SUPPORTING FOR TRAFFIC FORECAST

Supporting for Traffic Forecast

1 Telephone Traffic

This chapter states supplements of traffic analyses performed by the team stated in Chapter 5 of main document. Also, the team presents methodology for analyzing and estimating traffic matrix in detail.

1.1 Telephone Traffic Characteristics

(1) Calling Rate

Calling Rate for Namphou is shown in Table 1.1.

Table 1.1 Calling Rate

	1996	2001
Monday	0.13	0.14
Tuesday	0.12	0.13
Wednesday	0.13	0.13
Thursday	0.12	0.13
Friday	0.13	0.13
Saturday	0.1	0.1
Sunday	0.06	0.08
Average	0.11	0.12

Source: ETL and Study Team

From the analysis above, we set the calling rate as 0.12 in Table 5.1 of Main Report. However, as the calling rate for the mobile cellular telephone is not able to measure, we estimate the calling rate one sixth of the telephone traffic. The calling rate of 0.02 for mobile cellular telephone derived from the above method is equal to the designed value which LTC and ETL are utilizing.

The calling rate is also analyzed by utilizing measurement of line package busy ratio of digital switches in Thakhek and Savanakhet. The measurement result is not equal to the actual traffic (because it includes 8 subscribers and the lump indicates at least one subscriber is busy), however, the calling rate is able to estimate.

Table 1.2 Measurement at Numphon

Busy Package	Total number
8	22
1	10
9	32
4	32
10	32
5	27
8	32
1	3
46	190

Source: ETL and Study Team

From the busy ratio measured in Table 1.2 is equal to

46/160 = 0.24

The actual calling rate in Table 1.1, the adjustment factor is obtained as

0.12/0.24 = 0.05.

Table 1.3 Measurement at Savanakhet

Busy Package	Total number
9	32
7	32
9	32
7	32
8	32
4	32
8	32
7	32
3	32
11	32
15	32
88	352

Source: ETL and Study Team

The actual calling rate is obtained from Table 1.4 for Savanakhet is obtained as

88 / 352 x 0.05= 0.125

Table 1.4 Measurement at Takhek

Busy Package	Total number
12	32
11	32
12	32
35	96

Source: ETL and Study Team

The actual calling rate is obtained from Table 1.4 for Takhek is obtained as

35 / 96 x 0.05.= 0.18 .

From study above, the calling rate 0.12 is adequate, however, small switching systems may indicate higher than expected shown above. The Study team strongly suggest that field investigation should be performed.

The calling rate will be smaller in the future because current users in major cities are mainly from business users and the calling rate is higher. The calling rates are shown in Table 1.5 where every country use different rates. It is not easy to conclude from the table that the calling rate for LDC country is larger and that of developed countries like Japan is smaller. It is recommended that the calling rate should be estimated from the measurement.

Table 1.5 Calling Rate in other countries

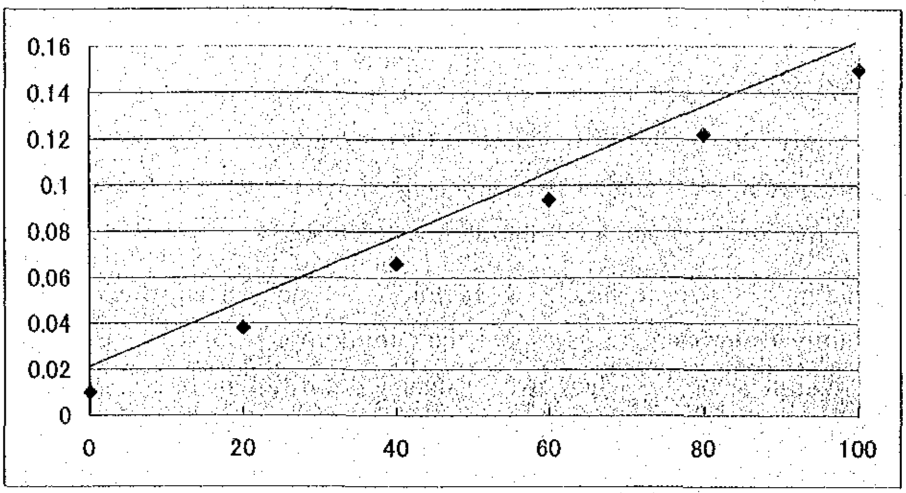
Country	Calling Rate
Nepale	0.06
India	0.1
Cambodia	0.086
Vietnum	0.04
Japan	0.05

Source: ITU and Study Team

However, it can be deduced that the calling rate is reducing as the economy grows. Then the calling rate for 0.12 should be reevaluated. One possible way is proposed from the experience in Japan as that the calling rate for business is 0.1 and for residential is 0.01. From this assumption, if most of all the subscribers are consist from business users, it should be 0.1 and if all the subscribers are consist from residential users, it should be 0.01. The subscribers are half and half of business and residential, it should be 0.055. Here, business subscriber is Y % and residential subscriber is (100-Y) %, the calling rate is given as,

0.15 x Y / 100 + 0.01 x (100-Y) /100

For the time being until 2005, the Study Team recommends that the calling rate should be 0.12 if no measurement is available. From 2005 to 2015, measure actual calling rate or calculate Y stated above. If there is no such value available, use 0.12. Because larger value gives the higher outcome and it deduced that the larger amount of circuit and switching capacity are planned. The outcome may give excess amount of equipment, and good quality of service.



X axis : Percentage of business subscriber

Y axis : Calling rate

Fig. 1.1 Estimation of calling rate from business subscriber

Source: Study Team

(2) Traffic Matrix for 2005, 2010, and 2015

The Traffic Matrix for analyzing transit network is estimated by utilizing Gravity model and algorism shown in Fig. 1.2.

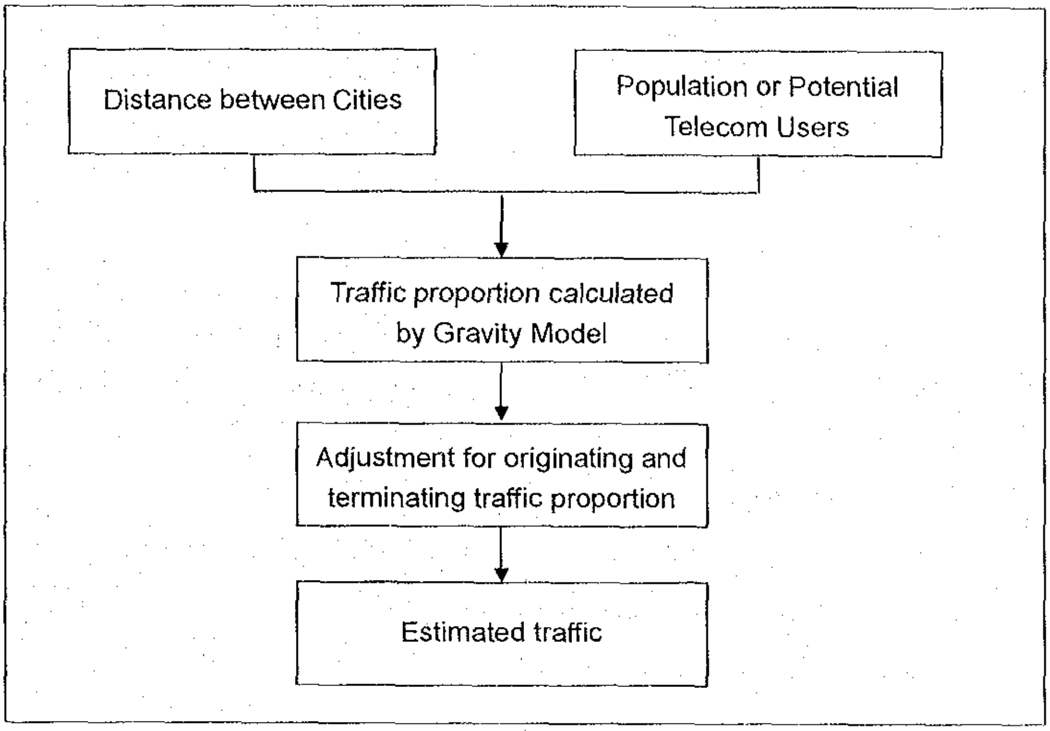


Fig. 1.2 Diagram for estimating traffic matrix

(1) Distance Matrix

Gravity model is widely utilized by not only for planning the cities, road and transportation for traveling or moving of people, but also telephone network planning. The assumption of the model is given as the following.

$$T_{ij} = P_{ij} \frac{A_i \quad A_j}{D_{ij}} \qquad (1)$$

Where T_{ij} is the traffic from thecity i to j, P_{ij} is the adjustment factor. A_i is the volume of city i. A_i will be chosen from the number of the population or available telephone terminals in the city i. And D_{ij} is the friction factor between city i to j. Also, total amount of telephone traffic T is defined as follows.

$$T = \sum_{i,j} T_{ij}$$

For the modeling we assumed two different ones.

D_{ij} is defined as the distance of city i to j, such as

$D_{ij} = (X_i - Xj)^2$

or

$D_{ij} = (X_i - Xj)^{1/2}$

In most of the cases in the previous study by ITU, m=2 or 1/2 are widely used. Once m is defined, we obtained two kind of D_{ij} as is shown in the Table 1.11, through Table 1.15.

Once A_i D_{ij} *and T are given, we obtain* T_{ij}

In the following, we obtained four kind of traffic matrixes generated;

Table 1.11 for m=2 and population,

Table 1.12 for m=2 and terminals,

Table 1.13 for m=1/2 and population,

Table 1.14 for m=1/2 and terminals.

In comparison above four traffic matrix, we finally chose m=1/2 and terminals. This is because in the Table 1.11 and 1.13, the traffic between Vientiane Municipality and Vientiane Province is to big, because the distance between two cities are too close and the f_{ij} is too large compared with other f_{ij}. Also, comparing population and terminals, there is not apparent difference between them. We chose terminals because of the telephone matrix.

Compared with existing traffic from Vientiane Municipality to Luangprabang is measured 58.23 erlang on 84 channels. The traffic in Table 1.16 is 32.36 erlang and total traffic including transit traffic on this route will be 100% more as 64.72 erlang. The method in Table 1.16 is recommended as the estimation for traffic matrix.

In practically, the traffic is not symmetric. The Study Team analyzed the traffic matrix of Japan how to adjust the traffic matrix.

For better understanding, the traffic matrix is not always symmetric rather asymmetric shown in the Table 1.16. We analyzed how we can adjust from the symmetric matrix. Note that we can set appropriate function f_{ij} (K_{ij}) to calculate directly if we can find such function. However, this approach has not been studied in ITU.

Here, the Study Team studied the traffic matrix to investigate the difference from the symmetric matrix form the actual traffic data of Japan. In general, we observe followings;

(1) Traffic flow T_{ij} from small city i to large city j

Traffic flow is bigger from the small city to large city.

$T_{ij} > Tj_i$

(2) Traffic flow T_{ij} from same size city i to city j

Traffic flow is more or less similar.

$T_{ij} <> Tj_i$

However, there is not apparent relation ship from the Tables 1.17, 1.18.

(T_{ij} - Tj_i) and T'_{ij} (symmetric matrix)

Some of the case, this exceed 0.2, or 0.02. We hereafter chose the following.

If Traffic flow from small city i to large city j is obtained by

T_{ij} (from small city i to large city j) = T'_{ij} (symmetric matrix) x (1+0.02)

T_{jij} (from large city i to small city j) = T'_{ij} (symmetric matrix) x (1-0.02) .

Then asymmetric Traffic Matrix is estimated shown in the Table 1.19. The Study Team calculated other years from the demand in each year.

Table 1.6 A_i as the number of the population for 2005

City	population of Year200(
Vientiane muni	599,405
Phongsaly	174,808
Luangnamtha	131,226
Oudomxay	240,407
Bokeo	129,935
Luangphabang	29,608
Houaphan	279,800
Xaiyabouly	333,682
Xiengkhuang	229,442
Vientiane province	327,735
Bolikhamxay	187,092
Khammouane	311,608
Savannakhet	768,269
Saravane	293,044
Sekong	73,389
Champasak	573,421
Attapeu	99,761
Xaysomboun	61,836
Total	4,844,468

This population is identical to the forecasted by the Team stated in Chapter 4

Source: Study Team

Table 1.7 A_i as the available telephone terminals for 2005

City	Fix Demand 2005
Vientiane muni.	103,010
Phongsaly	625
Luangnamtha	1,409
Oudomxay	1,620
Bokeo	605
Luangphabang	11,457
Houaphan	834
Xaiyabouly	1,057
Xiengkhuang	4,177
Vientiane province	4,472
Bolikhamxay	8,086
Khammouane	12,034
Sayannakhet	21,925
Saravane	2,783
Sekong	731
Champasak	8,609
Attapeu	315
Xaysomboun	264
Total	184,013

This terminal number is identical to the forecasted one by the Team stated in Chapter 4

Source: *Study Team*

Table 1.8 Distance Matrix used of gravity model for traffic estimation D_{ij}

Unit Km

	Vientiane muni.	Phongsaly	Luangnamtha	Oudomxay	Bokeo	Luangphabang	Houaphan	Xaiyabouly	Xiengkhuang	Vientiane province.	Bolikhamxay	Khammouane	Savannakhet	Saravane	Sekong	Champasak	Attapeu
Phongsaly	815.6																
Luangnamtha	698.65	367.05															
Oudomxay	583.6	232.0	115.05														
Bokeo	893.65	542.05	195.0	310.05													
Luangphabang	389.6	426.0	309.05	194.0	504.05												
Houaphan	639.6	665.0	548.05	433.0	743.05	512.0											
Xaiyabouly	458.6	543.0	426.05	311.0	621.05	117.0	581.0										
Xiengkhuang	389.6	688.0	571.05	456.0	766.05	262.0	250.0	331.0									
Vientiane province.	70.6	745.0	628.05	513.0	823.05	319.0	569.0	388.0	319.0								
Bolikhamxay	150.0	965.6	848.65	733.0	1043.65	539.0	789.6	558.6	539.6	220.6							
Khammouane	353.0	1168.6	1051.65	936.6	1246.65	742.0	992.0	761.6	742.6	423.6	203.0						
Savannakhet	460.0	1284.0	1167.05	1052.6	1362.65	858.6	1108.6	877.6	858.6	530.6	319.0	116.0					
Saravane	682.7	1614.35	1497.4	1382.35	1692.4	1072.3	1322.3	1091.3	1072.3	753.3	532.7	329.7	255.2				
Sekong	814.0	1629.6	1512.65	1397.6	1707.05	1203.6	1453.6	1222.6	1203.6	884.6	664.0	461.0	386.5	86.0			
Champasak	675.0	1490.6	1373.65	1258.0	1568.65	1064.6	1314.6	1083.6	1064.6	745.6	525.0	322.0	247.5	144.5	139.0		
Attapeu	838.0	1653.6	1536.65	1421.6	1731.65	1227.6	1477.6	1246.6	1227.6	908.6	688.0	485.0	410.5	164.0	78.0	163.0	
Xaysomboun	254.6	801.0	684.05	569.0	879.05	375.0	381.0	444.0	131.0	184.0	404.6	503.0	619.0	832.7	984.0	825.0	988.0

Note: Vertical Axis : Originating for measurement Province Center, Horizontal Axis: Terminating measurement Province Center

Source: Study Team

Table 1.9 f_{ij} for Year 2005 m=2

Unit 1/km^2

	Vientiane muni.	Phongsaly	Luangnamtha	Oudomxay	Bokeo	Luangphabang	Houaphan	Xaiyabouly	Xiengkhuang	Vientiane province.	Bolikhamxay	Khammouane	Savannakhet	Saravane	Sekong	Champasak	Attapeu
Phongsaly	157517																
Luangnamtha	161146	170267															
Oudomxay	423095	780787	2383384														
Bokeo	97524	77305	448410	324945													
Luangphabang	116923	28521	40680	189130	15142												
Houaphan	409969	110602	122244	358773	65847	31603											
Xaiyabouly	951010	197830	241230	829391	112410	721733	276584										
Xiengkhuang	906057	84734	92330	265272	50802	98966	1027166	698794									
Vientiane province.	39412463	103222	109032	299389	62863	95358	283234	726426	738948								
Bolikhamxay	4984171	35077	34089	83713	22319	19067	83963	200072	147429	1259987							
Khammouane	1498924	39888	36973	85398	26052	16758	88600	179261	129650	569139	1414721						
Savannakhet	2176299	81460	74021	166700	53761	30857	174909	332853	239114	894337	1412495	17791222					
Saravane	376871	19656	17150	36868	13294	7546	46894	82106	58475	169246	193207	840045	3456882				
Sekong	66390	4831	4209	9033	3272	1500	9718	16383	11624	30737	31142	107607	377439	2907825			
Champasak	754374	45114	39879	87108	30279	14980	92840	162955	116084	338053	389233	1723337	7191788	8047675	2178095		
Attapeu	85152	6378	5544	11867	4323	1960	12785	21421	15189	39604	39431	132156	454830	1086942	1203386	2153080	
Xaysomboun	571801	16848	17341	45916	10398	13020	119190	104666	826744	598588	70671	76158	123986	26133	4687	52096	6320
Total	53149686	1802517	3666515	2793502	470763	1053347	2215883	2524938	2283256	3899691	3550901	20670525	11604926	12068575	3386169	2205176	6320

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center

Source: Study Team

Table 1.10 f_{ij} for Year 2005 m=1/2

Unit 1/km

	Vientiane muni.	Phongsaly	Luangnamtha	Oudomxay	Bokeo	Luangphabang	Houaphan	Xaiyabouly	Xiengkhuang	Vientiane province.	Bolikhamxay	Khammouane	Savannakhet	Saravane	Sekong	Champasak	Attapeu
Phongsaly	2254347																
Luangnamtha	5491115	4280916															
Oudomxay	6907752	9864700	31580249														
Bokeo	2084736	3488070	13110480	11954297													
Luangphabang	59791690	896584	2373081	3443738	797874												
Houaphan	3396966	6781361	16840252	21783053	6210035	141671868											
Xaiyabouly	5084372	8949783	22777870	30652593	8100736	353435672	11545437										
Xiengkhuang	21798890	5467119	13528408	17406255	5015331	162402617	12102325	13330110									
Vientiane province.	54825024	7504542	18426218	23441136	6911377	210231552	11458618	17586582	76646346								
Bolikhamxay	68009173	3763017	9049019	11194838	3503747	92327552	5552867	8367184	33642115	56331826							
Khammouane	65978440	5697119	13538907	16494766	5339386	131062120	8251225	11934926	47763400	67706762	176845473						
Savannakhet	105302837	13400193	31686904	38361614	12591479	300392449	19243858	27411968	109517261	149152904	347817906	858409575					
Saravane	10971794	4558412	10670246	12768456	4309593	102528623	6720993	9376382	37379948	47747449	102665554	194215058	402190337				
Sekong	2639274	1136246	2658732	3180214	1074645	24236090	1605374	2218531	8836008	11034713	23029390	41133179	81846024	22024026			
Champasak	34133452	9282677	21799509	26190781	8759234	201349912	13189945	18412563	73408273	93912328	202361481	384552673	799145325	132755660	35553613		
Attapeu	1120903	1533297	3585792	4286353	1450397	32621510	2164458	2986572	11893170	14800521	30753964	54513081	107955459	21679680	8257178	67269855	
Xaysomboun	1704332	1365541	3331256	4199522	1261797	36584429	2642071	3101876	22566792	20386087	24857749	33179284	54492317	5963619	1440990	18533896	619688
Total	451495098	87969578	214956922	225357617	65325631	1788844395	94477173	114726696	421653313	461072593	908331516	1566002850	1445629463	182422986	45251781	85803752	619688

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center
Source: Study Team

Table 1.11 Estimated Traffic Matrix for Year 2005 by m=2 a and population

nit Erlang

	Vientiane muni.	Phongsaly	Luangnamtha	Oudomxay	Bokeo	Luangphabang	Houaphan	Xaiyabouly	Xiengkhuang	Vientiane province.	Bolikhamxay	Khammouane	Savannakhet	Saravane	Sekong	Champasak	Attapeu	Xaysomboun
Vientiane muni.																		
Phongsaly	5.200																	
Luangnamtha	5.320	5.621																
Oudomxay	13.967	25.776	78.681															
Bokeo	3.219	2.552	14.803	10.727														
Luangphabang	3.860	0.942	1.343	6.244	0.500													
Houaphan	13.534	3.651	4.036	11.844	2.174	1.043												
Xaiyabouly	31.395	6.531	7.964	27.380	3.711	23.826	9.131											
Xiengkhuang	29.911	2.797	3.048	8.757	1.677	3.267	33.909	23.069										
Vientiane province.	1301.094	3.408	3.599	9.883	2.075	3.148	9.350	23.981	24.394									
Bolikhamxay	164.539	1.158	1.125	2.764	0.737	0.629	2.772	6.605	4.867	41.595								
Khammouane	49.483	1.317	1.221	2.819	0.860	0.553	2.925	5.918	4.280	18.789	46.703							
Savannakhet	71.845	2.689	2.444	5.503	1.775	1.019	5.774	10.988	7.894	29.524	46.630	587.328						
Saravane	12.441	0.649	0.566	1.217	0.439	0.249	1.548	2.711	1.930	5.587	6.378	27.732	114.119					
Sekong	2.192	0.159	0.139	0.298	0.108	0.050	0.321	0.541	0.384	1.015	1.028	3.552	12.460	95.994				
Champasak	24.904	1.489	1.316	2.876	1.000	0.495	3.065	5.380	3.832	11.160	12.849	56.891	237.417	265.672	71.904			
Attapeu	2.811	0.211	0.183	0.392	0.143	0.065	0.422	0.707	0.501	1.307	1.302	4.363	15.015	35.882	39.727	71.078		
Xaysomboun	18.876	0.556	0.572	1.516	0.343	0.430	3.935	3.455	27.293	19.761	2.333	2.514	4.093	0.863	0.155	1.720	0.209	
Total	1754.591	59.505	121.040	92.220	15.541	34.773	73.151	83.354	75.375	128.738	117.223	682.381	383.105	398.411	111.785	72.798	0.209	0.000

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center

Source: Study Team

Table 1.12 Estimated Traffic Matrix for Year 2005 by m=2 a and terminals

Unit Erlang

	Vientiane muni.	Phongsaly	Luangnamtha	Oudomxay	Bokeo	Luangphabang	Houaphan	Xaiyabouly	Xiengkhuang	Vientiane province.	Bolikhamxay	Khammouane	Savannakhet	Saravane	Sekong	Champasak	Attapeu	Xaysomboun
Vientiane muni.																		
Phongsaly	1.760																	
Luangnamtha	5.408	0.119																
Oudomxay	8.910	0.342	3.136															
Bokeo	1.419	0.023	0.408	0.185														
Luangphabang	114.791	0.583	2.495	7.281	0.403													
Houaphan	3.819	0.021	0.071	0.131	0.017	0.538												
Xaiyabouly	9.415	0.041	0.149	0.322	0.030	13.061	0.047											
Xiengkhuang	18.142	0.035	0.116	0.208	0.028	3.622	0.357	0.258										
Vientiane province.	1439.480	0.078	0.249	0.429	0.062	6.366	0.179	0.489	1.006									
Bolikhamxay	67.940	0.010	0.029	0.045	0.008	0.475	0.020	0.050	0.075	1.168								
Khammouane	180.916	0.100	0.279	0.404	0.085	3.697	0.185	0.399	0.583	4.671	4.334							
Savannakhet	194.107	0.151	0.412	0.583	0.130	5.031	0.271	0.547	0.795	5.424	3.197	356.591						
Saravane	8.216	0.009	0.023	0.032	0.008	0.301	0.018	0.033	0.048	0.251	0.107	4.115	12.514					
Sekong	2.067	0.003	0.008	0.011	0.003	0.085	0.005	0.009	0.013	0.065	0.025	0.753	1.951	3.674				
Champasak	35.397	0.044	0.117	0.160	0.038	1.285	0.076	0.141	0.203	1.079	0.464	18.171	56.038	15.326	5.923			
Attapeu	0.840	0.001	0.003	0.005	0.001	0.035	0.002	0.004	0.006	0.027	0.010	0.293	0.745	0.435	0.688	1.856		
Xaysomboun	4.393	0.003	0.008	0.014	0.002	0.183	0.016	0.015	0.237	0.313	0.014	0.131	0.158	0.008	0.002	0.035	0.001	
Total	2097.020	1.564	7.504	9.809	0.815	34.679	1.176	1.945	2.966	12.997	8.150	380.055	71.406	19.444	6.614	1.891	0.001	0.000

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center

Source: Study Team

Table 1.13 Estimated Traffic Matrix for Year 2005 by m=1/2 a and population and transferred to symmetric matrix

Unit Erlang

	Vientiane muni.	Phongsaly	Luangnamtha	Oudomxay	Bokeo	Luangphabang	Houaphan	Xaiyabouly	Xiengkhuang	Vientiane province.	Bolikhamxay	Khammouane	Savannakhet	Saravane	Sekong	Champasak	Attapeu	Xaysomboun
Vientiane muni.		48.198	39.093	78.361	34.226	11.812	87.117	122.695	91.532	307.137	120.288	130.597	282.063	88.314	20.255	173.793	27.136	30.516
Phongsaly	48.198		15.729	36.246	12.816	3.294	24.917	32.884	20.088	27.574	13.826	20.933	49.236	16.749	4.175	34.107	5.634	5.017
Luangnamtha	39.093	15.729		38.638	16.040	2.903	20.604	27.868	16.552	22.544	11.071	16.565	38.768	13.055	3.253	26.671	4.387	4.076
Oudomxay	78.361	36.246	38.638		23.305	6.714	42.466	59.757	33.934	45.699	21.824	32.157	74.786	24.892	6.200	51.059	8.356	8.187
Bokeo	34.226	12.816	16.040	23.305		2.251	17.521	22.855	14.150	19.500	9.885	15.064	35.525	12.159	3.032	24.713	4.092	3.560
Luangphabang	11.812	3.294	2.903	6.714	2.251		4.810	11.999	5.514	7.137	3.134	4.450	10.198	3.481	0.823	6.836	1.107	1.242
Houaphan	87.117	24.917	20.604	42.466	17.521	4.810		50.884	53.339	50.502	24.473	36.366	84.813	29.621	7.075	58.132	9.539	11.644
Xaiyabouly	122.695	32.884	27.868	59.757	22.855	11.999	50.884		55.282	72.934	34.700	49.496	113.681	38.885	9.201	76.359	12.386	12.864
Xiengkhuang	91.532	20.088	16.552	33.934	14.150	5.514	53.339	55.282		55.308	24.276	34.466	79.028	26.974	6.376	52.972	8.582	16.284
Vientiane province.	307.137	27.574	22.544	45.699	19.500	7.137	50.502	72.934	55.308		54.233	65.184	143.596	45.969	10.624	90.414	14.249	19.627
Bolikhamxay	120.288	13.826	11.071	21.824	9.885	3.134	24.473	34.700	24.276	54.233		53.753	105.722	31.206	7.000	61.509	9.348	7.556
Khammouane	130.597	20.933	16.565	32.157	15.064	4.450	36.366	49.496	34.466	65.184	53.753		292.001	66.065	13.992	130.811	18.543	11.286
Savannakhet	282.063	49.236	38.768	74.786	35.525	10.198	84.813	113.681	79.028	143.596	105.722	292.001		185.138	37.676	367.867	49.695	25.084
Saravane	88.314	16.749	13.055	24.892	12.159	3.481	29.621	38.885	26.974	45.969	31.206	66.065	185.138		30.465	183.638	29.989	8.249
Sekong	20.255	4.175	3.253	6.200	3.032	0.823	7.075	9.201	6.376	10.624	7.000	13.992	37.676	30.465		46.891	10.890	1.900
Champasak	173.793	34.107	26.671	51.059	24.713	6.836	58.132	76.359	52.972	90.414	61.509	130.811	367.867	183.638	46.891		58.862	16.217
Attapeu	27.136	5.634	4.387	8.356	4.092	1.107	9.539	12.386	8.582	14.249	9.348	18.543	49.695	29.989	10.890	58.862		2.578
Xaysomboun	30.516	5.017	4.076	8.187	3.560	1.242	11.644	12.864	16.284	19.627	7.556	11.286	25.084	8.249	1.900	16.217	2.578	
Total	1693.134	371.423	317.819	592.580	270.695	87.705	613.824	804.730	594.656	1052.229	593.806	991.729	1974.878	834.850	219.828	1460.852	275.375	185.889

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center

Source: Study Team

Table 1.14 Estimated Traffic Matrix for Year 2005 by m=1/2 a and terminals and transferred to symmetric matrix

Unit Erlang

	Vientiane muni.	Phongsaly	Luangnamtha	Oudomxay	Bokeo	Luangphabang	Houaphan	Xaiyabouly	Xiengkhuang	Vientiane province.	Bolikhamxay	Khammouane	Savannakhet	Saravane	Sekong	Champasak	Attapeu	Xaysomboun
Vientiane muni.		1.220	2.972	3.739	1.128	32.360	1.839	2.752	11.798	29.672	36.808	35.709	56.992	5.938	1.428	18.474	0.607	0.922
Phongsaly	1.220		2.317	5.339	1.888	0.485	3.670	4.844	2.959	4.062	2.037	3.083	7.252	2.467	0.615	5.024	0.830	0.739
Luangnamtha	2.972	2.317		17.092	7.096	1.284	9.114	12.328	7.322	9.973	4.897	7.328	17.150	5.775	1.439	11.798	1.941	1.803
Oudomxay	3.739	5.339	17.092		6.470	1.864	11.789	16.590	9.421	12.687	6.059	8.927	20.762	6.911	1.721	14.175	2.320	2.273
Bokeo	1.128	1.888	7.096	6.470		0.432	3.361	4.384	2.714	3.741	1.896	2.890	6.815	2.332	0.582	4.741	0.785	0.683
Luangphabang	32.360	0.485	1.284	1.864	0.432		76.675	191.286	87.895	113.781	49.969	70.933	162.578	55.490	13.117	108.974	17.655	19.800
Houaphan	1.839	3.670	9.114	11.789	3.361	76.675		6.249	6.550	6.202	3.005	4.466	10.415	3.638	0.869	7.139	1.171	1.430
Xaiyabouly	2.752	4.844	12.328	16.590	4.384	191.286	6.249		7.215	9.518	4.528	6.459	14.836	5.075	1.201	9.965	1.616	1.679
Xiengkhuang	11.798	2.959	7.322	9.421	2.714	87.895	6.550	7.215		41.482	18.208	25.850	59.273	20.231	4.782	39.730	6.437	12.214
Vientiane province.	29.672	4.062	9.973	12.687	3.741	113.781	6.202	9.518	41.482		30.488	36.644	80.724	25.842	5.972	50.827	8.010	11.033
Bolikhamxay	36.808	2.037	4.897	6.059	1.896	49.969	3.005	4.528	18.208	30.488		95.712	188.246	55.565	12.464	109.522	16.645	13.453
Khammouane	35.709	3.083	7.328	8.927	2.890	70.933	4.466	6.459	25.850	36.644	95.712		464.587	105.113	22.262	208.127	29.503	17.957
Savannakhet	56.992	7.252	17.150	20.762	6.815	162.578	10.415	14.836	59.273	80.724	188.246	464.587		217.673	44.297	432.512	58.428	29.492
Saravane	5.938	2.467	5.775	6.911	2.332	55.490	3.638	5.075	20.231	25.842	55.565	105.113	217.673		11.920	71.850	11.733	3.228
Sekong	1.428	0.615	1.439	1.721	0.582	13.117	0.869	1.201	4.782	5.972	12.464	22.262	44.297	11.920		19.242	4.469	0.780
Champasak	18.474	5.024	11.798	14.175	4.741	108.974	7.139	9.965	39.730	50.827	109.522	208.127	432.512	71.850	19.242		36.408	10.031
Attapeu	0.607	0.830	1.941	2.320	0.785	17.655	1.171	1.616	6.437	8.010	16.645	29.503	58.428	11.733	4.469	36.408		0.335
Xaysomboun	0.922	0.739	1.803	2.273	0.683	19.800	1.430	1.679	12.214	11.033	13.453	17.957	29.492	3.228	0.780	10.031	0.335	
Total	244.358	48.831	121.627	148.137	51.937	1004.582	157.582	300.524	364.080	480.658	649.502	1145.552	1872.031	610.779	147.160	1158.539	198.893	127.853

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center

Source: Study Team

Table 1.15 Symmetric Traffic Matrix for Year 2005

Unit Erlang

	Vientiane muni.	Phongsaly	Luangnamtha	Oudomxay	Bokeo	Luangphabang	Houaphan	Xaiyabouly	Xiengkhuang	Vientiane province.	Bolikhamxay	Khammouane	Savannakhet	Saravane	Sekong	Champasak	Attapeu	Xaysomboun
Vientiane muni.		1.220	2.972	3.739	1.128	32.360	1.839	2.752	11.798	29.672	36.808	35.709	56.992	5.938	1.428	18.474	0.607`	0.922
Phongsaly	1.220		2.317	5.339	1.888	0.485	3.670	4.844	2.959	4.062	2.037	3.083	7.252	2.467	0.615	5.024	0.830	0.739
Luangnamtha	2.972	2.317		17.092	7.096	1.284	9.114	12.328	7.322	9.973	4.897	7.328	17.150	5.775	1.439	11.798	1.941	1.803
Oudomxay	3.739	5.339	17.092		6.470	1.864	11.789	16.590	9.421	12.687	6.059	8.927	20.762	6.911	1.721	14.175	2.320	2.273
Bokeo	1.128	1.888	7.096	6.470		0.432	3.361	4.384	2.714	3.741	1.896	2.890	6.815	2.332	0.582	4.741	0.785	0.683
Luangphabang	32.360	0.485	1.284	1.864	0.432		76.675	191.286	87.895	113.781	49.969	70.933	162.578	55.490	13.117	108.974	17.655	19.800
Houaphan	1.839	3.670	9.114	11.789	3.361	76.675		6.249	6.550	6.202	3.005	4.466	10.415	3.638	0.869	7.139	1.171	1.430
Xaiyabouly	2.752	4.844	12.328	16.590	4.384	191.286	6.249		7.215	9.518	4.528	6.459	14.836	5.075	1.201	9.965	1.616	1.679
Xiengkhuang	11.798	2.959	7.322	9.421	2.714	87.895	6.550	7.215		41.482	18.208	25.850	59.273	20.231	4.782	39.730	6.437	12.214
Vientiane province.	29.672	4.062	9.973	12.687	3.741	113.781	6.202	9.518	41.482		30.488	36.644	80.724	25.842	5.972	50.827	8.010	11.033
Bolikhamxay	36.808	2.037	4.897	6.059	1.896	49.969	3.005	4.528	18.208	30.488		95.712	188.246	55.565	12.464	109.522	16.645	13.453
Khammouane	35.709	3.083	7.328	8.927	2.890	70.933	4.466	6.459	25.850	36.644	95.712		464.587	105.113	22.262	208.127	29.503	17.957
Savannakhet	56.992	7.252	17.150	20.762	6.815	162.578	10.415	14.836	59.273	80.724	188.246	464.587		217.673	44.297	432.512	58.428	29.492
Saravane	5.938	2.467	5.775	6.911	2.332	55.490	3.638	5.075	20.231	25.842	55.565	105.113	217.673		11.920	71.850	11.733	3.228
Sekong	1.428	0.615	1.439	1.721	0.582	13.117	0.869	1.201	4.782	5.972	12.464	22.262	44.297	11.920		19.242	4.469	0.780
Champasak	18.474	5.024	11.798	14.175	4.741	108.974	7.139	9.965	39.730	50.827	109.522	208.127	432.512	71.850	19.242		36.408	10.031
Attapeu	0.607	0.830	1.941	2.320	0.785	17.655	1.171	1.616	6.437	8.010	16.645	29.503	58.428	11.733	4.469	36.408		0.335
Xaysomboun	0.922	0.739	1.803	2.273	0.683	19.800	1.430	1.679	12.214	11.033	13.453	17.957	29.492	3.228	0.780	10.031	0.335	
Total	244.358	48.831	121.627	148.137	51.937	1004.582	157.582	300.524	364.080	480.658	649.502	1145.552	1872.031	610.779	147.160	1158.539	198.893	127.853

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center

Source: Study Team

Table 1.16 Asymmetric Traffic Matrix for Year 1999 (Japan)

Unit Erlang

	Hokkaido	Tohoku	Kantou	Shinetsu	Hokuriku	Tokai	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Hokkaido	3336	41	176	7	5	19	35	7	4	10	1
Tohoku	27	4891	420	26	7	32	49	9	4	12	1
Kantou	162	418	28227	282	94	576	720	181	84	284	25
Shinetsu	5	23	272	2282	15	42	33	6	2	7	0
Hokuriku	3	6	84	16	1559	45	88	6	2	6	0
Tokai	17	31	569	49	47	7871	273	17	17	49	3
Kinki	30	47	708	40	79	279	12699	203	108	167	9
Chugoku	5	8	170	6	6	36	193	4057	52	85	2
Shikoku	2	3	78	2	2	16	112	63	2001	17	1
Kyusyu	10	15	290	9	8	58	181	96	23	7490	18
Okinawa	1	1	22	1	0	3	9	2	1	23	665
Total	3598	5484	31016	2720	1822	8977	14392	4647	2298	8150	725

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center

Source: MPT of Japan i(1999)

Table 1.17 Difference from Symmetric Traffic Matrix for Year 1999 (Japan)

Unit Erlang

	Hokkaido	Tohoku	Kantou	Shinetsu	Hokuriku	Tokai	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Hokkaido		-0.20588	-0.04142	-0.16667	-0.25	-0.05556	-0.07692	-0.16667	-0.33333	0	0
Tohoku	0.205882353		-0.00239	-0.06122	-0.07692	-0.01587	-0.02083	-0.05882	-0.14286	0.111111	0
Kantou	0.041420118	0.002387		-0.01805	-0.05618	-0.00611	-0.0084	-0.03134	-0.03704	0.010453	-0.06383
Shinetsu	0.166666667	0.061224	0.018051		0.032258	0.076923	0.09589	0	0	0.125	1
Hokuriku	0.25	0.076923	0.05618	-0.03226		0.021739	-0.05389	0	0	0.142857	0
Tokai	0.055555556	0.015873	0.006114	-0.07692	-0.02174		0.01087	0.358491	-0.0303	0.084112	0
Kinki	0.076923077	0.020833	0.008403	-0.09589	0.053892	-0.01087		-0.02525	0.018182	0.04023	0
Chugoku	0.166666667	0.058824	0.031339	0	0	-0.35849	0.025253		0.095652	0.060773	0
Shikoku	0.333333333	0.142857	0.037037	0	0	0.030303	-0.01818	-0.09565		0.15	0
Kyusyu	0	-0.11111	-0.01045	-0.125	-0.14286	-0.08411	-0.04023	-0.06077	-0.15		0.121951
Okinawa	0	0	0.06383	-1	0	0	0	0	0	-0.12195	

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center

Source: Study Team analyzed from Table 1.16

Table 1.18 Final (Asymmetric) Traffic Matrix for Year 2005

Unit Erlang

	Vientiane muni.	Phongsaly	Luangnamtha	Oudomxay	Bokeo	Luangphabang	Houaphan	Xaiyabouly	Xiengkhuang	Vientiane province.	Bolikhamxay	Khammouane	Savannakhet	Saravane	Sekong	Champasak	Attapeu	Xaysomboun
Vientiane muni.		1.244	3.031	3.812	1.151	32.936	1.875	2.806	12.024	30.240	37.486	36.340	57.889	6.054	1.457	18.812	0.619	0.941
Phongsaly	1.203		2.363	5.444	1.925	0.494	3.743	4.940	3.016	4.139	2.074	3.138	7.367	2.515	0.627	5.116	0.846	0.754
Luangnamtha	2.925	2.281		17.428	7.237	1.307	9.295	12.572	7.462	10.163	4.988	7.457	17.420	5.887	1.468	12.015	1.979	1.839
Oudomxay	3.694	5.275	16.887		6.599	1.897	12.023	16.918	9.601	12.929	6.171	9.085	21.089	7.045	1.755	14.435	2.366	2.318
Bokeo	1.111	1.858	6.984	6.369		0.440	3.428	4.471	2.766	3.812	1.931	2.941	6.922	2.378	0.593	4.828	0.801	0.697
Luangphabang	31.745	0.476	1.260	1.828	0.424		78.197	195.072	89.582	115.958	50.890	72.186	165.137	56.570	13.378	110.972	18.007	20.195
Houaphan	1.819	3.631	9.017	11.664	3.325	75.858		6.372	6.676	6.320	3.061	4.545	10.579	3.708	0.886	7.269	1.195	1.458
Xaiyabouly	2.727	4.801	12.219	16.443	4.345	189.590	6.193		7.353	9.700	4.612	6.574	15.069	5.173	1.225	10.148	1.649	1.712
Xiengkhuang	11.652	2.922	7.231	9.304	2.681	86.810	6.469	7.125		42.276	18.543	26.307	60.206	20.624	4.877	40.458	6.565	12.457
Vientiane province.	29.403	4.025	9.882	12.572	3.707	112.750	6.145	9.432	41.106		31.050	37.291	81.995	26.345	6.091	51.759	8.170	11.253
Bolikhamxay	36.301	2.009	4.830	5.976	1.870	49.282	2.964	4.466	17.957	30.068		97.403	191.209	56.646	12.711	111.529	16.976	13.722
Khammouane	35.366	3.054	7.257	8.842	2.862	70.252	4.423	6.397	25.602	36.292	94.793		471.901	107.158	22.704	211.942	30.092	18.315
Savannakhet	57.313	7.293	17.246	20.879	6.853	163.494	10.474	14.919	59.607	81.179	189.306	467.205		221.909	45.176	440.440	59.592	30.081
Saravane	5.877	2.442	5.716	6.840	2.309	54.923	3.600	5.023	20.024	25.578	54.997	104.038	215.448		12.157	73.167	11.967	3.292
Sekong	1.403	0.604	1.414	1.691	0.571	12.887	0.854	1.180	4.698	5.867	12.245	21.871	43.519	11.711		19.595	4.558	0.795
Champasak	18.458	5.020	11.788	14.163	4.737	108.880	7.132	9.957	39.695	50.783	109.427	207.947	432.137	71.788	19.226		37.134	10.231
Attapeu	0.597	0.816	1.908	2.281	0.772	17.361	1.152	1.589	6.329	7.877	16.367	29.012	57.453	11.538	4.394	35.801		0.342
Xaysomboun	0.906	0.726	1.771	2.232	0.671	19.445	1.404	1.649	11.994	10.835	13.212	17.635	28.963	3.170	0.766	9.851	0.329	
Total	242.501	48.477	120.804	147.767	52.037	998.605	159.372	304.889	365.495	484.019	651.153	1150.973	1884.305	620.218	149.490	1178.135	202.846	130.403

Note: Vertical Axis : Originating Province Center, Horizontal Axis: Terminating Province Center

Source: Study Team

2 International Telephone Traffic

International telephone traffic is increasing during the observation by the Study

ITU Recommendation E.506 describes in the followings;

(1) Direct Erlang Forecasting

Direct Erlang Forecast strategy is used for short – term planning, the traffic carried in Erlangs, or measured usage, for each relation would be regarded as the base data in forecasting traffic growth.

(2) Composite Forecasting

Composite forecasting is used for medium-term or long term planning, based on historical international accounting data of monthly or annual paid minute traffic and number of factors which are used for converting a paid-minutes forecast on the basis of the accounting data into busy hour Erlang forecasts.

It is recommended to used the following formula to estimate mean offered busy-hour traffic (in Erlang) from the Micro-forecasts (in annual paid-minutes).

$$E = (A \times M \times D \times H) / (60 \times \tau)$$

Where E: the estimated mean traffic in Erlangs offered in the busy-hour

A: the total annual paid minutes

M: Busy month to year ratio (e.g. M=month/year: 20%)

D: Weekday to busy month ratio (e.g. D=day/month: 5%)

H: Busy hour to weekday ratio (e.g. H=hour/day: 20%)

τ: The efficiency factor, i.e. Paid minutes to circuits holding time ratio

D, and H are obtained from the traffic study in 2001.

Here M is estimated from the visitor to Lao P.D.R. from the world which is shown in the Fig. 1.3.

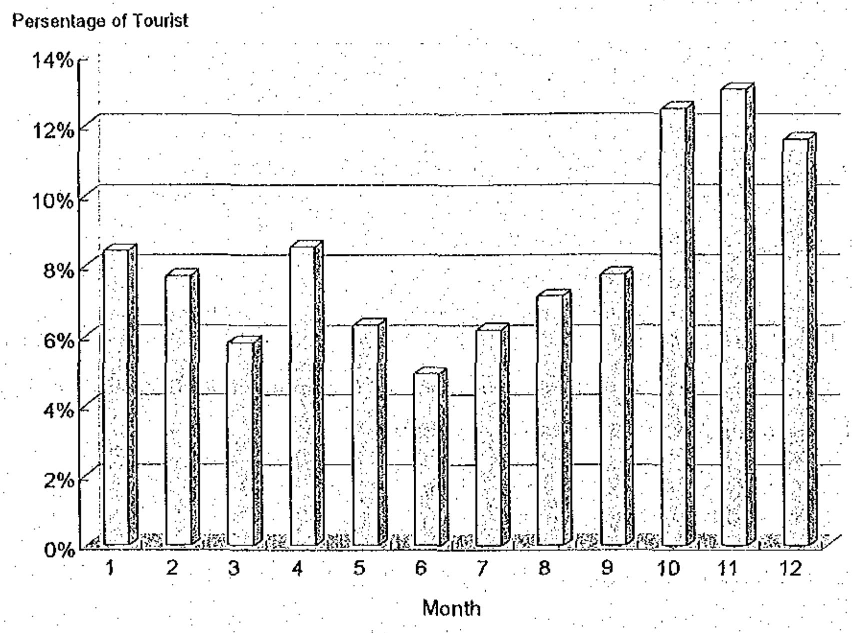


Fig. 1.3 Travers from the world to Lao P.D.R. (where peak ratio is equal to 0.2)

Source: Lao tourist Buro and Study Team

After calculation of the offered busy-hour traffic (in Erlang), the number of required circuits can be obtained by using

Traffic is estimated first total number of calls for target year and distributed it to all the destinations.

Utilizing the holding time for each destination from Table 1.19 multiplying with the number of calls and we can obtain total minutes of target year as shown in the Table 1.20. In total of Table 1.20, we get the target number of calls.

Table 1.19 Original Traffic

Year	Country	Outgoing Call (a)	Outgoing Minute (b)	Holding Time (b) / (a)	Traffic
2000	THAILAND	2,010,024	5,031,568	2.47	9.57
2000	VIETNAM	257,929	635,185	2.46	1.21
2000	U.S.A.	150,458	430,101	2.86	0.82
2000	CHINA	115,307	336,654	2.92	0.64
2000	AUSTRALIA	61,365	294,977	4.81	0.56
2000	FRANCE	85,878	282,454	3.29	0.54
2000	JAPAN-KDD	80,047	279,994	3.50	0.53
2000	SINGAPORE	47,539	115,861	2.44	0.22
2000	CAMBODIA	27,927	85,366	3.06	0.16
2000	KOREA SOUTH	29,347	82,453	2.81	0.16
2000	GERMANY	24,156	76,938	3.19	0.15
2000	TAIWAN	25,292	76,292	3.02	0.15
2000	MALAYSIA	27,727	69,977	2.52	0.13
2000	HONGKONG	19,569	52,745	2.70	0.10
2000	U.K.	14,361	52,479	3.65	0.10
2000	CANADA	11,100	46,806	3.32	0.09
2000	PHILIPPINES	12,954	45,204	3.49	0.09
2000	INDONESIA	11,968	43,416	3.63	0.08
2000	SWEDEN	12,162	41,788	3.44	0.08
2000	INDIA	11,145	30,553	2.74	0.06
2000	BELGIUM	9,843	30,501	3.10	0.06
2000	MYANMAR	7,319	30,368	4.15	0.06
2000	NEW ZEALAND	7,721	27,270	3.53	0.05
2000	RUSSIA	5,993	21,422	3.57	0.04
2000	SWITZERLAND	6,484	20,587	3.18	0.04
2000	SRI LANKA	4,962	17,571	3.54	0.03
2000	NORWAY	4,063	16,867	4.15	0.03
2000	ITALY	5,996	15,200	2.54	0.03
2000	HAWAII	3,430	13,224	3.86	0.03
2000	NETHERLANDS	3,680	11,208	3.05	0.02
2000	DENMARK	2,618	10,569	4.04	0.02
2000	FINLAND	2,625	9,919	3.78	0.02
2000	PAKISTAN	2,093	8,038	3.84	0.02
2000	MACAO	2,602	7,609	2.92	0.01
2000	AUSTRIA	2,073	6,875	3.32	0.01
2000	BRUNEI	2,046	6,057	2.96	0.01
2000	ZIMBABWE	747	5,659	7.58	0.01
2000	NEPAL	1,203	5,436	4.52	0.01
2000	SPAIN	1,389	5,009	3.61	0.01
2000	POLAND	1,453	4,010	2.76	0.01
2000	IRELAND	1,002	3,820	3.81	0.01
2000	LUXEMBOURG	958	3,745	3.91	0.01
2000	BANGLADESH	1,586	3,637	2.29	0.01
2000	ISRAEL	1,621	3,235	2.00	0.01
2000	U.A.E.	1,112	3,034	2.73	0.01
2000	INMARSAT IOR.	928	2,904	3.13	0.01
2000	ALASKA	950	2,418	2.55	0.00
2000	SOUTH AFRICA	526	2,026	3.85	0.00
2000	KOREA NORTH	841	1,884	2.24	0.00
2000	INMARSAT M.	570	1,558	2.73	0.00
2000	MONGOLIA	699	1,543	2.21	0.00
2000	CUBA	571	1,430	2.50	0.00
2000	HUNGARY	500	1,358	2.72	0.00
2000	MADAGASCAR	225	1,256	5.58	0.00
2000	BRAZIL	248	1,159	4.67	0.00
2000	GREECE	472	1,139	2.41	0.00
2000	KENYA	288	1,107	3.84	0.00
2000	FRENCH POLYNESIA	258	1,069	4.14	0.00
2000	KYRGYZSTAN	136	1,038	7.63	0.00
2000	NIGERIA	283	927	3.28	0.00
2000	MOROCCO	217	857	3.95	0.00
2000	KUWAIT	161	811	5.04	0.00
2000	ALGERIA	124	789	6.36	0.00
2000	TUNISIA	265	784	2.96	0.00
2000	UKRAINE	224	762	3.40	0.00
2000	IRAN	177	726	4.10	0.00

Source: LTC

Table 1.20 Estimated Traffic

2005	16550.46537	Busy season ratio	0.2
QoS	0.01	Busy Hour ratio	0.1
Outgoing		Traffic	BH Traffic
Call (a)	Minute (b)		
10,658	26,287,787	50.01	144.04
1,348	3,318,569	6.31	18.18
786	2,247,093	4.28	12.31
602	1,758,873	3.35	9.64
321	1,541,128	2.93	8.44
449	1,475,701	2.81	8.09
418	1,462,849	2.78	8.02
248	605,324	1.15	3.32
146	446,001	0.85	2.44
153	430,782	0.82	2.36
126	401,968	0.76	2.20
132	398,593	0.76	2.18
145	365,600	0.70	2.00
102	275,570	0.52	1.51
75	274,180	0.52	1.50
74	244,541	0.47	1.34
68	236,172	0.45	1.29
63	226,830	0.43	1.24
64	218,324	0.42	1.20
58	159,626	0.30	0.87
51	159,355	0.30	0.87
38	158,660	0.30	0.87
40	142,474	0.27	0.78
31	111,921	0.21	0.61
34	107,558	0.20	0.59
26	91,801	0.17	0.50
21	88,123	0.17	0.48
31	79,413	0.15	0.44
18	69,090	0.13	0.38
19	58,557	0.11	0.32
14	55,218	0.11	0.30
14	51,823	0.10	0.28
11	41,995	0.08	0.23
14	39,754	0.08	0.22
11	35,919	0.07	0.20
11	31,645	0.06	0.17
4	29,566	0.06	0.16
6	28,401	0.05	0.16
7	26,170	0.05	0.14
8	20,951	0.04	0.11
5	19,958	0.04	0.11
5	19,566	0.04	0.11
8	19,002	0.04	0.10
8	16,901	0.03	0.09
6	15,851	0.03	0.09
5	15,172	0.03	0.08
5	12,633	0.02	0.07
3	10,585	0.02	0.06
4	9,843	0.02	0.05
3	8,140	0.02	0.04
4	8,062	0.02	0.04
3	7,471	0.01	0.04
3	7,095	0.01	0.04
1	6,562	0.01	0.04
1	6,055	0.01	0.03
2	5,951	0.01	0.03
2	5,784	0.01	0.03
1	5,585	0.01	0.03
1	5,423	0.01	0.03
1	4,843	0.01	0.03
1	4,477	0.01	0.02
1	4,237	0.01	0.02
1	4,122	0.01	0.02

Source: Study Team

SUPPORTING FOR NETWORK DEVELOPMENT PLANNING

Supporting for Network Development Planning

1 Access Technologies

1.1 Digital Subscriber Line (xDSL)

Digital Subscriber Line (xDSL) technology allows high bit-rate services to be carried over embedded copper distribution plants, thereby extending the life of these facilities. Many different types of xDSL are available or under development, and these are summarized in the following table:

Table 1.1 xDSL services

Technology	Downstream	Upstream
ADSL	1 to 8 Mbps	128 to 640 Kbps
VDSL	13 to 52 Mbps	1 to 4 Mbps
SDSL	784 Kbps	784 Kbps
HDSL (2 pair)	1.544/2.048 Mbps	1.544/2.048 Mbps
RADSL	128 Kbps to 8 Mbps	128 to 640 Kbps

ADSL - Asymmetric Digital Subscriber Line
VDSL - Very high-speed DSL
SDSL - Symmetric DSL (does not support POTS on the same loop)
HDSL - High-speed DSL (does not support POTS on the same loops)
RADSL - Rate Adaptive DSL

The basic xDSL architecture is depicted in Fig. 1.1, but individual implementations may vary, depending on the vendor product chosen and how DSL is integrated into the overall architecture. xDSL makes use of an xDSL modem, located at the customer's premises, and a DSL Access Multiplexer (DSLAM), located in the network. The xDSL modem modulates the customer's data (typically IP packets) and voice telephony onto the twisted pair, which is connected directly to the DSLAM. The DSLAM demodulates the data, providing traditional interfaces (*e.g.* E1 or E3) to the packet network, and splits off the voice portion of the access as analogue voice.

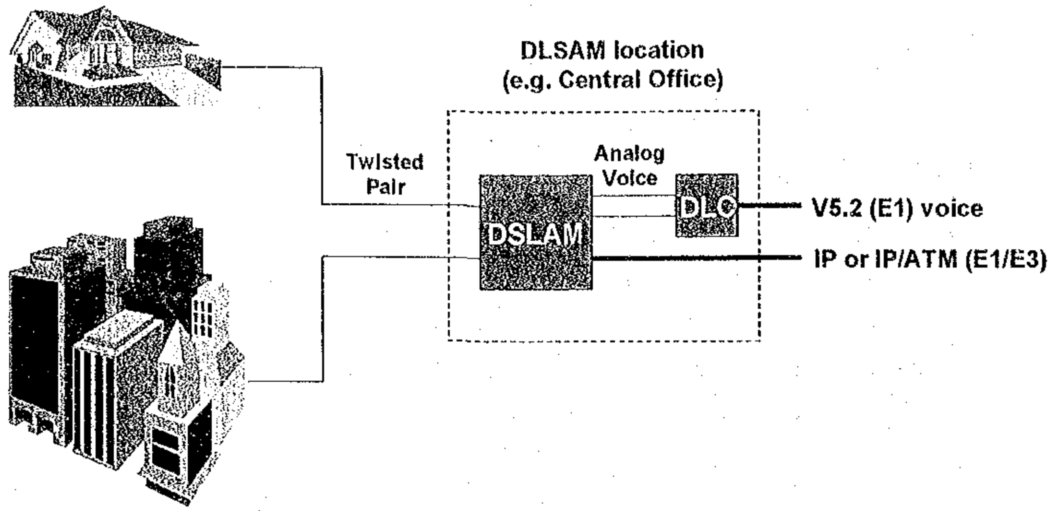


Fig. 1.1 Basic xDSL Architecture

xDSL access technology may be an option for OPERATOR, but only under limited circumstances. First of all, xDSL is used in conjunction with copper loops of good quality. Loops must be pre-qualified on a per-subscriber basis before it can be known whether xDSL will work for that customer.

One limited application of xDSL is in a large building containing many small businesses that have only copper access to telephone networks and no enterprise LANs. In this instance, xDSL using the copper wiring in the building may be a very attractive choice for offering high bit-rate services to those small businesses that do not have high-speed access. The economics of placing a DSLAM in the building must be carefully analyzed for each potential set of customers to determine if it makes economic sense for OPERATOR, while taking into consideration xDSL's technical limitations, such as the need for using qualified loops.

1.2 Fiber-to-the-Loop

Fiber-in-the-Loop (FITL) is another possible access technology. While the team does not generally recommend earliest deployment, we recommend that this technology be chosen under certain circumstances whenever necessary in the future. Evaluations should be made on a case-by-case basis to determine when FITL is an appropriate access technology choice, and when it is not.

With FITL, fiber is deployed to a cabinet located close to the customer locations to be served. Twisted pair is deployed from the cabinet to the customer locations. The cabinet contains the electronics required to perform the electrical/optical conversions.

The non-VoIP and VoIP FITL/xDSL architectures are depicted in Fig. 1.2.

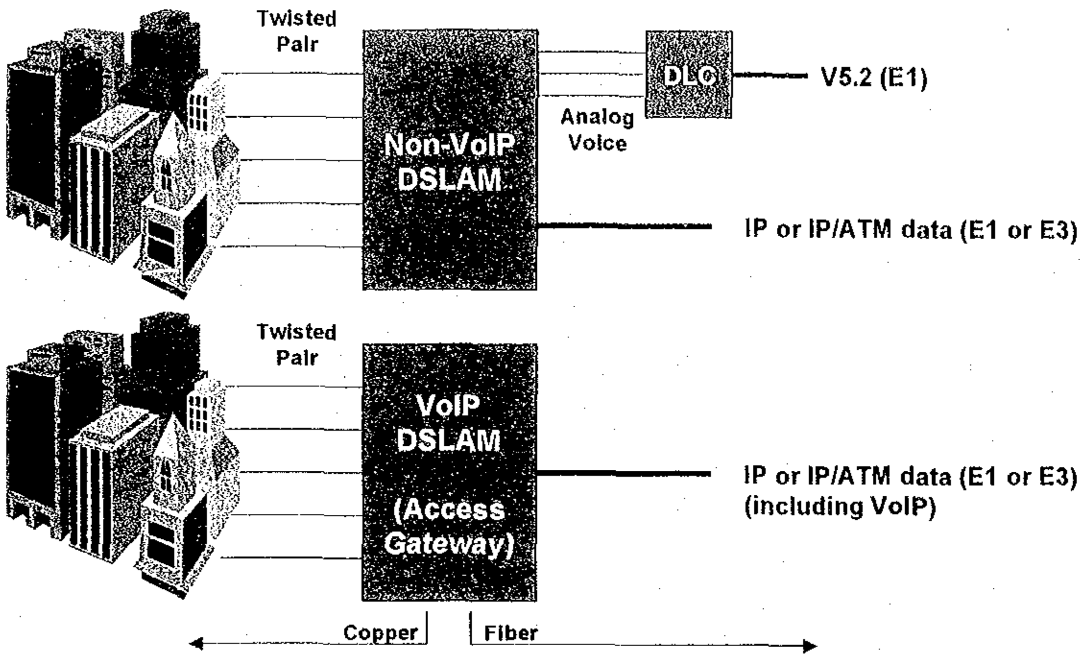


Fig. 1.2 FITL/xDSL Architecture

1.3 Wireless Local Loop

Wireless Local Loop (WLL) is another possible technology for serving customers in areas not covered by common infrastructure. Wireless LAN of wireless services may be useful if an IP connection is strongly required.

(1) Local Multipoint Distribution Service

Local Multipoint Distribution Service (LMDS) is an access technology that provides two-way wireless broadband data capability. From a service point-of-view, this technology would be appropriate for OPERATOR, but LMDS has significant technical limitations that will preclude its applicability.

One limitation is that LMDS requires a line-of-sight to be available between the local antenna and the antenna at the customer's premises; LMDS signals will not pass through foliage or buildings. Another limitation is that LMDS propagation is severely impacted by rain or haze. This would seem to be the larger concern for OPERATOR, given the Lao PDR's significant humidity, cloud-cover, and rain.

(2) Multi-channel Multipoint Distribution Service

Multichannel Multipoint Distribution Service (MMDS) is a technology for the delivery of broadcast video and data services. It is designed for one-way traffic, and only very limited upstream bandwidth is available. Two-way systems have been proposed, but are not yet available.

2. Transport Technologies

2.1 Introduction

The selection of the right backbone transport technology is outlined. The transport network must support the types of traffic and connections needed to support the service offerings, while maintaining flexibility and expandability. The backbone network must meet the following needs:

(1) Large bandwidth in the backbone transport network
(2) Expandability of the backbone transport network to accommodate demand for rapidly-growing data services
(3) Highly reliable communications
(4) A flexible architecture
- a variety of connection needs
- a variety of traffic types in a seamless manner

2.2 Voice Traffic

In the near-term, voice traffic will be carried as TDM in SDH Virtual Containers. These Virtual Containers will represent E1, E2, or E3 connections in the network. For the longer term, VoIP technology may be applied and voice traffic may be carried over the IP network.

The networks of incumbent carriers are designed for supporting voice services; however, service trends indicate that data traffic volume will quickly overtake voice traffic volume and the volume of data is expected to continue to grow rapidly. For this reason, we recommend that new telecommunications networks be designed around the transport of data (packet) traffic rather than voice. Over the long-term, voice will increasingly be transported in packets, which will appear to the network like any other data packet. Voice packets (and real-time video) are different from data packets in that they are not delay-tolerant as are data packets, and protocols are being developed to support the transport of voice-bearing packets across the network with a minimum of delay.

2.3 Data Traffic

Data services to be provided are as follows:

- IP packet data
- ATM
- Leased lines

2.4 IP vs ATM

(1) IP

There are two choices in the marketplace today: IP and ATM. Each has its advantages and disadvantages. At this point in time, we recommend IP over ATM, as discussed below.

(a) Advantages

Most computers and a significant part of the data communications equipment have IP capabilities. Much of the research and development funding in telecommunications is directed at IP standards, products and services; so an increasing amount of the telecommunications infrastructure will use IP in some capacity.

IP itself was designed to be independent of the underlying transport mechanism, although connectionless protocols tend to work easier with the IP toolbox of routing and address resolution mechanisms.

Hence IP can work with wired or wireless, narrowband or broadband, or almost any other conceivable medium. A performance and financial benefit of this aspect is that IP can leverage advances in hardware performance and innovation more easily than most technologies. Recent examples have included 100 Mbps and 1,000 Mbps Ethernet, and Gigabit routers.

IP technology has been around for many years. It has been deployed, tested and enhanced. Network managers are comfortable and familiar with IP technology. The Internet is a testimony to the interoperability of equipment manufactured, deployed and managed by disparate organizations.

(b) Disadvantages

IP is still lacking a proven set of real-time capabilities. Some elements, such as RTP, are mature, but most are still in the RFC process or waiting for the first vendor implementations. For some functions, the IETF is standardizing multiple approaches that have different degrees of usefulness in carrier networks. Several interim approaches can be used to manage performance. One approach is to use the conventional mechanisms (such as priorities, over-provisioning, and packet size control) to give a good, but not assured, level of performance. Another approach is to use an underlying ATM network for real-time support.

In a pure connectionless network with dynamic routing, control of performance is difficult due to the dynamic nature of route calculation, selection, and reconfiguration. Policy routing techniques are at an embryonic stage. Also, in networks of multiple providers, there is no prescribed method of allocating impairments or other performance degradations.

(c) Analysis

IP is the critical building block for future data networks, but it is not yet completely suited to supporting real-time transport services or connection-oriented services such as Frame Relay.

(2) ATM

(a) Advantages

ATM has a several built-in techniques for ensuring a high grade of service. It uses short, fixed-length cells to reduce waiting time for real-time traffic, thus minimizing transit delay. ATM also uses traffic-management techniques, such as admission controls and traffic policing that help ensure delay-sensitive traffic gets through. ATM has performance objectives for equipment that support end-to-end performance objectives. All of these techniques support Quality of Service (QoS) in ATM equipment in a way that guarantees acceptable performance.

ATM offers the best integration of different services across switching, transport, and operations domains. ATM was developed, in part, because of its ability to simultaneously handle diverse applications. ATM supports connections that carry constant bit rate traffic as well as connections that carry variable bit rate traffic. In addition, ATM supports the flexible allocation of the access line bandwidth to logical connections supported across an interface. ATM also allows multiple services to be managed on a single network platform.

ATM was designed with flexibility and scalability. There is large number of user interface types, and the communications rates can be chosen in very small increments (cells per second). There is no known upper limit on the interface speeds, so that ATM UNIs (user-to-network interfaces) will be available as OPERATOR grows its SDH network and adds WDM technology.

(b) Disadvantages

To carry packets or frames, ATM encapsulates them in ATM cells and introduces additional overhead from the ATM cell headers. (Frame Relay frames can also be translated into native ATM transport.) Besides this overhead, there are protocol procedures required to emulate the required IP or Frame Relay service. When the traffic is native ATM traffic (e.g. data placed directly into ATM cells), there is no additional overhead.

ATM equipment can be more expensive because traffic has to be placed into cells. ATM can be more complex because it supports multiple services through explicit QoS support and traffic management. However, these are precisely the factors that are needed in packet-based technologies to support voice and other real-time services.

ATM is a newer technology than either SDH or IP. For basic PVC connections supporting some QoS categories, ATM is now mature and interoperable. Other capabilities, such as AAL2 and SVC services, are in the early stages of deployment and interoperability testing.

(c) Analysis

ATM can support many services well, including the transport of real time traffic, so it is an attractive choice for new networks. Although ATM is not strictly efficient from an overhead viewpoint, its ability to gain ***overall*** network efficiencies and manageability have led many enterprises and network providers to use ATM in their networks for IP and Frame Relay traffic transport.

(d) Recommendation

ATM was designed to be an integrating technology. It is very flexible and scalable, supports a wide range of traffic types, and has built-in quality of service features. We recommend that ATM be adopted for integrating a service platform, supporting IP, ATM, and leased lines.

We also recommend taking advantage of the wide deployment of IP technology by adding an IP layer to its network model. This will create future advantages for supporting IP data services directly, such as Internet access and IP Virtual Private Networks, as well as providing the necessary platform for VoIP services.

In summary, we recommend that a network model with IP over ATM is better.

2.5 SDH

The SDH hierarchy provides bandwidths up to 10 Gbps. This capacity can be expanded more than ten times over with the use of Wavelength Division Multiplexing (WDM) transmission equipment supporting 8, 16, 32, and more wavelengths on a single fiber. SDH provides mature, reliable protection mechanisms that aid in providing highly reliable and survivable communications. The "virtual container" structure of SDH provides the ability to support a wide variety of connection bandwidths; and, when combined with ATM cell technology, supports virtually any traffic type and connection bandwidth.

Although SDH was originally created for fixed bandwidth connections (e.g. E1 and E3), SDH can be leveraged to support other connections, such as IP and ATM that do not necessarily have a fixed bandwidth. SDH transport is most commonly seen deployed in ring topologies, but other topologies are also supported and may be more appropriate than rings under certain circumstances

The SDH hierarchy is organized into fixed-bandwidth Virtual Containers (VCs), which can be inefficient for low-bandwidth connections. The advanced protection and survivability features are among the prime benefits of SDH, but they also add to its cost.

2.6 Recommendation for transport technology

We recommend that Synchronous Digital Hierarchy (SDH) transport technology should be utilized. SDH is widely deployed in telecommunications networks and is a mature, well-understood technology. In addition, the selection of STM4 or STM 16 may be critical because of the cost. However, if the traffic estimated is over 2.4G bps in the next 10 years, STM16 should be applied.

We recommend that OPERATOR adopt the IP/ATM/SDH layering scheme. Although this may be more complicated than an IP over SDH or ATM over SDH solution, IP/ATM/SDH has significant advantages for the long term:

- Integrates all traffic. At the SDH level, there are two basic connection types – SDH virtual containers carrying TDM connections (voice or leased lines) and virtual containers carrying ATM cells.
- Provides bandwidth efficiency. With the use of ATM-capable Add-Drop Multiplexer (ADM), all of the routers on an SDH ring could share the same SDH tributary. This means that the fixed-size tributaries can be efficiently filled with ATM cells from multiple cell streams.
- Provides SDH protection to the IP traffic. Although new technologies like ATM rings will provide protection functions in the future (with only limited support now), SDH provides mature protection functionality at the present time.
- Multiprotocol Label Switching (MPLS) routers can switch IP traffic in a simplified and more efficient manner than routing table lookups. Possible alternative of ATM for transport layer.

Some of the disadvantages of the IP/ATM/SDH layering scheme are:

- A three-layer network is generally more complex than a two-layer network. Managing an additional layer in the network increases network management costs. This is offset by the management of a single integrated transport network.
- Transport of IP over ATM is less efficient than transport of IP over SDH directly. Adding ATM cell headers decreases the efficiency of the transport. This is offset by the overall increase in bandwidth efficiency that ATM provides.

Because the advantages of this approach outweigh the disadvantages, we recommend the use of an IP/ATM/SDH layering scheme for the network for the near future.

With this layering scheme, all data traffic, including IP and Frame Relay, is encapsulated in ATM cells. ATM cells are then placed on SDH tributaries for transport to other network elements. When appropriate, data network equipment should support ATM Adaptation Layer (AAL) functionality to encapsulate the IP packets and Frame Relay frames into ATM cells. The underlying SDH technology also permits the transport of circuit-switched voice in the near term as well supporting TDM leased lines with traditional bandwidths (E1, E3, etc.). Fig. 2.1 shows network functions required to support services on the IP/ATM/SDH network.

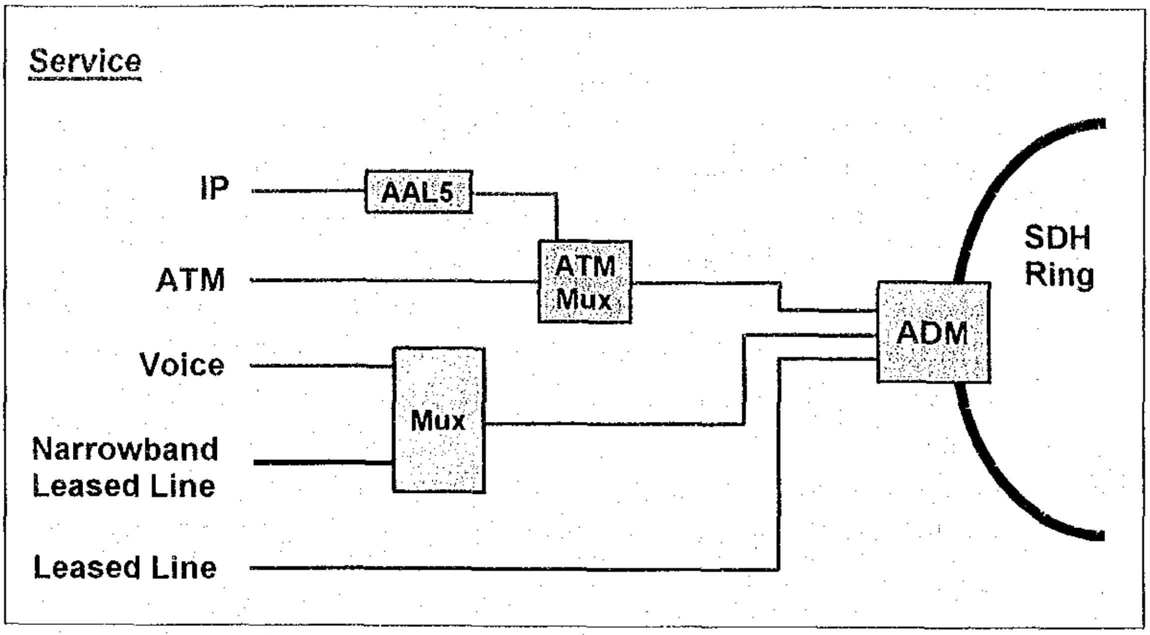


Fig. 2.1 Services on the IP/ ATM/ SDH Network.

Fig. 2.1 shows some of the network functions required to support these services on the IP/ATM/SDH network.

The physical and logical relationships among the IP, ATM, and SDH network elements are depicted in Fig. 2.2. For the logical connections, the IP layer shows three interconnected IP Routers. The ATM layer shows four ATM switches, connected as a full mesh ATM network. At the SDH layer there are two interconnected SDH rings having a total of five ADMs.

For the physical connections, two routers are connected directly to ATM switches, and the third router is connected directly to an ADM. Its connectivity to the other routers is via an ATM PVC over an SDH VC. The four ATM switches are connected to four of the ADMs. Notice that within the IP and ATM layers there are no direct physical connections to the other elements in the same layer – physical connections extend between layers to take advantage of the characteristics of the supporting layers (*e.g.* survivability, QoS management, and traffic management.

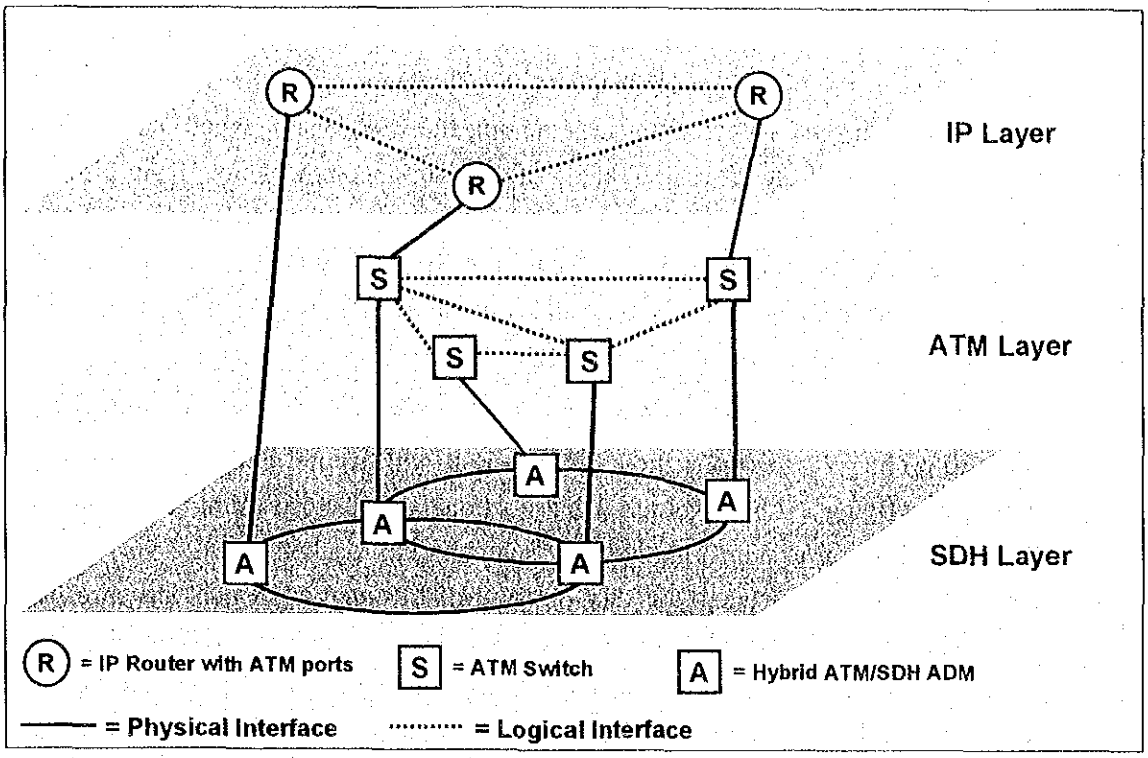


Fig. 2.2. IP over ATM over SDH: Physical and Logical Relationships

2.7 Multiprotocol Label Switching

Multiprotocol Label Switching (MPLS) routers will represent an attractive addition to operators network in the not-too-distant future. Below we present an introduction to the technology and describe its potential benefits to operator.

In traditional IP routed networks, packets are forwarded toward their destinations on a store-and-forward basis. Each router consults a routing table to determine the best next-hop for the packet. This is accomplished by searching the routing table for the most-specific (longest) address prefix that matches the packet's destination address. In addition, other layer-3 processing (such as address filtering for security purposes) may be performed.

An MPLS network consists of a network of Label Switching Routers (LSRs). The LSRs distribute destination-based routing information among themselves using standard IP routing protocols, such as OSPF or BGP-4. At the ingress to the MPLS network, the first LSR in the packet's path performs a longest prefix match on the destination address to determine its next hop and outgoing interface. Before forwarding the packet across the interface, the LSR attaches a short (20 bits), fixed length label to the packet. Subsequent LSRs along the packet's path make forwarding decisions by consulting a table that maps incoming labels to outgoing labels, rather than normal longest prefix match searching. Before transmitting the packet over the outgoing link, the incoming label is replaced with the outgoing label found in the table ("label swapping"). The associations between incoming and outgoing labels are communicated among the LSRs via a Label Distribution Protocol (LDP). In most cases, each LSR assigns incoming labels from a local pool of available labels and receives outgoing labels from the "downstream" next-hop router for the outgoing packet. The resulting Label Switched Path (LSP) through the MPLS network is typically the same path that is defined by the network's internal routing protocol (IGP).

Consider the network shown in Fig. 2.3 below. Router B (a LSR) has established a route to prefix 128.96/16 via the network's IGP, with Router C designated as the next hop. Being a LSR, Router B has to populate its Forwarding Information Base (FIB) prior to performing label switching of packets to 128.96/16. It requests an outgoing label for this prefix from Router C, which has already established an incoming label for this prefix. Because Router B is the first LSR in the path, it does not expect to receive labeled packets to this destination, hence does not require an incoming label. The creation or modification of a LSP is triggered by the network's routing protocol (e.g. OSPF) as IP forwarding tables are created and modified within routers. Thus, when a router creates an entry in its forwarding table, it must also create label bindings via LDP. Thus, the creation of LSPs is "topology driven," not "flow driven," as in certain other IP switching approaches (e.g. MPOA). It is generally acknowledged that this topology-driven approach is more robust and therefore preferable for carrier-scale implementations. When the packet reaches the egress LSR at the edge of the MPLS network, the label is stripped off and the standard IP packet is passed to the host or non-LSR router.

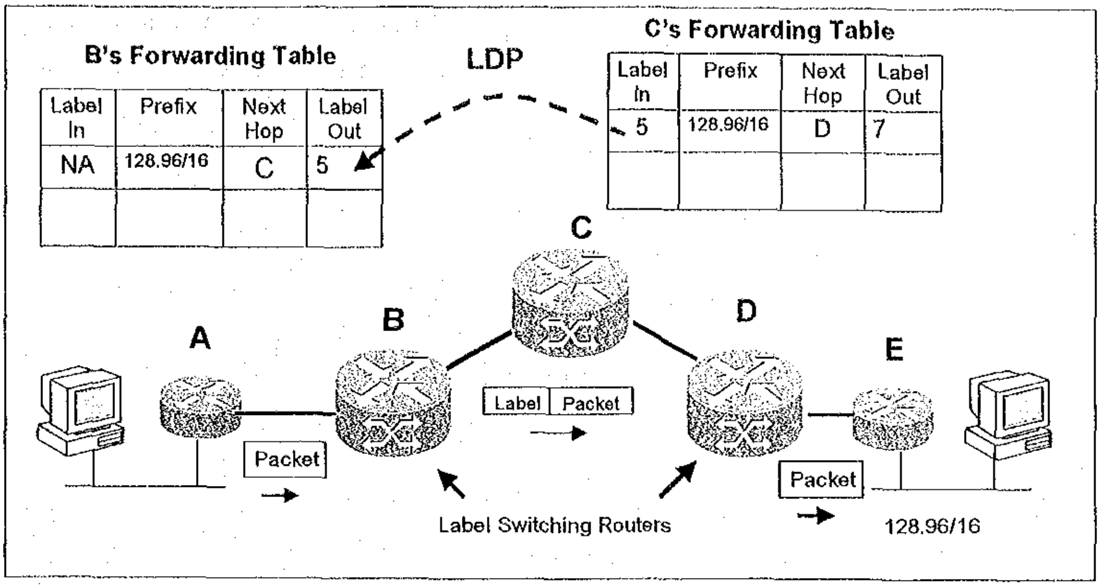


Fig. 2.3 MPLS

In practice, the Label Switching Router (LSR) is typically an enhanced ATM switch, though other transport technologies (SDH, Frame Relay) are also applicable. The label information is encoded in the VPI/VCI field of the ATM cell; so "label swapping" corresponds to the normal cell-relay forwarding technique used in ATM networks. The major difference with Label Switching across an ATM core is that the virtual channel connection carrying the IP packets from source to destination is established by the IP routing and LDP procedures, not by the normal ATM control plane. Because the LSR must run standard IP routing software as well as the LDP, a significant upgrade to the ATM switch's control software is required to turn it into a LSR.

Routing ATM cells (carrying IP packets) based on these labels should yield significant performance and flexibility advantages. The foreseen benefits of MPLS are one of the reasons that we recommend the IP/ATM/SDH layer model for OPERATOR; it positions OPERATOR to take advantage of MPLS to full extent. MPLS standards are maturing, and vendor products are beginning to appear. OPERATOR should carefully monitor developments with MPLS and plan on deploying MPLS routers over the next few years.

Interoffice Transport

Transport between the data network elements (primarily IP routers and ATM switches) will occur over the SDH backbone. If OPERATOR deploys IP routers with ATM interfaces (as we have recommended), then connections among routers on the same ring can share an SDH virtual container. The hybrid SDH/ATM ADMs can perform the ATM cell adds and drops according to the ATM Virtual Path Identifier (connections between routers must have unique ATM VPIs).

3. Existing Service Standards

Normally, an analysis of service standards requires access to detailed figures of network characteristics and maintenance statistics.

For the experts it was not possible to see any records of maintenance statistics, neither in the fields of transmission and switching nor in the outside plant. Those figures have been requested several times, but they have not been delivered. Small ideas only could be learned about the network characteristics and service quality while visiting different provinces and having discussions with the directors and staff.

That information given by the directors was not sufficient enough for any study. Consequently, this output is not able to evaluate and comment the existing situations.

Service standards as they exist within Lao Telecom are mainly rules for decentralised operated telephone service. They are in principal still in force but considered obsolete. Whether they are still observed is an open question. However, no statistics are maintained in this regard. For national and international services the standard rule says that no subscriber should wait for more than 30 minutes to get his communication. "Immediate" service should be put through in less than 10 minutes, and "very urgent" calls should be dealt with in less than 5 minutes.

For telegraph operations a general service standard for the delivery of telegrams is 1,5 hours in the cities and less than 2 days in remote areas, thus giving a rather wide range of interpretation for the use of an adequate standard.

For subscriber complaints concerning the outside plant, no standards are identified. A follow-up system clearing the faults within a specific time is obviously not available.

New service regulations were issued in 1992 called "The Rules and Regulations of Telegraph Operations", which have been introduced since. These rules, however, do not elaborate on service standards. Service standards for maintenance could not be verified. The general line as expressed by Lao Telecom is to follow ITU-T (former CCITT) Recommendations.

4. New Set of Service Standards

4.1 General

A number of standards to be introduced will allow:

- ❑ Observation of the service quality per organization unit
- ❑ Comparison and evaluation to provide comprehensive data for decision making

4.2 Service Standards

From the E.400 Recommendations "Quality of Service" the standards as shown in the "List of Service Standards" have been chosen. These standards have been discussed in detail with all concerned and are proposed to be introduced as a first step.

Other standards shall follow whenever their consequences for the service are known or can be assessed.

4.2.1 General Development

"Telephone Penetration" and "Service Automation" are not standards but essential information to be used as components of a management information database.

(1) Telephone Penetration

This is the general information on availability and acceptance of service and should in any case be established and maintained. A recording frequency of 3 months is proposed.

The information should be collected and maintained on the following levels:

- ❑ National
- ❑ Organization Unit
- ❑ Exchange

The following data is to be recorded:

(i) The number of direct exchange lines/ main stations in operation
A classification as follows is suggested:

- ❑ a business line serving business premises
- ❑ a residential line serving residential premises
- ❑ a governmental line serving state-owned industrial and commercial enterprises to be classified as business lines

(ii) The number of subscriber or billing addresses
(iii)The number of unsatisfied applications for a telephone line

It is desirable that the geographical location of waiting applicants is known in order to determine planning priorities. The waiting applicants are also to classify as "residential", "business" and "governmental".

(2) Service Automation

This is expressed as the percentage of automatic calls compared to total number of calls and will be still useful for a certain time because of the manual operated traffic created by:

- ❑ Rural subscribers connected to manual exchanges for local and national traffic
- ❑ Subscribers not having access to IDD for international traffic

However, it can be expected that in a relatively short time the level of automation will be close to 100% and further maintaining of such a record should be reviewed.

4.2.2 Overall Services

(1) Subscriber Complaints per 100 Subscribers per Year

This is an important indication of the quality of service from the users point of view. It must be ensured that the complaints service collects all complaints received, whether verbally or in writing. On the other hand, it must be ensured that one fault, which may be subject of repeat fault reports, is counted only once and that complaints not originated by a fault but by other reasons like subscriber error etc., are separately dealt with in the statistics.

(2) Subscriber Satisfaction on Overall Quality of Service

To see the best impression what customers think about the quality of service requires surveys by means of interviews or opinion polls. Because it is time- and cost-consuming, this exercise should be considered exceptional as a means of getting the desired information. CCITT considers a 12-months-period as a reasonable interval for such surveys. See also Recommendation E.125, which describes in detail a method of conducting such a poll.

4.2.3 Customer Relations

The data to be maintained under this heading should be integrated in the database referred to in section 4.2.1.

(1) Average Waiting Time for Service Installation

It is certainly in the interest of Lao Telecom to reduce waiting time for service installation to a relative minimum. Relative only, because the wish for fast revenues can be in conflict with organizational and internal service matters and related costs.

In general, a short waiting time can indicate a well functioning subscriber services organization, a good developed local network and furthermore a good planning standard. But it also can indicate that the supplied resources are overdimensioned (such as local lines, switching capacity and manpower) and that they therefore are contradictory to an optimized revenue/ expenditure relation. Related statistics should be carefully maintained and evaluated.

(2) Average Waiting Time for Repair

This is a very useful standard because of its close relationship to the "Overall Services" (subscriber complaints/subscriber satisfaction) and towards manpower and other resource requirements of the Operation and Maintenance (O&M) organization. By manipulating of this standard, costs of O&M -services and subscriber satisfaction can be balanced.

4.2.4 Customer Relation with Service

(1) Connection Establishment

As standards for connection establishment Answer Bid Ratio ABR and Answer Seizure Ratio ASR are recommended. The method for measuring ABR and ASR has been described in ITU-T (former CCITT) Recommendation E.420 for international traffic but it can be used for national traffic as well.

A bid is an attempt to obtain a circuit in a wanted circuit group or destination. A seizure is a successful bid or "a bid that obtains the use of a resource of the type of consideration" as defined by ITU-T (former CCITT) Rec.E.600.

Answer bid ratio is defined as the relationship between the number of bids (or attempts from the users point of view) that result in an answering signal and the total number of bids. It can be observed on a circuit group or bundle or a destination base. It indicates the effectiveness of traffic onwards from the point of measurement.

Answer seizure ratio (ASR) is defined as the relationship of the number of seizures resulting in an answering signal compared with the total number of seizures. Like ABR it gives the percentage of the effectiveness of the service offered but does not include unsuccessful bids.

Two methods of measuring are in use, namely:

(i) The traffic supervision printout of an SPC (digital) exchange automatically provides this information.

(ii) Another method is simulated traffic generated by operator test calls. These observations can be carried out with a minimum of equipment. Another advantage is the possibility to detect abnormalities, usually not detectable with methods (i) or (ii), like poor speech quality or other deficiencies. The conditions to be observed in order to make the simulated traffic as realistic as possible have been defined in ITU-T (former CCITT) recommendation E.421.

(2) Dial Tone Delay

The Q.500 Recommendation, dealing with digital exchange performance objectives apply to local, combined, transit and international exchanges. Although partly defined as design objectives, the recommendations must be taken into account when considering the operational performance requirements of an exchange in the particular environment of Lao Telecom.

Since the following standards depend on the dynamic exchange performance, reference is made to ITU-T (former CCITT) Recommendation Q.543 and annexes A and B of this recommendation, dealing with exchange capacity and its processing capacity. Certainly, the standards as discussed here have to be established during acceptance testing of the exchange by an adequate traffic simulator. The values then should be checked in reasonably long intervals and according to a test plan during appropriate periods of the year and during busy hours.

The reference loads mentioned are traffic load conditions under which the performance objectives are to be met. They are described in the mentioned Recommendation and defined as follows:

Reference load A:

Erlangs average occupancy on all incoming circuits.

Call attempts/h = 0.7 x number of incoming circuits/Average holding time in hours

Reference load B:

Erlangs average occupancy on all incoming circuits with 1.2 times the call attempts/h for reference load A.

- Average dial tone delay (local exchange call request delay)

For analogue subscribers this is defined as "... the interval from the instant when off-hook condition is recognizable at the subscriber line interface of the exchange until the exchange begins to apply dial tone to the line..."

The following values are recommended:

	Reference load A	Reference load B
Mean value	< 400 ms	< 800 ms
probability of not exceeding	ms	ms

Average post dialing delay (Answering sending delay):

	Reference load A	Reference load B
Mean value	< 100 ms	< 150 ms
probability of not exceeding	ms	ms

4.2.5 Connection Retention

(1) Percentage of Calls Interrupted to Total Inquiries

Call interruptions have a significant impact on the subscriber's judgement of the quality of services offered to him. By the very nature of this fault, its detection can be difficult and costly. It is therefore recommended to start investigation only as a last means, that is, when the cut-off ratio, which is "the percentage of the established calls that are released for a reason other than intentionally by any of the parties involved in the call" (Rec.G.181) has become a matter of concern and other available information cannot help to solve the problem. This Recommendation refers in particular to analogue exchanges. Whilst digital exchanges can automatically provide information concerning cut-offs, thus enabling relatively easy fault detection, analogue switches do not have this possibility and need additional test equipment.

Connection quality standards as discussed in the following paragraphs contain subjective (by subscriber observations) and objective (by technical measurements) assessments of the quality of connections.

(2) Percentage of Customers Satisfied with Quality

An assessment of this aspect would come as a special issue into a subscriber interview action/ opinion poll as already mentioned in paragraph 4.2.2 (2). According to TSB, the subscribers' response as good or excellent should exceed

95%.

(3) Percentage of Circuits Exceeding Loss/Noise Parameter

Not more than 2% of circuits should fail to meet the appropriate analogue or digital transmission performance requirement. The 2% allowance is intended to account for deficiencies in the local and subscriber networks.

4.2.6 Billing Integrity

The number of subscriber complaints about their bills or the percentage of complaints of the total number of bills issued is an indication of the trustworthiness of the billing service in the eyes of the subscriber and of the billing integrity. The required information can be derived from the number of complaints received by the billing service (accounts) for a particular specified period.

(1) Percentage of Bills Disputed (billing complaints)

Recommended is a percentage of <1%.

(2) Overcharging/Undercharging Percentage

The existence of overcharging or undercharging will have to be checked through charge analysing data or by making test calls. In the case of overcharging test calls are made to busy subscribers or subscribers who may not answer, so that the receipt of a false counting signal can be detected.

In the case of undercharging test calls can be made either to subscribers or to automatic answering equipment.

The percentage of overcharging/ undercharging complaints/ faults should be less than 0.2%.

(3) Availability of Transmission Links

The availability of transmission circuits is considered to be relevant because of its close relationship to the other subscriber-oriented criteria.

Percentages of availability for transmission systems should be for both microwave and optical fibre circuits in the range of 99.9% or better.

(4) Success Rate of Calls

Automatic Calls

The success rate of automatic calls should be observed while taking account of the different possibilities for a call not being successful like:

- called subscriber occupied or not answering
- dialling fault of calling subscriber
- circuits/ equipment occupied.

Normally, observed through a printout of the digital exchanges twice a year (or whenever it is considered necessary), it provides data for planning section, subscriber services/public relations or other services.

Manual Calls

For manual calls the standards identified in para 1 "Existing Service Standards" should be maintained and eventually improved with the development of the entire network and under consideration of the operation costs involved.

(5) Percentage Availability of Detailed Billing

For subscriber connected to digital exchanges, detailed billing should be available on request.

(6) Service Hours per Day

Different services shall be available to the customer during certain hours per day. For example, customer services should be handled during normal working hours, whilst customer service complaints should be received until 20:00. Emergency cases however (i.e. hospitals or other very important services or customers) must be dealt with during 24 hours. In this latter case procedures must be established to ascertain fault-clearing actions without delay. These emergency lines should be strictly defined.

Public call offices should be accessible from 08:00 to 20:00 as seems to be the norm in many areas now. The opening time of public call offices can be reviewed when new services are offered, i.e. external card-phones at all key locations.

Some examples for recommended opening times are:

- General customer services: 8 hours
- Inquiries: 24 hours
- Complaints (ordinary): 12 hours
- Complaints (urgent): 24 hours

- ☐ National operator service: 24 hours
- ☐ International operator service: 24 hours
- ☐ Telegram service: 24 hours

(7) Percentage of Complaints

This is the relation of single complaints to repeated complaints. It gives a good view of the efficiency of the complaint service and the fault clearance service. For the subscriber, who has reason for a repeated complaint, this is an important indicator for his satisfaction with the offered service quality.

(8) Availability of Complaint Reception

This has been dealt with already in paragraph 4.2.6 (6) Whilst "ordinary" complaints, i.e. complaints from residential or business subscribers, do not have a priority, which needs a special action, other subscribers like hospitals, police or certain government subscribers have an importance, which demands immediate action in case of a fault. This means that, apart of a complaint service for urgent matters, technicians of different expertise must be available in case of emergency, ready to deal with faults of "emergency lines" immediately.

No	Indicator	Proposed symbol	Formula/Expression	Method of observation	Target Value	Proposed objective Range in LAO PDR	Remarks
	General Development						
1	Telephone penetration (Telephone per 100 population)	T.P	No of main telephone stations Population / 100	Readily available from ongoing development reports and census			
2	Service automatisation (& calls on automatic)	S.A	No of calls using auto. serv. Total number of calls	Traffic data from automatic & manual exchange			
	Overall Service						
3	Subscriber complaints per 100 subscribers per year	S.C	Total No of subs. complaints in 1 year No of subs. in service / 100	Oral or written subs.compl., received by the line complain service, billing or *other technical services*. Not counting the repeat complaints			
4	Subscriber satisfaction on overall Quality of Service	S.S	No of answers as excellent + good No of Subs. interviewed / 100	Oral interview/Opinion poll			
	Customer Relations						
5(a)	Average waiting time for service installation	Ti	Total time to process service request No of service requests	Commercial department records			Before payment After payment
5(*b*)	*Percentage of cases with waiting time* exceeding a certain limit	E.Ti	No of requests waiting longer than Ti Total No of service requests	From commercial records			Ti can be given several values
6(a)	Average waiting time for repair	TR	Total repair time Total No of repaiir reports	Subscriber line repair service reports			internal + external faults
6(b)	Percentage of cases with repair time exceeding a limit	E.Tr	No of cases with repair time > Tr Total No of repair reports / 100	Subscriber line repair service reports			usually Tr' is assigned value of 1 day, 2 days 3 days, 7 days and 30 days

No	Indicator	Proposed symbol	Formula/Expression	Method of observation	Target Value	Proposed objective Range in LAO PDR	Remarks
	Customer Relation with Service						
7	Connection establishment a) Answer Bid Ratio	ABR	<u>Bids receiving answer x 100</u> Total No of bids	i) Traffic supervision reports printout from SPC exchange			
	b) Answer Seizure Ratio	ASR	<u>Seizure receiving answer signal</u> Total No of seizures / 100	ii) Reports of observation position on live traffic iii) Operator originated test calls in *sufficient number*			
8	Dial tone delay a) Average dial tone delay	DTD	<u>Total dial tone delay observed</u> Total No of bids observed	1) Automatic measuring equipment available in market			
	b)Percent bids with delay in excess of N seconds	EDT	<u>No of bids with delay > N sec</u> Total bids / 100	2) Manual observation			
9 (a)	Average Post Dialling delay		<u>Total Post Dialling delay</u> Total bids	i) Statistic from SPC exchange *ii) manual observation in other* exchanges			
9 (b)	Percentage of calls with post dialling delay in excess of a value tp		<u>No of calls with P.D. delay tp</u> Total No of calls observed / 100				
	Connection Retention						
10	Percentage of call interrupted (cut-off) complaints to total inquiries		<u>Number of cut-off reports</u> Total No of inquiries	Through subs. interviews/Poll (subs. are not likely to report every cut-off in the normal course to the complaint service)			
	Connection Quality						
11 (a)	Percentage of customers satisfied with quality		<u>Number of inquiries with reply "good"</u> Total No of inquiries / 100	subscriber interview or opinion poll			
11 (b)	Percentage of circuits exceeding loss/noise parameter (circuit grade)		<u>No of circuits found exceeding limit</u> Total No of circuits measured	i) Technical measurement ii) Fault reports regarding poor transmission			

No	Indicator	Proposed symbol	Formula/Expression	Method of observation	Target Value	Proposed objective Range in LAO PDR	Remarks
	Billing Integrity						
12 (a)	Percentage of bills disputed (billing complaints)		No of billing error reports Total No of bills rendered / 100	Billing complaints received by accounts office	BP		BP = Billing period
12 (b)	Overcharging percentage		*No of calls with answer signal but no conversation* Total No fo calls observed / 100	Test calls to busy or N.A. subscriber			
12 (c)	Undercharging percentage		No of signals not getting answer signals Total No of calls observed / 100	Test calls to subscriber or answer devices			
13	Availability of Transmission links		Time a transmission link is in service *Total time of observation period / 100*	Record of OMC			
14	Success rate of calls						
	(a) automatic calls		No of successful call attempts No of call attempts observed / 100	i) Observation of operator-generated test calls ii) Traffic analyser connected to a register junctor			
	b) manual calls		*No of calls put through by operators* No of calls demanded by subs. / 100	*i) Calculated from call tickets* ii) automatically given in case of modern paperless positions			
15	Percentage of detailed billing		Total No of detailed bills Total No of bills / 100				