PLANNING THE ITALIAN PACKET SWITCHING DATA NETWORK ITAPAC USING PLANNER 4

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Abstract:

ITAPAC is the Italian PSDN, organized in eight geographical switching regions covering the whole national territory.
It is not easy to plan the ITAPAC network resources on one hand for the network dimension and on the other hand for the two different routing (static and dynamic) used by nodes. PLANNER 4 helps network planners to solve problems concerning planning and dimensioning of the ITAPAC network resources. It may be used either as a planning tool, or as a network checking tool: PLANNER 4 suggests the network dimensioning on the basis of users and traffic forecasts and the system makes it possible to verify node capability and link throughput on the basis of the real traffic.

1. Introduction

In these years ITAPAC is having a great evolution. Italian PSDN has about 200 nodes (transit and local), 200 concentrators and more than 60.000 access points with different access protocols (X25, X28, SDLC, X32) with transmition speed that varies from 2400 b/s to 64000 b/s. The development has been both qualitative and quantitative. In the last two years the number of nodes grew from 50 to 199 units. The new nodes introduced are of Alcatel technology with dynamic routing and with a high switching capability (4000 packets/s).
Today Italian PSDN ITAPAC is composed of old generation nodes (EDXP, local switching node with static routing) and concentrators (ANP, ACP, ACP2) of Siemens/Italtel technology and of new generation nodes with dynamic routing (TSM: transit node, PSX: local switching node) of Alcatel technology [1].

2. Network topology

Italian Itapac network is composed of eight regions.
Each one of the eight switching regions of the Italian network, is composed of some TSM nodes with transit function, of some PSX and EDXP nodes, and some concentrators ANP, ACP, ACP2.

The eight regions are subdivided in four couples. Each region in the couple, acts as a back-up region for the EDXP nodes of the other. Each EDXP node uses the back-up region as a second choice, i.e when the links connecting the EDXP to the TSM's of its region are overloaded, all calls follow a path through the TSM of the back-up region (see fig.1):

In each region, TSM nodes are fully connected to each other. Furthermore TSM nodes of different regions have to be connected to guarantee that every region can communicate with all the others. PSX and EDXP nodes are star connected to some TSM nodes of the same region. EDXP nodes are also connected to one or more TSM node of the backup region.

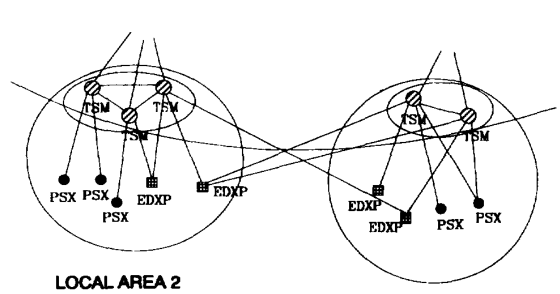

Figure 1
Network architecture

3. Load evaluation model

To evaluate the load of ITAPAC network elements, nodes and links, we have to define:
- Network topology
- Subscribers number
- Traffic rate in terms of packets and calls per second
- Traffic Interest among nodes
- Routing and link costs

Traffic interest among nodes are evaluated in two ways. The first way is based on the equal distribution of traffic. The second way is based on a traffic matrix obtained from real data about the number of calls and packets occuring between a couple of nodes in a period of time.

In ITAPAC network, nodes use two different ways of routing: static (EDXP nodes) and dynamic (PSX, TSM nodes).
When a TSM or PSX node has to route calls and/or packets to an other node of the network, they choose the routing characterized by lower cost. The cost of the routing is the sum of the cost of each single segment that constitute the routing and that cost depends on the current load of each segment.
EDXP nodes have static routing. If the subscribers, connected to an EDXP node, generate k calls per second and the EDXP node is connected to n TSM nodes of its region, then k/n calls (and the related packets) are routed on each link connecting the EDXP node to each TSM node. From the TSM node to others points of the network the routing is again dynamic.

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Once the number of calls and packets sent from each node to an other (this number is computed on the basis of traffic interest and on the traffic generated by subscribers connected to each node) and the routing choosen by calls and packets in a given moment of the simulation are known, we are able to calculate the number of calls and packets crossing each link and each node, as described in [2] [3].

4. Simulation process

In the network, the dynamic routing is based on the updating of the "costs" variable that represents the percentage of busy resources of a network element. Each node contains a table with the costs of the whole routing necessary to reach every other node of the network and it is updated when some thresholds are exceeded. From this table it can choose the minimum cost routing.

The simulation reproduces this behaviour [2].
The first operation of the simulator is the initialization of all the variables on the basis of which it computes all minimum cost routings between every couple of network nodes. Then, the distribution of calls and packets begins. This operation happens gradually during each step (corresponding to a user defined time interval). At the end of each step all variables and parameters are updated (like node and link costs) and if a threshold is exceeded, a new set of minimum cost routings is computed.

Let's indicate with "d_i" the different duration of calls sent by users characterized by different transmitting speeds and protocols. Some time intervals between t=0 and t=d_i (called phase-i) can be found, at the end of which a set of operations (depending on t=d_i) are computed. With the following example it is possible to see which kind of operations are made.
Referring to fig. 2, during the time interval T, between 4T=d1 and 5T, new calls of every kind are generated and the calls of d_1 duration generated during the time interval between t=0 and t=T are eliminated, while the d_1 duration calls generated between t=T and t=2T are eliminated during the interval between t=5T and t=6T, and so on.

PLANNER 4 simulates the generation and termination of calls until a so called "*equilibrium point*" (EQ) is reached where the number of active calls throughout the network is constant. EQ corresponds to the longest among d_i. From this point on, it is possible to estimate the load of network elements such as nodes and links. The fixed time gaps at the end of which it is possible to estimate the load of the network elements are called "*observation points*".

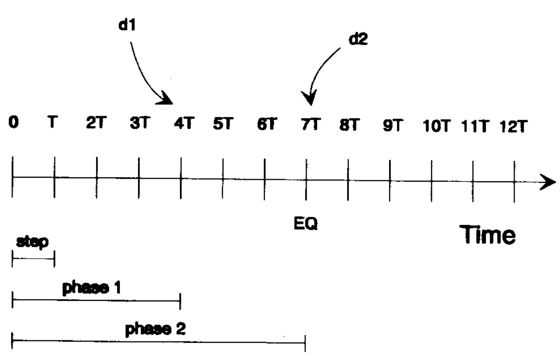

Figure 2
Time advancement model

5. Planner 4 technical data

The *PLANNER 4* system runs on Personal Computer 486 with MS-DOS operating System. The dimension of all the modules is about 200 Kbyte, while that of the data base is about 600 Kbyte.

6. Network Simulations

In the following sections we describe the hypotheses and results of one of the executed simulations.

6.1 Hypotheses

On the ITAPAC-like network model described above we executed a simulation using data traffic matrix.
The following hypotheses characterizing the behaviour of the network users have been assumed. For each class of users, average number of calls per second generated: 0.05, duration of the connection: 1000 seconds.
The average number of packets per second generated is described in table 1:

User Class Protocol	Speed Rate	Packets per second
X.25	2400,4800,9600	1
X.25	19200,48000	2
X.25	64000	4
X.28		0.5
X.32		0.5

Table 1
Subscribers access speeds and protocols

About the dynamic routing of Alcatel nodes, we assume that the maximum number of links from source node to destination node is 3.
The step of the simulation has been fixed in 50 seconds.
In the below described simulation, the first five steps immediately following the equilibrium point have been chosen as observation points.

6.2 Simulation Results

In this section, the results of the simulation are described in terms of nodes' load factor and inter and intra area links' load factor.

Nodes' load-factors

Table 2 contains, in the first column, the percentage of usage; in the second column, the network identifier used for the routing (IR) whose first digit identifies the region; in the third, the name of the TSM; in the fourth, the PU load factor.
The values of Table 2 are obtained as average values among the results of considered observation points.
Processing Units (PUs) of TSM nodes have an average load-factor between 20% and 65%.
Within a single area, the TSM node characterized by the minimum IR is usually charged more than the others.
That's because of Planner 4's dynamic routing algorithm: if there is more than one path with the same cost, PLANNER 4 chooses the path associated with the minimum IR.
Looking at the single observation points, none of the TSMs seem to be overloaded, maximum values being less than 80%.
From the results of simulation, a great number of PU of PSX nodes have an average load-factor between 5% and 55%.
The amount of traffic directed to EDXP nodes is very high, and they generally have a load-factor greater than 70%.

	I.R.	TSM	PU Load Factor
50-70%	301	TSM301	0,6301
	501	TSM501	0,5825
	601	TSM601	0,5522
	701	TSM701	0,5246
30-50%	101	TSM101	0,4671
	401	TSM401	0,4525
	502	TSM502	0,3754
	302	TSM302	0,3648
	801	TSM801	0,3335
	201	TSM201	0,3069
< 30%	304	TSM304	0,2990
	702	TSM702	0,2973
	703	TSM703	0,2934
	602	TSM602	0,2882
	403	TSM403	0,2864
	402	TSM402	0,2784
	802	TSM802	0,2754
	202	TSM202	0,2638
	603	TSM603	0,2609
	102	TSM102	0,2497
	103	TSM103	0,2397
	104	TSM104	0,2393
	605	TSM105	0,1927
	604	TSM104	0,1908

Table 2
TSM PU Load Factor

Intra-area links' load-factors

Links between TSMs have a very low average load-factor (<20%). In fact, because of the star-connection of PSXs and EDXPs to the TSMs of the same area, communications between a couple of nodes belonging to the same area usually occur by crossing just 2 links, i.e. just one TSM. So, links between TSMs of the same area, being involved by local traffic only, are rarely used.
Links between TSM and PSX, or PSX and PSX, are rather loaded: the number or the speed of links could be increased.
Some of the most loaded links between TSM and PSX nodes are shown in table 3. Table 3 contains, in the first column, the percentage of usage; in the second column, the link; in the third, the number of the region; in the fourth, the throughput load factor.

	Link	Area	Throuhput Load Factor
30-60%	TSM103-PSX112	1	0,45
	TSM103-PSX125	1	0,48
	TSM102-PSX112	1	0,58
	TSM102-PSX125	1	0,59
60-90%	TSM101-PSX112	1	0,72
	TSM101-PSX125	1	0,85
	TSM101-PSX116	1	0,87

Table 3
Intra area links' load factor (Area 1, TSM-PSX)

Links between TSM and EDXP belonging to the same area are overloaded. Some of them are shown in table 4.

	Link	Area	Throuhput Load Factor
70-100%	TSM103-EDXP150	1	0,81
	TSM103-EDXP151	1	0,83
	TSM102-EDXP150	1	0,88
	TSM102-EDXP151	1	0,99
>100%	TSM101-EDXP150	1	1,03
	TSM101-EDXP153	1	1,09
	TSM101-EDXP154	1	1,12

Table 4
Intra area links' load factor (Area 1, TSM-EDXP)

Looking at the set of the links between a fixed EDXP node and all the TSMs of the same area, it can be noticed that the one involving the minimum IR-TSM is the most charged. That's because of Planner 4's dynamic routing algorithm: if there is more than one path with the same cost, PLANNER 4 chooses the path associated with the minimum IR.
Finally, links between TSM and EDXP belonging to the backup area have mostly an average load-factor less than 50%, but, for the direction TSM→EDXP, there also exist values greater than 80%.

Inter-area links

Most of inter-area links (table 5) have an average load factor lower than 80%, with few exceptions.
Traffic seems quite well distributed among inter-area links.

	Links	Throughput Load Factor
50-60%	Area 5-Area 2	0,5300
	Area 7-Area 2	0,5376
	Area 8-Area 2	0,5557
	Area 5-Area 6	0,5604
	Area 7-Area 8	0,5764
	Area 6-Area 2	0,5919
	Area 1-Area 3	0,5929
60-80%	Area 4-Area 6	0,6128
	Area 5-Area 8	0,6246
	Area 6-Area 8	0,6333
	Area 4-Area 7	0,7535
	Area 1-Area 6	0,7987
> 80%	Area 3-Area 8	0,8144
	Area 4-Area 5	0,8396
	Area 4-Area 8	0,8568

Table 5
Inter area links' load factor

7. Conclusions

Many simulations were made modifying all input parameters and verifying the sensibility of the model to the variation of input parameters..

In the simulations, we used different values of:
- call/sec, packet/sec, call duration for each type of subscriber;
- routing parameters;
- maximum number of links from source node to destination node;
- time interval corresponding to a step;
- number and time position of observation points;

Beyond, we also used different traffic matrixes

- equal distributed;
- based on different data matrixes;

The results of these simulations were analysed to identify the elements overloadedl.

Network planners, using the simulation results, have designed a new network, increasing the number of links or inserting links with larger capability. This new network has bene tested with the input parameters previously used to verify that the planning is correct i.e. there's no network element overloaded.

Planner 4 was used to plan ITAPAC network in 1993.
A new version of the system was developped in 1993. This new version considers the introduction of 2 Mbit/s links and a new routing algorithm between TSM.

Reference:

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