PRELIMINARY DESIGN ASSESSMENT OF OPTICAL FIBER COMMUNICATION NETWORK FOR MOFA INDONESIA

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Abstract– MOFA is one of entities in Indonesia that having an important part in international diplomacy business. The networks are not integrated between one office and another. When one office needs to make communication with other office, they should connect to public network first. The usages of multiple public service access for each MOFA locations are providing overly redundant service, which is unnecessary. While each access allows same bandwidth available for all office locations, it tends to be under-utilized in branch offices while the Head Office suffers from traffic overload, as reflected in very low data rate of only 9.3 kbps per-terminal. This can be disadvantageous since most of activities are done at the Head Office. This condition makes the data transferring process becoming slower and if seen from the security side, it is also have a low security level. Because of that reason, MOFA have a plan to make an integrated communication system using fiber optic that connecting all four offices that place in Jakarta. The purpose in designing communication system using fiber optic at MOFA is to make an integrated network between head office and other three branch offices that located in Jakarta in order to fulfill requirement for simple, fast, and secure data transfer process including filing and data back up. The use of dedicated network allows for easier load balancing between office locations and increasing the bandwidth from 293,949 Mbps to 306 Mbps, while the use of optical fiber network allows for higher transmission security.
Key Words– optical fiber; voice over internet protocol (VoIP); communication systems; virtual private network (VPN); ring topology

Abstrak– MOFA memiliki empat kantor yang berada di Jakarta yaitu kantor pusat, kantor arsip, Data Center, dan Pusat Pendidikan dan Pelatihan (Pusdiklat). Keempat kantor ini belum terintegrasi dalam sebuah jaringan terpadu. Pada tugas akhir ini akan dilakukan perancangan sebuah sistem komunikasi menggunakan serat optik di MOFA guna mengintegrasikan keempat kantor yang berada di Jakarta tersebut. Perancangan dilakukan dengan mempertimbangkan pengembangan jaringan di masa yang akan datang. Serat optik digunakan sebagai media transmisi dengan alasan kebutuhan akan kemampuan transfer data berukuran besar, berkualitas baik, dan proses transfer data berkecepatan tinggi. Sistem komunikasi serat optik ialah sistem komunikasi yang menggunakan serat optik sebagai media transmisinya yang menggunakan cahaya sebagai pembawa sinyal informasinya. Hasil yang didapat dari analisis Power Budget dan Rise Time Budget pada perancangan yang dilakukan adalah sebesar 200,05 km untuk jarak maksimum yang dapat dicapai tanpa harus menggunakan penguat optik dan 483,4 Mbps untuk kecepatan maksimum yang dapat dicapai oleh sistem dimana kebutuhan sistem dengan mempertimbangkan kebutuhan pengembangan jaringan hingga lima tahun kedepan adalah sebesar 306 Mbps.
Kata Kunci– Media transmisi, Serat optik, Sistem komunikasi serat optik, Perancangan jaringan telekomunikasi

I. PENDAHULUAN

MOFA is one of entities in Indonesia that having an important part in international diplomacy business. Currently, MOFA has four offices in Jakarta. The offices are:

1. Headquarter in Pejambon, Central Jakarta.
2. Education and training center in Kebayoran Baru, South Jakarta.
3. Archives office in Kreo, South Jakarta.
4. Data Center (DC) in Cijantung, East Jakarta.

Each office has separated communication network. The networks are not integrated between one office and another. When one office needs to make communication with other office, they should connect to public network first. This condition makes the data transferring process becoming slower and if seen from the security side, it is also have a low security level. Because of that reason, MOFA have a plan to make an integrated communication system using fiber optic that connecting all four offices that place in Jakarta. The reason for using fiber optic as a transmission media are:

1. Resistance from Radio Frequency Interference (RFI).
2. More security.
3. Wide bandwidth.
4. High transfer rate.

With this integrated communication system, transfer data process will be faster and maintenance process will be easier.

The objective from this assessment is to design a communication system using fiber optic in MOFA as a tool for data, voice, and video exchange. This plan should be possible to implementing in order to facilitate information flow in MOFA.

II. COMMUNICATION SYSTEM IN MOFA INDONESIA

MOFA has four offices located in different parts of Jakarta, one head office and three branch offices. The head office is located in Pejambon, Central Jakarta. The three other branch offices are Education and Training Center located in Kebayoran Baru, South Jakarta; Archives Office located in Kreo, South Jakarta; and Data Center (DC) located in Cijantung, East Jakarta. Currently, the four offices still not having an integrated network. Each office have their own communication network. When one office needs to make communication with other office, they should connect to public network first. When they need to transfer a classified data, they using a virtual private network (VPN). Each office using a leased line service for their internet connection and using a bandwidth manager application to manage their bandwidth usage.

A. Communication Network at Head Office

Communication network in head office is the biggest network compared to the other three branch offices. Communication network in head office is also has the highest load because of the number of terminal that connected to the network. The Head Office has six building in one location. The six buildings are namely: Main Tower, Main Building, Vice Building, BP7, Protkons, and PWNI/BHI. They are connected to each other and centralized to one server that placed in Communication Center in Main Building. At this time of writing, some of the building is still connected using Unshielded Twisted Pairs (UTP) cable that makes the connection unstable. Head Office has a total of 3240 terminals that connected to the network:

1. Main Tower : 1240 terminals
2. Main Building : 1200 terminals
3. Vice Building : 40 terminals
4. BP7 Building : 520 terminals
5. Protkons Building : 120 terminals
6. PWNI/BHI Building : 120 terminals

In addition to these terminals, Head Office also has 1139 telephone connection that connected to IP PABX.

Head Office has internet connection with bandwidth 100 Mbps for national and 80 Mbps for international. Head Office also has a back up connection of 82 Mbps in order to anticipate if there is a failed connection. Main internet connection and backup internet connection uses two different internet service provider (ISP). Bandwidth allocation in head office can be seen on Table 1.

TABLE I. HEAD OFFICE BANDWIDTH ALLOCATION

Connection		Usage	Bandwidth
National	Data	Internet	30 Mbps
		Local Applications	10 Mbps
	VoIP	VoIP (soft phone) and IP PABX	40 Mbps
	Spare		20 Mbps
Inter-national	Data	Internet	40 Mbps
	VoIP	VoIP (soft phone)	40 Mbps
Back Up			82 Mbps

The 100 Mbps bandwidth for national connection is divided into three allocations: 40 Mbps for data, 40 Mbps for audio (Voice over Internet Protocol, VoIP), and the remaining 20 Mbps for spare. The 80 Mbps international connection bandwidth is shared into 40 Mbps for data and 40 Mbps for audio (VoIP).

From Table 1, we can calculate the bandwidth for each terminal that connected to the network when they want to make a national internet data connection. The calculation is as follows:

$$\text{BW per terminal} = \frac{30 \times 10^3 \, kbps}{3240} = 9.3 \text{ kbps}$$

This bandwidth seems not enough to give a good connection speed for each terminal. But in fact, each terminal still can get a data rate from 60 until 70 kbps. This can be happen because of these following reasons:

- Not all terminals accessing the internet at the same time.
- There is rule that manage ehich websites can be accessed and which websites can not be accessed.
- There is a rule that control which websites can be accessed during working hours.
- Most of terminal accessing local applications during working hours.
- There is a rule to manage priorities in internet connection.
- There are national connection and international connection.

Because of these, bandwidth that provided is still sufficient to meet the needs of users, although it is undeniable when all terminal do a connection in the same time, some connection will be dropped. Ideally, a good communication system must be able to provide each terminal with the same data speed, so each terminal can do a connection at the same time.

Bandwidth required for VoIP is 17 kbps per terminal. So, for 3240 terminals and for 1139

telephone connections that connected to IP PABX, bandwidth that needed is:

(3240 terminals x 17 kbps) + (1139 telephone x 17 kbps) = 74,443 Mbps

From the calculation above and compare with bandwidth allocation that shown in Table 1, we can see that bandwidth still can not give an ideal communication system for users. But only because, it is so seldom for all terminals using VoIP at the same time, the existing bandwidth still can provide a good service to users.

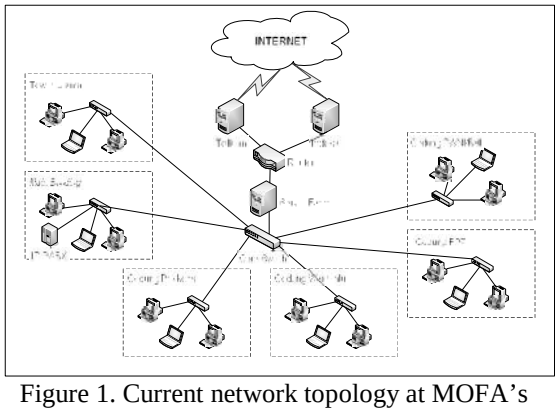

Figure 1. Current network topology at MOFA's Head Office

Each terminal in Head Office is connected to the switch in each building. The switches that located in each building will be connected to the main switch that located in main building. That main switch will be connected to the server farm that providing local applications. When terminal want to connect to the internet, main switch will direct to router that connect to the internet connection. In Figure 1, we can see current network topology at MOFA's head office. In the future, this head office will become a center for information and communication technology in MOFA. All development and maintenance activity will be centralized here.

B. Communication Network at Education and Training Center

Communication network in Education and Training Center is the second largest network among MOFA offices in Jakarta; it has three building in its location. Bandwidth that provided is 80 Mbps: 40 Mbps for data and 40 Mbps for VoIP. Total terminals that connected to this network are 240 terminals and 99 telephone connection that connected to IP PABX here. This allows for the 240 terminals a Bandwidth-per-terminal rate of 166.67 kbps. With 99 line of 17 kbps rate for VoIPs, the total bandwidth requirement is 5.763 Mbps, which is still sufficient for current and foreseeable future loads.

C. Network Communication at Archives Office

In Archives Office, there are 30 terminals that connected to the network and an additional 13 telephone connection that connected to IP PABX here. Nowadays, this archives office is being used to safekeep documents in a hardcopy form during certain period. Bandwidth that provided in this office is 80 Mbps, 40 Mbps for data and 40 Mbps for VoIP, similar to the Education and Training Center.

With this configuration, the current Bandwidth-per-terminal available for 30 terminals is 1.3 Mbps, and the total with VoIps are 0.713 Mbps. this available bandwidth is still not used effectively to support activities in Archives Office. In future, this archives office will be used to save not only hardcopy documents but also in softcopy. Documents in softcopy will be directly sent from Head Office to Archives Office through communication network.

D. Network communication at Data Center (DC)

There are 30 terminals that connected to network at DC, but only 10 terminals that effectively used everyday. Another 20 terminals just used occasionally, because 20 terminals are in the classroom and will be used if there is a training there. Besides those 30 terminals, DC also has 6 telephone connections that connected to IP PABX. Current network topology that using at DC is like common LAN. All terminals connected to the router that connects to the internet. The bandwidth in Data Center is similar to the one in Head Office but without 82 Mbps backup. The available Bandwidth-per-terminal here is 1 Mbps. Bandwidth for local application is already provided, but until now, this bandwidth still not be used because the network at data center and head office still not integrated yet. Bandwidth required for VoIP is 17 kbps per terminal. So, for 30 terminals and for 6 telephone connections that connected to IP PABX, bandwidth that needed is 0.612 Mbps.

Currently, Data Center is still not effectively used. It is because the connection from main server in head office to backup server in data center still not good, Back up process is still manual, not automatic. In future, back up process will be automatic by using mirroring process: when the data is saved to the main server, it will be automatically saved to the back up server in data center. So if there is something happen in main server that can make data lost, there will be data back up in data center that can be used. For this mirroring process, wide bandwidth will be needed because data transfer should be fast and real time since the data that will be transferred usually in large-sized files.

III. NETWORKS CONNECTION BETWEEN HEAD OFFICE AND BRANCH OFFICES

Head Office and branch offices connected each other by using internet connection which is a public network. This kind of connection is not secure for classified data exchange. Be aware of this condition, team network try to find a way to secure it. Finally, classified data exchange process is doing by using virtual private network (VPN). VPN needs certain server and certain application in each terminal complete with special username and password. But VPN not completely safe, because VPN still operating in public network. VPN functions just like a tunnel in public network, the possibility of data leakage of classified documents still high. Figure 2 shows current network topology in MOFA and also shows the connection between Head Office and its branch offices.

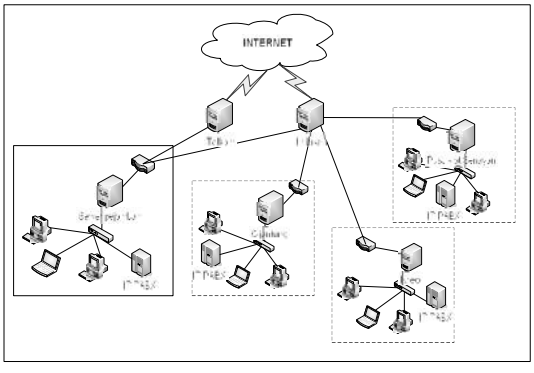

Figure 2. Current network topology and network connection in MOFA

With this current topology, data transfer process is slower and not secure enough, furthermore, it will be more difficult for maintenance process. Maintenance will be more complicated, because each office has their network and should be maintained by team network at each office. Maintenance process will be easier when using integrated network, so maintenance and controlling network will be centralized. From budget point of view, un-integrated network like now is take more budget because each office has their own internet connection based on each office policies.

IV. NEW MOFA COMMUNICATION SYSTEM DESIGN

The purpose in designing communication system using fiber optic at MOFA is to make an integrated network between head office and other three branch offices that located in Jakarta in order to fulfill requirement for simple, fast, and secure data transfer process including filing and data back up. This integrated network will be used for:

- VoIP facility to connect IP Phone through IP PABX that located at each offices.
- VoIP facility to connect all terminals in each offices.
- Data back up facility for Data Center (DC).
- Facility for electronic filing at archives office.
- Local applications and information systems.
- Internet interconnection.

Network Topology

Topology that will be using in this design is ring topology. This type of topology is chosen because with this type of topology, when one line is failed, the connection still can be doing through another line. So, network performances will not have interfere. Figure 3 shows future network topology at MOFA. From Figure 3, it can be seen that this final assignment will be designing an integrated network using fiber optic that connected all four MOFA's offices that located in Jakarta. For internet connection, router at head office and router at data center as a back up will be connected to internet service provider (ISP). We will use three different ISP in order to have spares when one connection failed.

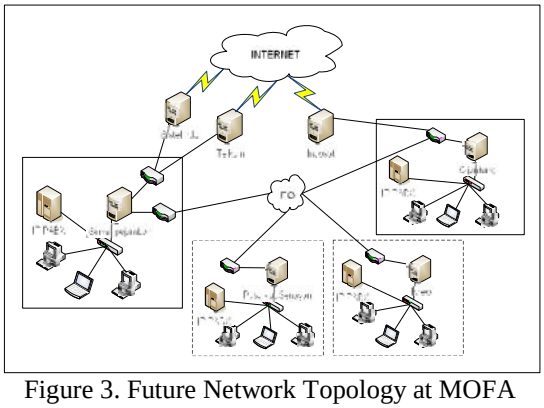

Figure 3. Future Network Topology at MOFA

Location and requirements identification is doing by designing based on current requirements and on predicted future development. Future development calculated by estimating the number of terminal growth in the next five years.

A. *Existing Usage*

The designed optical fiber communication system for MOFA is consisted of four segments, namely:

Pejambon (Head Office) – Senayan, Senayan (Education and Training Center) – Kreo, Kreo (Archives Office) – Cijantung, Cijantung (Data Center) – Pejambon

The specification that needed is:

1. Data transmission and VoIP:
   a. Head Office = Data + VoIP

= $(T_{HO} \times Bw_{data}) + [(T_{HO} \times Bw_{voip}) + (T_{tel} \times Bw_{voip})]$
=(3240×60kbps) + [(3240×17kbps) + (1139×17kbps)]
= 268,843 Mbps
where:
T_{HO} = terminal numbers at head office
T_{tel} = telephone connection numbers at head office
Bw_{data} = *bandwidth* data per terminal
Bw_{voip} = *bandwidth* VoIP per terminal

b. ETC = Data + VoIP
= $(T_{ETC} \times Bw_{data}) + [(T_{ETC} \times Bw_{voip}) + (T_{tel} \times Bw_{voip})]$
= (240×60kbps) + [(240×17kbps) + (99×17kbps)]
= 20,163 Mbps
where:
T_{ETC} = terminal numbers at ETC
T_{tel} = telephone connection numbers at ETC
Bw_{data} = *bandwidth* data per terminal
Bw_{voip} = *bandwidth* VoIP per-terminal

c. Archives Office = Data + VoIP
= $(T_{AO} \times Bw_{data}) + [(T_{AO} \times Bw_{voip}) + (T_{tel} \times Bw_{voip})]$
= (30×60kbps) + [(30×17kbps) + (13×17kbps)]
= 2,531 Mbps
where:
T_{AO} = terminal numbers at archives office
T_{tel} = telephone connection numbers at archives office
Bw_{data} = *bandwidth* data per terminal
Bw_{voip} = *bandwidth* VoIP per terminal

d. Data Center = Data + VoIP
= $(T_{DC} \times Bw_{data}) + [(T_{DC} \times Bw_{voip}) + (T_{telDC} \times Bw_{voip})]$
= (30×60kbps) + [(30×17kbps) + (6×17kbps)]
= 2,412 Mbps
where:
T_{DC} = terminal numbers at *data center*
T_{telDC} = telephone connection numbers at *data center*
Bw_{data} = *bandwidth* data per terminal
Bw_{voip} = *bandwidth* VoIP per terminal

Total transmission requirement is:

R = 268,843 + 20,163 + 2,531 + 2,412

≈ 293,949 Mbps

2. Transmission type : Digital (NRZ)
3. Wavelength : 1550 nm
4. Transmission distance :
   a. Pejambon – Pusdiklat : 8400 m
   b. Pusdiklat – Kreo : 7000 m
   c. Kreo – Cijantung : 22500 m
   d. Cijantung – Pejambon : 29500 m
5. *Bit Error Rate* (BER) : 10^{-10}

Requirements above are for the existing usage. In designing a system, future development requirements should be considered. This consideration is doing to make a communication network that can be used not only for now, but also for future development and expansion [1].

B. Future Usage

Communication system using optical fiber that will be designed is also considering about future development and expansion. Future usage will be considering based on estimation of users and terminals growth [2]. The estimation for the next five years will be:

- Estimated increase of 15 terminals and 5 telephone connections every year at Head Office.
- Estimated increase of 10 terminals and 2 telephone connections every year at Education and Training Center.
- Estimated increase of 2 terminals and 1 telephone connections every year at Archives Office.
- Estimated increase of 2 terminals and 1 telephone connections every year at Data Center.

With all the estimations above, requirements for the next five years will become:

1. Data transmission and VoIP:

   a. Head Office = Data + VoIP
   = $(T_{HO} \times Bw_{data}) + [(T_{HO} \times Bw_{voip}) + (T_{tel} \times Bw_{voip})]$
   = (3315×60kbps) + [(3315×17kbps) + (1164×17kbps)]
   = 275,043 Mbps
   where:
   T_{HO} = terminal numbers at head office
   T_{tel} = telephone connection numbers at head office
   Bw_{data} = *bandwidth* data per terminal
   Bw_{voip} = *bandwidth* VoIP per terminal

   b. ETC = Data + VoIP
   = $(T_{ETC} \times Bw_{data}) + [(T_{ETC} \times Bw_{voip}) + (T_{tel} \times Bw_{voip})]$
   = (290×60kbps) + [(290×17kbps) + (109×17kbps)]
   = 24,183 Mbps
   where:
   T_{ETC} = terminal numbers at ETC
   T_{tel} = telephone connection numbers at ETC

Bw_{data} = *bandwidth* data per terminal
Bw_{voip} = *bandwidth* VoIP per-terminal

c. Archives Office = Data + VoIP
= $(T_{AO} \times Bw_{data})$ + $[(T_{AO} \times Bw_{voip})$ + $(T_{tel} \times Bw_{voip})]$
= (40×60kbps) + [(40×17kbps) + (18×17kbps)]
= 3,386 Mbps
where:
T_{AO} = terminal numbers at archives office
T_{tel} = telephone connection numbers at archives office
Bw_{data} = *bandwidth* data per terminal
Bw_{voip} = *bandwidth* VoIP per terminal

d. Data Center = Data + VoIP
= $(T_{DC} \times Bw_{data})$ + $[(T_{DC} \times Bw_{voip})$ + $(T_{telDC} \times Bw_{voip})]$
= (40×60kbps) + [(40×17kbps) + (11×17kbps)]
= 3,267 Mbps
where:
T_{DC} = terminal numbers at *data center*
T_{telDC} = telephone connection numbers at *data center*
Bw_{data} = *bandwidth* data per terminal
Bw_{voip} = *bandwidth* VoIP per terminal

Total transmission requirement is:

R = 275,043 + 24,183 + 3,386 + 3,267

≈ 306 Mbps

2. Transmission type : Digital (NRZ)
3. Wavelength : 1550 nm
4. Transmission distance :
   a. Pejambon – Pusdiklat : 8400 m
   b. Pusdiklat – Kreo : 7000 m
   c. Kreo – Cijantung : 22500 m
   d. Cijantung – Pejambon : 29500 m
5. *Bit Error Rate* (BER) : 10^{-10}

V. CONCLUSION

The usages of multiple public service access for each MOFA locations are providing overly redundant service, which is unnecessary. While each access allows same bandwidth available for all office locations, it tends to be under-utilized in branch offices while the Head Office suffers from traffic overload, as reflected in very low data rate of only 9.3 kbps per-terminal. This can be disadvantageous since most of activities are done at the Head Office.

The use of dedicated network allows for easier load balancing between office locations and increasing the bandwidth from 293,949 Mbps to 306 Mbps, while the use of optical fiber network allows for higher transmission security.

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