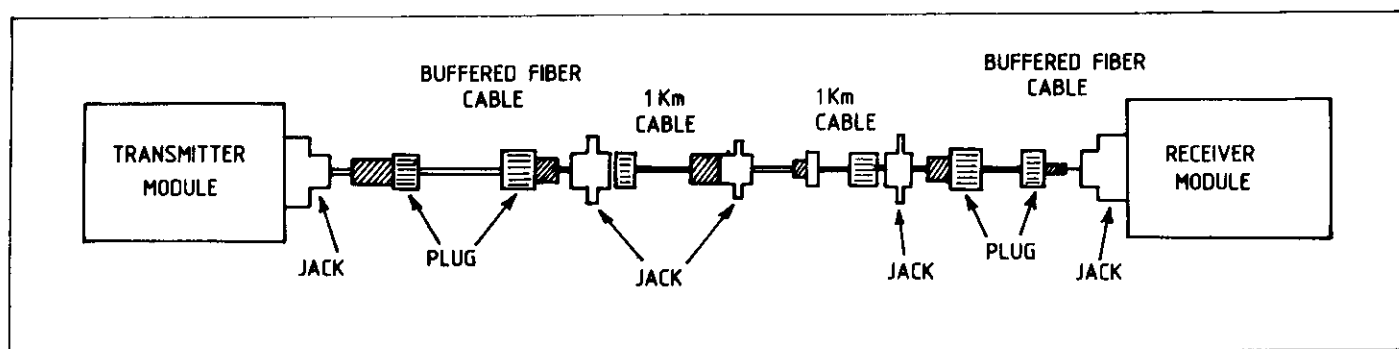


Fig. 2 Link design for 2 - Km link using digital transmission system

and low transmission loss, the optical fiber waveguide is a most promising transmission line.

ADVANTAGES/DISADVANTAGES AND CHARACTERISTICS OF OPTICAL COMMUNICATIONS

Optical fibers make better use of the advantages of light transmission than any other optical waveguide system and have following properties. It has low loss over a wide range of wavelengths (less than 0.2 dB/km). Large bandwidth (1 and 100 GHz, respectively, for multimode and single mode fibers over 1 km). Highly flexible, low weight, small size (a clad glass fiber has a diameter of about 100 μm and a total diameter, inclusive of plastic coatings of 1-2 mm). It is free from electromagnetic interference, crosstalk and has high security. Keeping these requirements and advantages in view, optical fiber communication network can be foreseen for interlinking various marine archaeological centres, museums and archives throughout the world.

FORMULATION OF THE PROBLEM

Marine Archaeology is an emerging field. It is very essential to have speedy information exchange for a particular center with the other center, in India or abroad. The information can be either about the shipwrecks, antiquities, submerged townships or about dating. The valuable data is required at the time of excavations and explorations from different centres, to know in detail about the finds. This goal can be achieved if a suitable network is designed so that information exchange can occur rapidly. The existing microwave telephone and telex networks are not sufficient to meet the growing requirements of the field. To provide the network enhancement, it is perceived to have broadband integrated switched digital network (BISDN) using optical fibers, will support communicative services such as video telephone and video conferencing. The ultimate objective is to have IBCN (Integrated Broadband Communication Network) which can handle narrowband and broadband distributive services and broadband communicative services supported by BISDN. This "Universal" broadband network will be based on the full integration of all services at all levels of the network (local and toll).

BROADBAND SERVICES

Broadband services have been classified by CCITT (Kompfner, 1965:149-155) into communicative services and distributive ser-

vices. Communicative services, which cover both symmetric and asymmetric bidirectional communication with or without store - and - forward functions, can be divided into three classes viz., *dialog services*, *messaging services* and *retrieval services*.

In contrast, distributive (or broadcast) services transport information from a central source to a large number of Marine Archaeological Centers (MAC). This category is divided into two classes depending on whether users can or cannot control the start of the information flow, which can be cyclical or continuous.

The IBCN will also bring various MAC's, a variety of existing and new narrowband non-voice services (eg. Video tex). Every MAC will require individual security, and utility control, it should be satisfied by narrowband teleservices supported by broadband services (Kao, 1982).

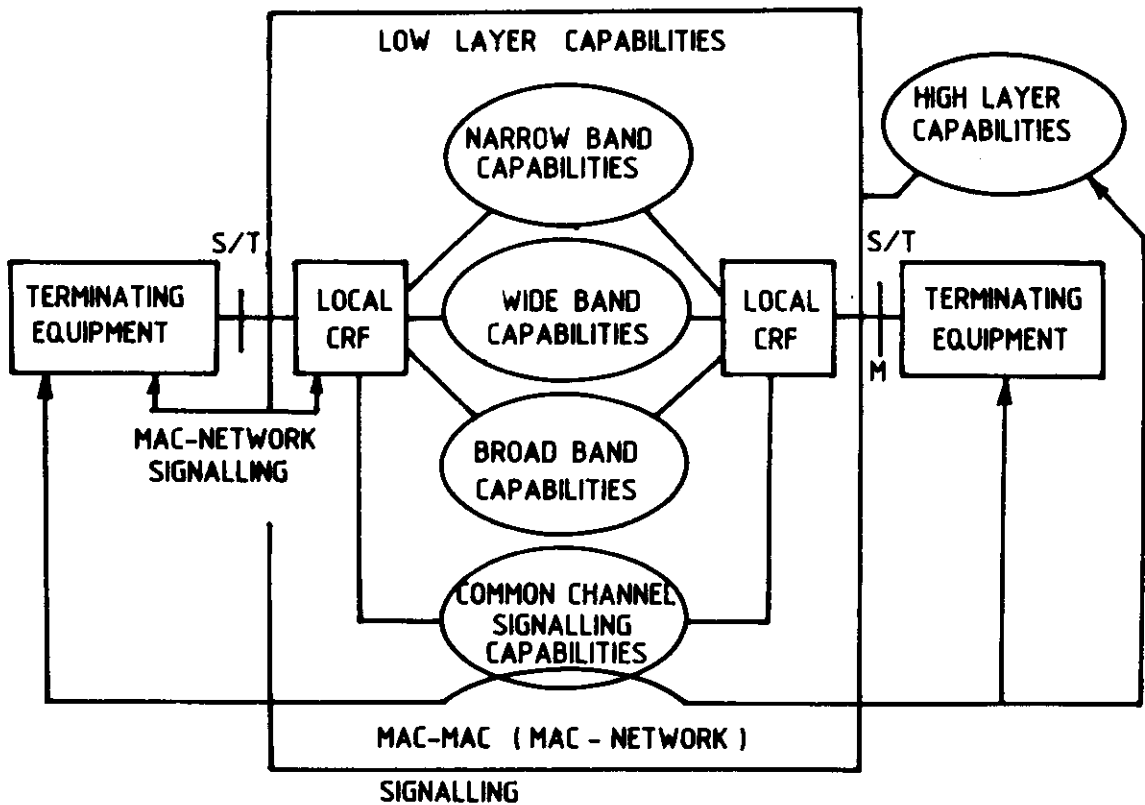
IBCN STRUCTURES

The basic IBCN architecture (Fig. 3) can provide 64 Kbit/s narrowband connections as well as $n \times 64$ Kbit/s videoband connections where ($n = 30$) and broadband connections operating at bit rates in excess of the primary rate (Miller, 1973: 1703-1751).

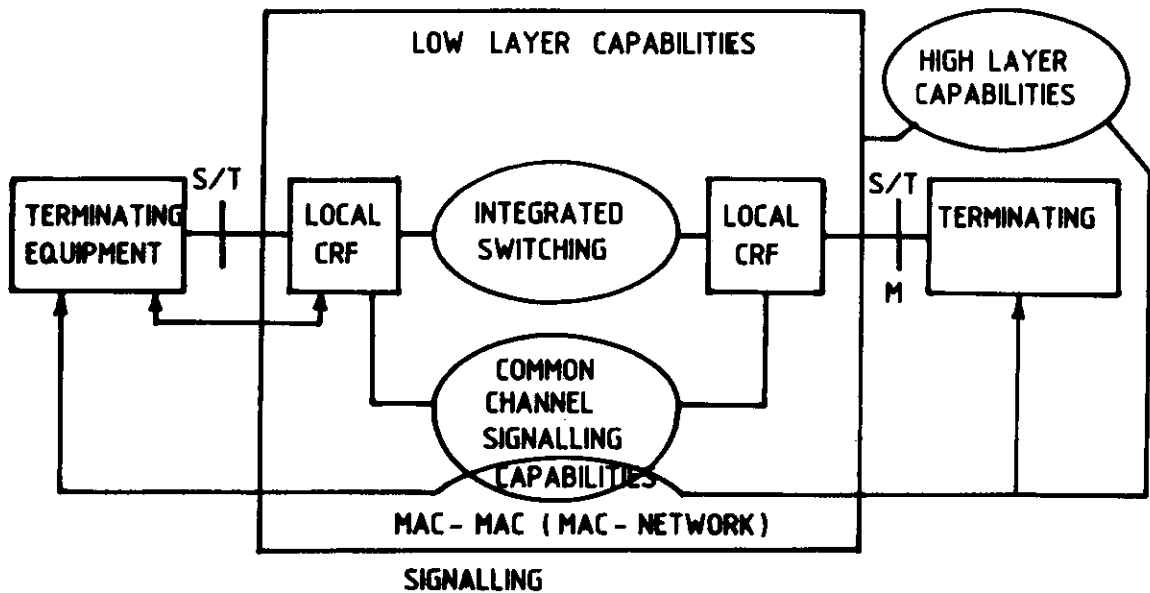
All connections can be switched or non-switched. In the case of switched connections switching can be performed either by separate specialized networks or by a unique integrated network. The IBCN architecture has also to provide connection - related functions such as different MAC - to - network signalling change and common channel signalling.

An IBCN can be divided into six main elements, each with specific technical and economic characteristics (Fig. 4).

- Fixed and mobile terminal equipment.
- MACPN (Marine Archaeological Center Premises Network) which can provide different functions and be of varying complexity depending on the environment.
- MAC access which provides the MAC - to - Network connection via a cable or radio transmission. A cable connection includes a network termination (NT - 1) to interface the MACPN with the MAC line, the line termination and the MAC line MACPN itself, a radio connection consists of a network adapter, including a transceiver.
- Local switching and distribution : Local exchanges, which provide point-to-point and point-to- multipoint switched connections for MAC-to-MAC and MAC-to-Service Center communications, and head-end stations, which combine



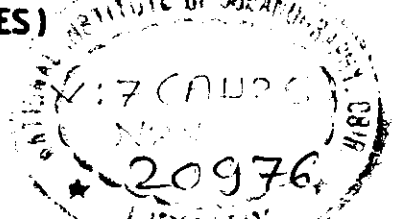
a) SEPARATE SWITCHING NETWORKS



b) INTEGRATED SWITCHING NETWORK

CRF : CONNECTION RELATED FUNCTIONS (COMMUNICATIVE AND DISTRIBUTIVE SERVICES)

Fig. 3 Basic architectural model of the IBCN



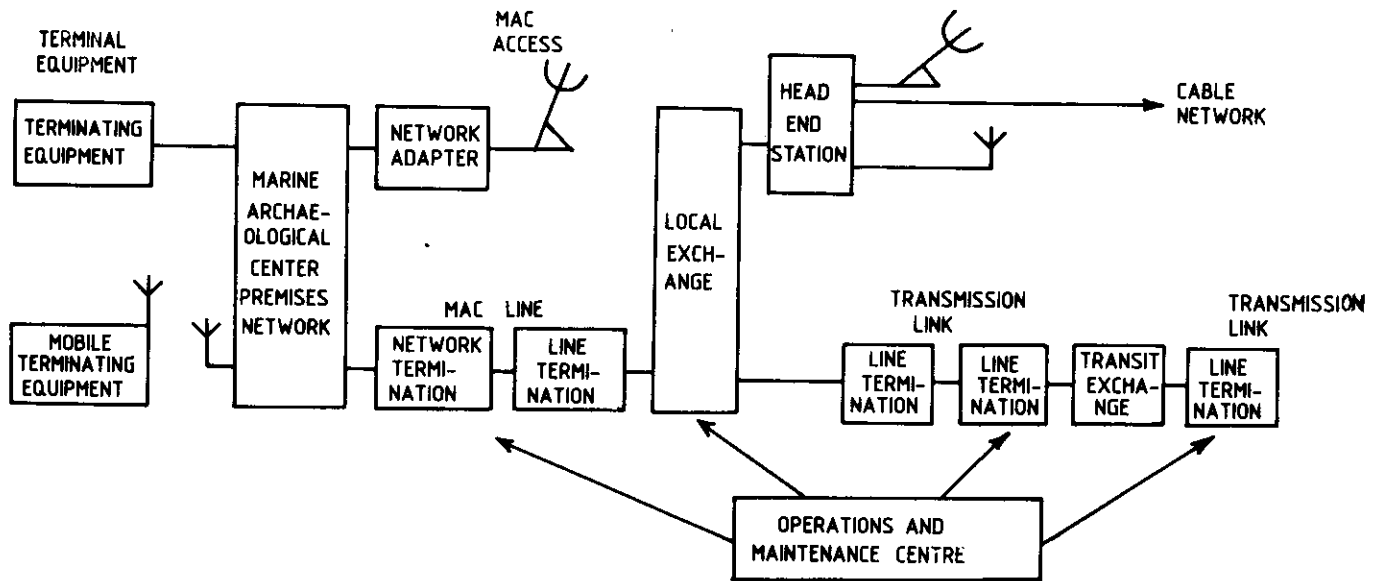


Fig. 4 Main elements of an IBCN

locally and remotely produced distributive services and forward them to local exchanges.

- Transit network; consisting of transmission links and transit exchanges.
- Operations and maintenance, which is distributed between MAC access local switching and distribution, and the transit network.
- The introduction of broadband services is likely to impose new requirements on the existing network structure.

Broadband traffic has two main characteristics. First, only traffic originated by some broadband services (normally the dialog and messaging classes) flows through the trunk network and only videotelephony has traffic characteristics (routing, holding time, number of busy hour call attempts) similar to telephony. Second, traffic originated by retrieval and distributive services has different routing patterns from telephony as it is restricted to the part of the network between MAC and network service center.

The main traffic characteristics of key IBCN services are shown in Table 1 where burstiness is the ratio between the time during which information is sent and the time for which the channel is occupied. This is an important parameter because frequently information is sent on the transmission channel in short bursts. As an example, voice traffic can occupy the bidirectional transmission channel between two MAC either throughout a call, or unidirectionally when only the MAC is talking.

Table 1 shows that broadband services require networks capable of handling a wide range of call types, from a large number of busy hour call attempts and short holding times (file transfers) to those with long holding times (distributive services). The table also shows that broadband services are expected to have a considerable effect on existing traffic volumes. The extent of these changes will depend mainly on the penetration of vid-

eotelephony, on its quality requirements, and on advances in bit rate compression techniques.

The traffic impact of distributive services will almost exclusively depend on the location of the head-end station. If it is directly connected to local exchanges by leased lines or packet-switched connections, the impact of distributive service traffic is limited to the distribution network.

IBCEN FEATURES AND REQUIREMENTS

The MAC line bit rate should be about 60 Mbit/s with a service bit rate upto 140 Mbit/s which is expected to be the minimum needed for high definition TV. MAC loop technology should make extensive use of optical fibers and where appropriate, of satellites. Switching will have to be capable of handling a wide range of different bit rates and traffic parameters, requiring novel switching techniques such as fast packet switching.

IBCEN SCENARIOS

Many scenarios can be envisaged covering different policies for providing services and various network solutions. The use of attributes to characterize services and networks in an ISDN can be extended to the IBCN, where the attributes are mainly related to information transfer modes and bit rates, and to the introduction of new switching and multiplexing techniques.

A number of steps are involved in the choice of an IBCN scenarios :

- All possible scenarios are listed according to selected attributes.
- Scenarios that are not feasible or are of little interest from a network and service viewpoint are excluded.
- Suitable criteria are selected on which the choice will be based.
- Scenarios and selection criteria are analyzed.

SERVICES	BIT RATE (K BITS/S)		CALL DURATION(SECS)		BURSTINESS	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
COMMUNICATIVE SERVICES						
DIALOG						
* TELEPHONE		64		10^2	0.3	1
* VIDEO TELEPHONE	64	$70 \cdot 10^3$		10^2	0.5	1
* TELEMETRY	10^{-2}	10	1	10	0.01	0.1
* TELETEX		10		10^2		1
* FACSIMILE (GROUP A)		64	10	10^2		1
* VIDEO SURVEILLANCE	10	$30 \cdot 10^3$	10^3	10^4	0.1	1
* VIDEO CONFERENCING	10^3	$70 \cdot 10^3$	10^3	10^4	0.5	1
RETRIEVAL						
* VIDEOTEX	1	64	10^2	10^3		0.1
* BROADBAND VIDEOTEX	10^3	$70 \cdot 10^3$	10^2	10^3	0.1	1
MESSAGING						
* VOICE MAIL	16	64	10	10^2	0.3	0.5
* VIDEO MAIL	10^3	$70 \cdot 10^3$	10	10^3	0.1	0.5
* ELECTRONIC MAIL		10		10^2		0.5
DISTRIBUTIVE SERVICES						
* HI-FI SOUND		768	10^3	10^4		1
* TV	$30 \cdot 10^3$	$70 \cdot 10^3$	10^3	10^4		1
* HD TV	$140 \cdot 10^3$	$565 \cdot 10^3$	10^3	10^4		1

Table 1 Traffic characteristics of IBCN services

-The most suitable scenarios are synthesized and the most likely applications identified.

Table 3 classifies the key options of alternative IBCN scenarios in terms of services, distribution network and switching system.

MAC distribution networks are likely to undergo considerable technological change. The main alternatives are :

Direct broadcast satellite (DBS) : will be used primarily to pro-

vide distributive services. MAC requiring communicative services will have to be equipped with satellite transceivers. DBS covers the entire service area; the route cost and performance are independent of distance.

Copper-pair cables : such networks either preclude broadband communication or limit the distance over which it can be provided, unless new videocoding techniques enable narrowband

ASPECTS	IBCN REQUIREMENTS
SERVICE	SUPPORT TO NARROWBAND AND BROADBAND SIGNALS INCLUDING FULL MOTION VIDEO OF DIFFERENT SERVICE QUALITY FROM HIGH DEFINITION TV TO HIGHLY REDUCED RESOLUTION VIDEO. DISTRIBUTIVE AND COMMUNICATIVE SERVICE CAPABILITY POINT TO POINT AND TO MULTIPPOINT CONNECTIONS.
NETWORK	COMPLIANCE WITH OSI NETWORK ARCHITECTURE REFERENCE MODEL INCLUDING SUBNETWORKS AND GATEWAYS. ABILITY TO BE TRANSPARENT OR TO PROVIDE VALUE-ADDED SERVICES (e.g. ENCRPTION, SPEED AND FORMAT CONVERSION) SMOOTH TRANSITION FROM NARROWBAND ISDN SAME NUMBERING FOR ALL SERVICES TO EACH MAC ACCESS POINT UNIQUE SIGNALLING CHANNEL FOR EACH MAC ACCESS POINT
SWITCHING	ABILITY TO SUPPORT MULTIRATE SWITCHED AND NON-SWITCHED CONNECTIONS. NETWORK STRUCTURE INDEPENDENT OF SWITCHING NOTE
TRANSMISSION	PROVISION OF A CHANNEL BANDWIDTH UPTO 140 M BITS/S SERVICE (e.g. COMPRESSIBILITY) MAC LINE BIT RATE RANGE BETWEEN 140 M BITS/S TO 565M BITS/S (AT T-REFERENCE POINT)
MAC	DYNAMIC ALLOCATION OF ACCESS CHANNELS (BANDWIDTH) FROM THE MAC. ATTRACTIVE TARIFF STRUCTURE.
OPERATIONAL	SIMPLE OPERATION AND MAINTENANCE. SIMPLE EXTENSION AND RECONFIGURATION PROCEDURES MAXIMUM USE OF EXISTING INFRASTRUCTURES.

TABLE 2 MAIN IBCN REQUIREMENTS

moving picture services of acceptable quality to be implemented.
Optical fiber cables : All services can be provided over this type of network, but remote power feeding of terminals does not appear feasible in the short term.

DBS and copper-pair cables: This combination can provide a limited broadband environment (eg. telematic services and broadband distributive services, typically TV). It is the least expensive solution and can be implemented rapidly.

DBS and optical fiber cables : This solution can provide all services, with distributive services being carried via DBS, cable, or both. Remote power feeding is not possible.

Copper-pair and optical fiber cables : All services can be provided, and telephony and telematic services can be separated from broadband services. Remote power feeding of the telephone subset is possible.

Various switching modes and network architectures can be used in the switching area. Possible switching modes includes circuit switching, conventional packet switching, fast packet switching (Boetetz, 1980 : 698-731; Kraemer, 1977 : 26-32) and hybrid switching. At present; there is considerable interest in fast packet switching because it has the potential to switch the high data rates needed for high definition television, and to handle all service switching requirements in a variable bit rate structure. Also the transmission capacity and MAC network interface structure can be adapted to specific service requirements.

These considerations do not apply to fast packet switching where the switch complexity depends on the maximum allowable bit rate. However, its development is less advanced than broadband circuit switching.

Table 2 Main IBCN requirements

SERVICES	BIT RATE	SERVICE CATEGORIES	SERVICE CLASSES
	TELEMATIC VIDEOMATIC TELEMATIC AND VIDEOMATIC		DISTRIBUTIVE COMMUNICATIVE
MAC DISTRIBUTION NETWORK	TRANSMISSION MEDIA		MULTIPLEXING METHODS
	RADIO WAVES	TERRESTIAL DBS	SPACE DIVISION (SMD)
	WIRED	COPPER PAIRS FIBER OPTICS COPPER PAIRS AND FIBER OPTICS	TIME DIVISION (TDM) WAVELENGTH DIVISION (WDM) HYBRID SDM & TDM WDM & TDM
	HYBRID	DBS & FO	
SWITCHING	SWITCHING NETWORK STRUCTURE	SWITCHING MODE	MULTIPLEXING METHODS
	SEPARATE SERVICE CATEGORIES - BIT RATES INTEGRATED	CIRCUIT SINGLE RATE - MULTIRATE FAST CIRCUIT FAST PACKET PACKET	SPACE DIVISION TIME DIVISION - ASYNCHRONOUS - SYNCHRONOUS WAVELENGTH DIVISION

Table 3 Options for IBCN reference

Two separate switching network structures can be used for the IBCN. The first switches communicative and distributive services separately, according to their different traffic characteristics. Separate switching of point-to-point and point-to-multipoint connections could reduce the total number of crosspoints. The second structure separates the switching of narrowband and broadband services, making it possible to add broadband switching to an existing narrowband exchange.

Feasible network structures can be derived by combining the distribution network and switching mode options. A limited set of IBCN scenarios can be selected by analyzing how well the resulting network structures can support the identified services categories. Such a service-network analysis shows that :

- Development of new switching concepts (eg. fast packet switching and hybrid switching) is justified when all classes of services are to be switched.
- Massive replacement of copper pairs by optical cable distribution networks should be considered as a strategic investment in the telecommunications infrastructure.
- Network operators should maintain existing copper pairs to meet the requirements for remote power feeding of telephone subsets. In this case, overlaid optical cable MAC loops are only justified if broadband distributive services are to be provided.

Assuming that all classes of services are to be provided, the following network scenarios appear to be most interesting :

Fiber optic distribution and separate circuit switched networks (FD/CS) : Narrowband communicative services are TDM (time division multiplexing) circuit switched, while broadband communicative services and all distributive services are SDM (space division multiplexing) circuit switched.

Fiber optic distribution and hybrid switching network(FD/HS) : Narrowband communicative services are TDM circuit switched, while narrowband distributive services and all broadband services are packet switched.

Copper pairs and fiber optic distribution with circuit switching (CP-FO/CS) : Narrowband communicative services use copper pairs and TDM circuit switching, while all other services use an optical cable MAC loop and SDM circuit switching.

Direct broadcast satellite and fiber optic distribution with circuit switching (DBS-FD/CS) : Broadband distributive services are supplied by DBS, while broadband communicative and all narrowband services are provided by the fiber optic network. Nar-

rowband communicative service are TDM circuit switched; broadband communicative services and narrowband distributive services are separately SDM circuit switched.

Consequently it is likely to be the most suitably longterm solution.

CONSLUSION

Evolutin towards marine archaeology is long term objective for all major countries, using optical fiber IBCN it will enhance the communicative and distributive services through the world. As shown in (Fig. 5) all the major MAC's will be interlinked and the information dissemination will occur rapidly.

Although the actual evolutionary states will differ between countries depending on the present availability of distributive services. In the short term, comprehensive field trials are needed to test the fiber optics IBCN enabling technologies and determine MAC demand for broadband services.

Some general trends can already be identified, in the long term a unique bearer channel and a unique switching technique (fast packet switching) seems appropriate for all services, with optical fibers providing cost-effective distribution networks. During the transition period, hybrid configurations are likely to emerge in distribution network and switching. It will fulfill the requirements of Mobile and stationed Marine Archaeological Centers throughout the world using Fiber Optic IBCN. It is expected that the IBCN will, in the long term, prove to be the natural extension of today's networks, for giving special services to Marine Archaeology.

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