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cc: Mr. Brian Dugan

To: Mr. Hamad Al-Daig and Mr. Anwar Motan
King Faisal Specialist Hospital & Research Centre

From: Gloria Rea October 27, 1994

Re: MIDDLE EAST INFOTECH 95 (30 May - 2 June 1995)

This is to acknowledge receipt of your abstract - **Setting up the Networking Infrastructure - How to Plan the Physical Layer?**

This has been forwarded to the Conference Organising committee and we will get back to you as soon as possible.

Kind regards,

Gloria Rea

Appears in the Proceedings of Infotech 95, Manama, Bahrain.

Setting up the networking infrastructure - How to plan the Physical Layer ?

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ABSTRACT

Physical Layer is the important foundation layer in the OSI model of computer networking for the setup of institutional infrastructure. This is where today's decisions will affect the future integration, upgrades, forward and backward compatibility. During the planning phase of the King Faisal Specialist Hospital & Research Center nework our goal was to create the basic infrastructure that would be effecient, reliable, open and meet our existing as well as future needs. The plan focussed on the three lower OSI layers : Physical, Link and Network. In this paper we discuss how we determined the type, layout, topology, quantity and quality of the CABLE PLANT in the Physical layer. We present the plans for the Campus backbone, building backbone and floor Cable distribution. We elaborate on the choice of two(2) pair, multimode optical fibre cable for the backbone and Unshielded Twisted Pair (UTP) grade 5 Copper Cable for the floor distribution. We will also touch on the Link and Network layers. As part of our discussion we would also include the telephony and audio/video requirements on the same cable.

INTRODUCTION

King Faisal Specialist Hospital & Research Centre(KFSH&RC) is a 517 bed tertiary care hospital and one of the most prestigious health care institutions in the Kingdom of Saudi Arabia. The hospital provides a variety of health services to the people of the kingdom, includes open heart surgery, bone marrow transplant, heart, kidney and liver transplant, etc. In addition to being a health care institution, it is also a research and educational center. Recently two hospitals have been added to the institution and expected number of beds could very well be over 900.

Traditionally the Computer and Hospital Information Center (CHIC) department was only reponsible for the Mainframe applications running on IBM Mainframe. Most of the Local Area Networks created in the hospital were accompolished by the user departments. This created different types of networks in the hospital. CHIC department took the initiative and took over the reponsibility about 4 years ago to integrate most of these network into a single Fibre Optic backbone network which could be usefull for the users through out the hospital. As time and budget permitted KFSH&RC went through an eloborated network plan to cover the whole institution.

Setting

The paper presented here includes six necessities in order of their importance for a successful information system: Institutional commitment, Leadership, Network, People, Database, and Applications. The network building relies on the institutional commitment in developing a world-class information system, and is necessary in order for databases and applications to be used to their fullest potential. This paper will only cover the planning to install optical fiber and twisted pair cables through out the KFSH&RC campus, in every building, and in every floor for wide and pervasive development of information and networking infrastructure. Cables within the buildings are to be connected to construct building networks using intelligent hubs. Building networks themselves are to be connected to campus routers to construct the campus-wide network. Redundancy is built-in to avoid single points of failure and for exploitation of future networking technologies. The proposed state-of-the-art network will successfully meet the current data communication, audiovisual and telephony needs at KFSH&RC.

Cable Layout

The layout describes the way cables should be installed to link buildings within the KFSH&RC campus, to link individual floors within a building, and to link workstations and hosts within a floor. Specifically, the types and quantities of such cable are described.

Campus Cable Layout

All inter-building cables at the campus level will be multi-mode (optical) fiber cable (62.5/125 micrometer). The *Main Hospital* building was divided into 4 sub-buildings (MH0, MHA, MHB, MHC) due its large span and limitations of lobe lengths. Similarly, the *Outpatient* building was divided into 2 sub-buildings (OPA, OPB) and the *Hospital Expansion Building* was sub-divided into 2 sub-buildings (HEBA, HEBB).

The number of fiber cables from one building to another building was determined based upon the desire to provide at least 2 central locations, *Main Hospital B Basement* (MHB-B) and *Computer and Hospital Information Centre* (CHIC), to be able to redundantly connect to all other buildings and to accommodate prominent current and future networking topologies. The quantities permit a dual star layout centred at both locations. CHICs central nature was derived from the maintenance and management viewpoint, and MHBs central nature was geographic. As new topologies come into existence, and are needed to co-exist with previous ones, more cables will be used from this pool. Furthermore, special requirements may be easily accommodated that need dedicated cables.

The cable paths were carefully chosen to follow the underground tunnel infrastructure at KFSH&RC in consultation with the Engineering department. Some locations had only a conduit access. The layout reflects redundant pathways to the main clinical areas (*Main Hospital*, *Outpatient*, and *Hospital Expansion Building*).

The Campus cables start from a Building Distribution Centre closet and end in another Building Distribution Centre, both of which were typically at the basement level. These closets will have Racks and Panels (for appropriate cable types), Uninterrupted Power Supply, and proper electrical grounding. All cables would be terminated at the panels. These closets would be separated from the Electric and the Telephone closets.

Building Cable Layout

Each floor in a building has a Floor Distribution Centre in a closet consisting of rack and panels for appropriate cable type. The closets will be aligned vertically and will be as close as possible. 8 multimode fiber cables and 8 Unshielded Twisted Pair - Category 5 (UTP) cables will be pulled between each adjacent closet and appropriately terminated at the panels. Additionally, 16 multimode fiber cables will be pulled from each floor closet to the building closet, which is the same as the floor closet in the basement. The building closet will use the pre-existing rack and panels as part of the campus cable layout.

For networking purposes, the floors within a building are identified in the sequence of Basement, 1st Floor, 2nd Floor, etc. (even when a building has an explicit Ground floor in which case the Ground floor is called 1st floor, and so on). The building on the KFSH&RC campus with the most occupied floors is the *Outpatient* building which has 4 floors and a basement. The chosen number of fiber cables reflect the possibilities of a chained or a star configuration from the basement (or any other floor) of a building. Also, these cables will be useful in future to accommodate high-speed networks, most likely used first within a building but across several floors (such as departmental distributions). The UTP cables are useful in overflow situations as explained in **Floor Cable Layout** and **Building Ethernet networks**.

The vertical arrangement of floor closets reflect the cable tray layouts. The relatively small number of floors permit modular vertical networks per building to be designed and implemented easily.

Floor Cable Layout

Each potential workstation location in a floor will be cabled with a UTP - Category 5 cable from the corresponding floor closet. This is a relatively simple and standard star configuration. Each cable from the floor closet to a work area is called a *lobe*. The cable layout design and the placement of closets will ensure that no lobe is longer than 100 meters (m); however, if a lobe is found to be longer than 100 m at installation time, it will be specially identified and documented. All of these cables will be terminated at both ends: on wall plates in the work area, and on panels in the closet.

Special Considerations

The imaging modalities in departments such as Radiology and Pathology will be the first to need high-speed networks to exchange images and video sequences. At present, these areas are in *Research Centre* (RC), *Main Hospital*, *Outpatient*, *Hospital Expansion Building*, and *East Wing* (EW). Similarly, Operating Rooms and the Intensive Care Units of the future will have higher needs to access data in the form of images and video sequences. In addition to appropriate UTP cables, fiber cables (2 pairs in the Operating Rooms which are then sealed, 1 pair at rest of the locations) will be pulled and terminated as horizontal lobes. These fiber cables may be used later with the spare building and campus fiber cables to construct imaging and video networks, which are then connected to the larger campus network.

Topology

We next describe how passive cables are connected with active devices such as Hubs and Routers to construct a functioning, active network. Special attention is given to redundant connections for additional reliability.

Building Ethernet networks

Out of 21 building segments, 14 will have an Ethernet segment at 10 Megabits per second (Mbps) as the building backbone. These 14 segments are called the *Primary* segments. This requires placement of Ethernet hubs in each floor closet, and connecting the hubs within a building in either a chain or a star configuration using building fiber cables. If a particular floor or basement has no workstation lobes, it is not necessary to place a hub in that floor closet (unless the closet is being used for establishing campus backbones). The 14 buildings are: CHIC, RC, *Oncology* (ONC), *Administration* (ADM), MH0, MHA, MHB, MHC, OPA, OPB, HEBA, HEBB, *Polyclinic and Family Health Care* (POL), and EW. In addition, but at a lower priority, 2 other Ethernet segments will be created that span the rest of the seven buildings. *West Segment* should span *Engineering & Print Shop* (EPS), *Materials Management* (MM), *Pharmacy Warehouse* (PWH), *Fire Safety* (FIRE), and *Utilities and Maintenance* (UU). *East Segment* should span *Safety and Security* (SAS) and *Home Health Care* (HHC). These 2 segments will use campus fiber in addition to individual building fiber.

Hubs

The hubs will use 10BaseT modules to connect the workstation lobes to the building Ethernet. The hubs will use 10BaseF(L/B) and/or FOIRL standards in connecting with each other over fiber cables. Both chained and star configurations (from a hub at the floor with largest number of workstations) will be considered in connecting more than 2 hubs under the following issues: price, fiber cable utilization, other campus backbone issues, and complexity. The hubs will be fully capable of supporting more than one segment concurrently. All hubs and modules will be fully manageable by network management software, with capability of dynamic port to segment assignments, turning ports on or off, etc. There will be at least one hub in the Primary segments that is Asynchronous Transfer Mode (ATM)-capable; it could be the hub with maximum number of workstation connections. This will permit an easier migration to ATM backbone network in future which will support over 155 Mbps bandwidth. Spare hubs and modules (2-4) will be purchased as fault replacement units or for future use.

Redundant, collapsed campus backbones

The 14 Primary will should be extended using the campus fiber cables to 2 central locations: the building distribution centre closets at MHB-B and CHIC-1. The East Segment will be extended to MHB-B and the West Segment will be extended to CHIC-1. A separate hub will be used at each of the 2 locations to accomplish the extensions. These will be ATM-capable hubs. These hubs will also provide more than one UTP port for each of these extended Ethernets. These campus closets will be the same as the corresponding building closets.

Additionally, with appropriate cabling the existing Administrative Affairs/Photography/Post-Graduate Education (AAPE) Ethernet and the existing RC Ethernet should be extended to MHB-B (see **Integration of existing networks**). In these cases, a lobe extension may be sufficient. Finally, the campus Token Ring network and the Laboratory Ethernet network will be available at CHIC-1.

The hubs that are used to extend the Primary segments and other Ethernets to the campus closets may themselves be used to create a repeated/switched campus backbone. This idea is rejected because of the immense size of the resulting single Ethernet segment. Bridges may be used instead to create a bridged backbone, which is also rejected due to the data traffic considerations of an institution as large as KFSH&RC and to avoid the well-known broadcast problems on bridged networks. Therefore we choose the collapsed backbone architecture in which 2 routers at the campus closets serve as campus backbones for the KFSH&RC campus where the 14 Primary segments are redundantly connected to both backbone routers.

Router

A multiprotocol router will be used at each campus closets to connect to all Ethernets at that location. Additionally, the CHIC router will be capable of Token Ring connectivity. The router must support routing of IP, Novell IPX, and AppleTalk. Additionally, bridging may selectively be turned on with capability to filter packets based on criteria such as source and destination address, packet type, etc. The routers must route at the speed of 100,000 packets per second, or higher, and should be capable of handling all necessary Ethernets and Token Rings in a straight-forward fashion. The routers should be capable of supporting high-speed serial connections for connections to the remote locations. The routers should be manageable with individual port and protocol control.

Integration of existing networks

We describe how the existing collection of networks are to be integrated to the KFSH&RC network.

Token Ring network

The Token Ring network was established primarily to access IBM mainframe (ES9000) applications such as ADT, Materials Management, Pharmacy, etc. Over time, other Novell server based systems and applications were introduced to this network.

Respiratory Care

There is a small Ethernet segment connecting about six workstations for Respiratory Care. There are several instruments connected also. A Netware server also functions as a Netware IPX router and is connected to the Token Ring network . This will migrate to the building Ethernet to its entirety.

Hemodialysis

This Ethernet segment at OPA-2 for Hemodialysis is identical to Respiratory Care in its disposition. Same steps as Respiratory Care need to be performed for Hemodialysis network migration.

Laboratory Ethernet network

The Meditech Laboratory application runs over Dec Alpha. Although this computer is on a Thick Ethernet segment, and all Laboratory Terminal Servers (DG, 3Com) are also on the same segment, there are several proprietary issues that make it extremely hard for the workstations on the new network to communicate with the Laboratory computers. The Meditech Magic system overrides the Dec Alpha operating system, sends proprietary Terminal Server operating software to the Terminal Servers over raw 802.3, and requires a proprietary Meditech terminal protocol (and thus a proprietary Meditech terminal).

Two solutions are possible for Laboratory access either the Meditech or the Laboratory Ethernet should be connected to the campus backbone. .

Academic Affairs/Photography/Postgraduate Education

The AAPE Thick Ethernet segment spans HEBA-3 and HEBB-3. In addition to a Novell file server, there are 4 CD ROM towers serving the MEDLINE and other library software needs of the campus. Separately, there is another Ethernet segment in the Photography division, and these two networks are bridged using a DEC bridge. Both segments have several Digital Electronics Multi-Port Repeaters (DEMPR) which then provide thin-wire (10Base2) connectivity to a large number of PCs, Macintoshes, and some VAX's. The AAPE network is connected via a Netware MultiProtocol Router to the Token Ring network at MHC-1.

The first step towards interconnection is to bring a lobe from AAPE network to MHB-B campus backbone and connect the AAPE network directly to the router). This will facilitate speedy access to library resources. The Netware MultiProtocol Router should be left as it is as a redundant connection. It should be emphasized that the campus backbone will not be a bridged network, so DEC LAT protocol will not work across the campus backbone routers. DECNet should be available on the new segments since it is a routable protocol.

Research Centre

The Research Centre's Thick Ethernet segment spans the entire RC building vertically with DEMPR based thin-wire (10Base2) Ethernet at each floor. A Cisco Router 4000 with 4 Ethernet interfaces and 1 Token-Ring interface is currently connecting the existing RC network to the Token Ring network. Since the Token Ring network (and others) is connected to campus backbone network, RC is connected to the campus-wide network. The RC Ethernet building backbone is connected directly to the campus backbone router at MHB-B. A plan to migrate the workstations to the RC Ethernet building backbone should be developed and implemented.

Liver Transplant

The Liver Transplant network is established at MH0-2 as per star wiring for UTP Category 5 connection to the workstations. A hub is used. Since this network will be functioning before the campus-wide network is installed, the existing Cisco Router 4000 will connect this network with the Token Ring network. That will be the first step towards interconnection. The hub for the Liver Transplant network may be incorporated into the MH0 building Ethernet backbone, thus providing seamless connectivity to the campus network.

Biomedical Engineering

The Biomedical Engineering network consists of several Thick and Thin Ethernet segments in MH0-B. They are connected to the same Cisco Router 4000, and thus that will be their first interconnection to the campus network. Later, their workstations should be moved over to the MH0 building backbone.

Inpatient Nursing

Inpatient Nursing is a very small Token Ring network with a Netware server at MH0-1. This server will be augmented with an Ethernet card and a tiny Ethernet segment that will then be connected to the Router Ethernet interface. Each of their workstations and the Netware server should be connected to the MH0 building backbone.

PET network

This network is not in existence as yet, but the work is progressing to connect the PET machine at the Research Centre to communicate with other hosts in Radiology and in Research Centre. Along with new Radiology modalities, the PET network should be merged to construct the institutional imaging network.

Communications

Currently KFSH&RC has the AT&T Dimension 2000 switch PBX. Individual telephones are connected to the Dimension 2000 (housed in PBX in basement of MH0) through metallic cable from the wall to the PBX. There are also connections betweeen ECTS (electronic telephones--multibutton phones) to the PBX. Bundles of cables reach from the main distribution frame (MDF) in the PBX to the terminal block in each building floor. The terminal blocks are usually in low current closets on each floor, sometimes shared with audiovisual and power.

Audiovisual

Audiovisual has an extensive coaxial cable network on campus connecting the television studio with patient rooms, campus offices, and residential compounds

Integration of data, audiovisual, and communications

Level of integration

We have chosen to use the same cable paths (conduits and tunnels) between campus buildings, vertical riser paths, and closets in building basements and on each floor, for all data, audiovisual, and communications needs. We will use separate multimode fiber optic cables for data, audiovisual, and communications, and will use separate wiring from the appropriate closed to user devises on each floor. Therefore the number of fiber cables connecting building segments is the sum of the needs of data, audiovisual, and communications.

Needs of Audiovisual

AV plans for the near future to utilize high bandwidth analog signals. Digital video is not yet cost effective, in their view; hoewver when the market is more mature, we would like to have the network to support it.. When digital transmission becomes practical, KFSH prefers systems based on SONET, which is an international standard and can handle gigabit per second transmision range, and so is suitable for multimedia service traffic, HDTV, and component digital standards. AV needs access to the common data backbone and sufficient cabling to support video and RF-based specialized applications. Office-to-office multimedia communication can be carried out using Picturetel/Vtel-based technolgy and multiples of half T1 bandwidth.

Signals from the headend will be carried in simplex mode to hospital wards, housing complexes (A, B, C, KAC, Medical Center Village, Palm Villas 1&2, West Compound) and E wing. Video and teleconferencing signals are carried in duplex mode beween the TV studio (to be located in ONC), Postgraduate Center classrooms (HEBA), auditoriums, the telemedicine conference room (HEBA), East Wing, medical records, Safety and Security, Photography, and any image archving locations. Two central locations are needed for the AV network: the TV studio for video and teleconferencing purposes, and headend for CATV transmission. For gateway connections to public networks, the interhospital network, and other specialized connections (satellite earthstations)

The fiber for CAV needs to be connected only to the ground floor of each patient ward building segment, and to the nearest building segment to residential areas, where it will eventually interfaced to existing coaxial cable leading to patient rooms.

Needs of Communications

There is also an extensive network providing telephone services to all campus buildings. Along with replacement of the main switch, this campus communications network needs replacement. This plan includes sufficient fiber to provide the campus backbone also for voice communications needs. To meet needs of telephony, 8 fiber cables will be connecting the PBX in MHO which each of the following locations: E complex, KAC and MCV, Safety Security and Communications