# PART1: From Circuit Switched to Packed Switched Networks

# Network Planning Strategies for Evolving Network Architectures

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# Network Planning Strategies for Evolving Network Architectures

- **Next Generation Network (NGN) :**

  **Evolution steps to NGN**

- **Telecom Indicators for CEE and CIS countries :**

  **Subscribers potential, Information technology and % digital**

- **Network planning strategies :**

  **Network planning and optimization**

# Evolving Network Architectures :

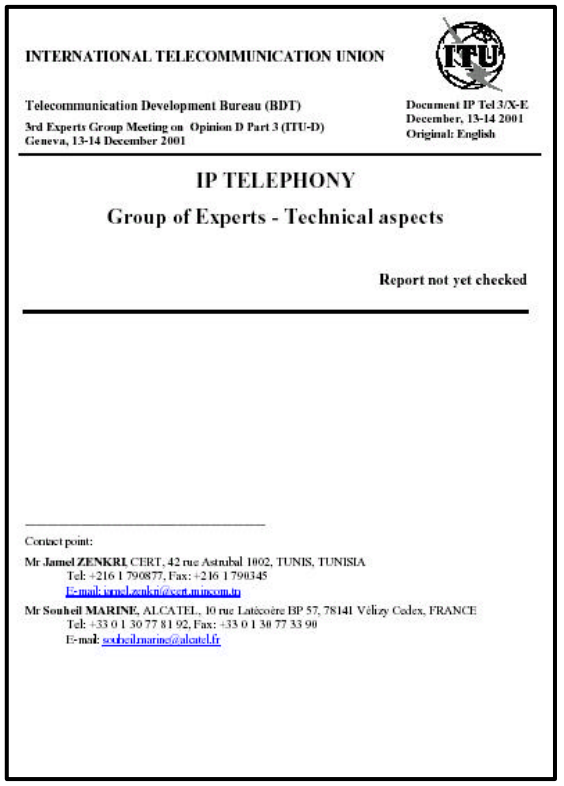
# Next Generation Network NGN

**A next generation network (NGN) is essentially characterized by packet-based transport layer for voice and data and separation of control and transport functions**

- all application data is carried in packets/cells
- broadband technology in the access
- QoS capable multiservice networks in the edge network
- optical networking in the core network
- open distributed control architecture replaces the classical "monolithic" switch
- distributed intelligent layer that separates control logic fro m transport
- open platforms for creation, provisioning and delivery of intelligent/enhanced services

# Evolving Network Architectures :

# Next Generation Network NGN



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Group of Experts - Technical aspects

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**Strategies for migrating TDM/PSTN towards NGN**

**Evolution steps to NGN**

# Evolution steps to NGN :

## Network architecture:

- Existing legacy Telephony network architectures
- Data network architectures
- Data invasion of the telecommunication network

❖ **Consolidation:**

**Optimization of the installed PSTN to reduce CAPEX and OPEX; can be combined with a selection of future-safe products to prepare migration to NGN**

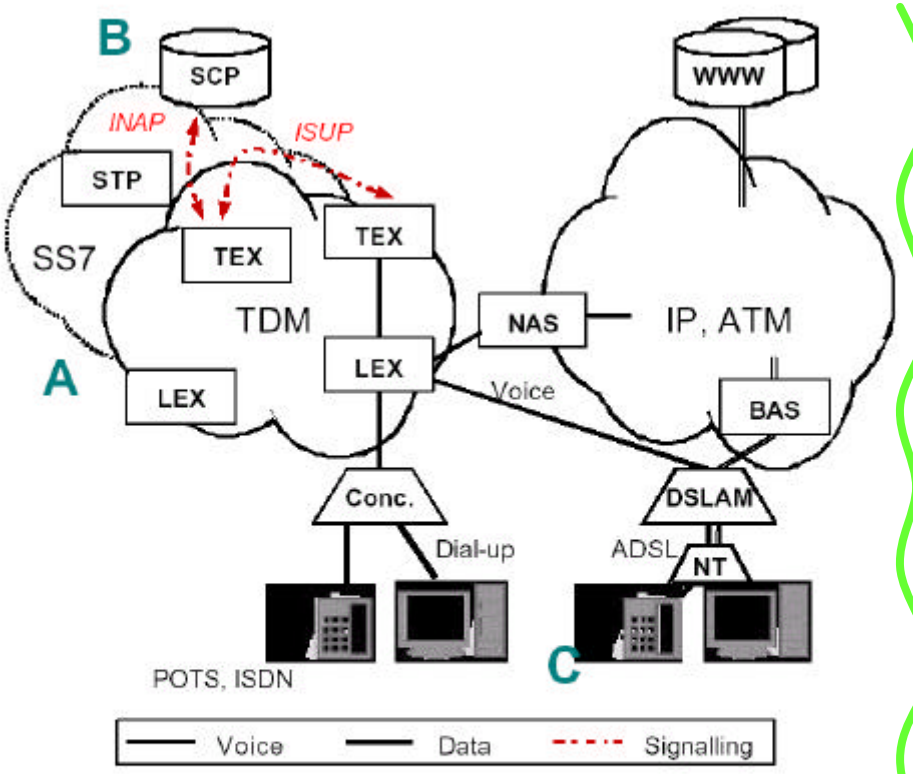
❖ **Expansion:**

**Keeping the existing PSTN infrastructure and services, but introducing an overlay NGN for addressing new customers and introducing new services**

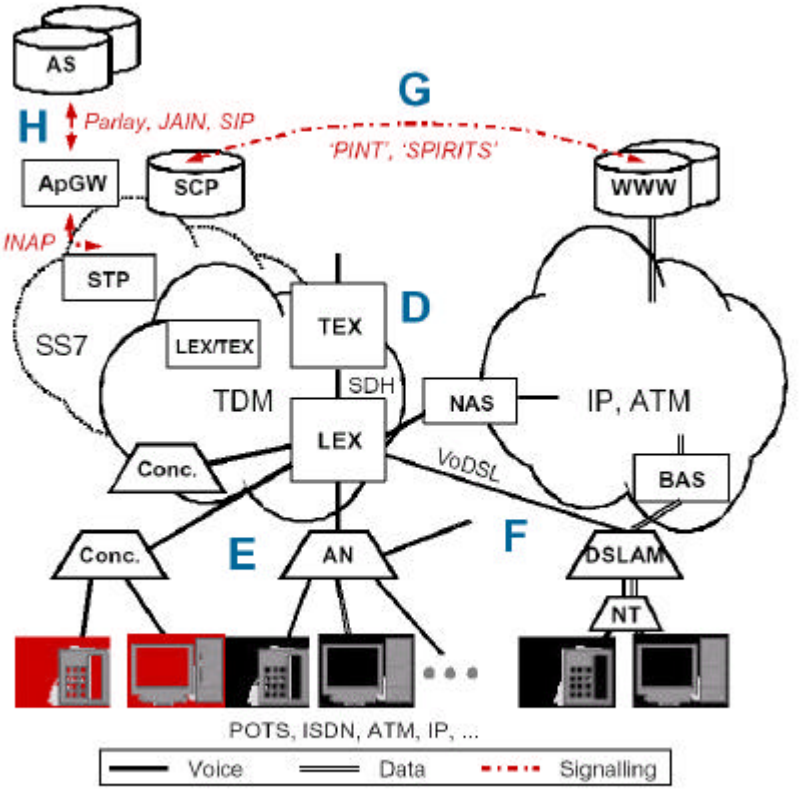
❖ **Replacement:**

**Replacing PSTN components (at their end-of-life) with equivalent NGN components**

# Evolution steps to NGN

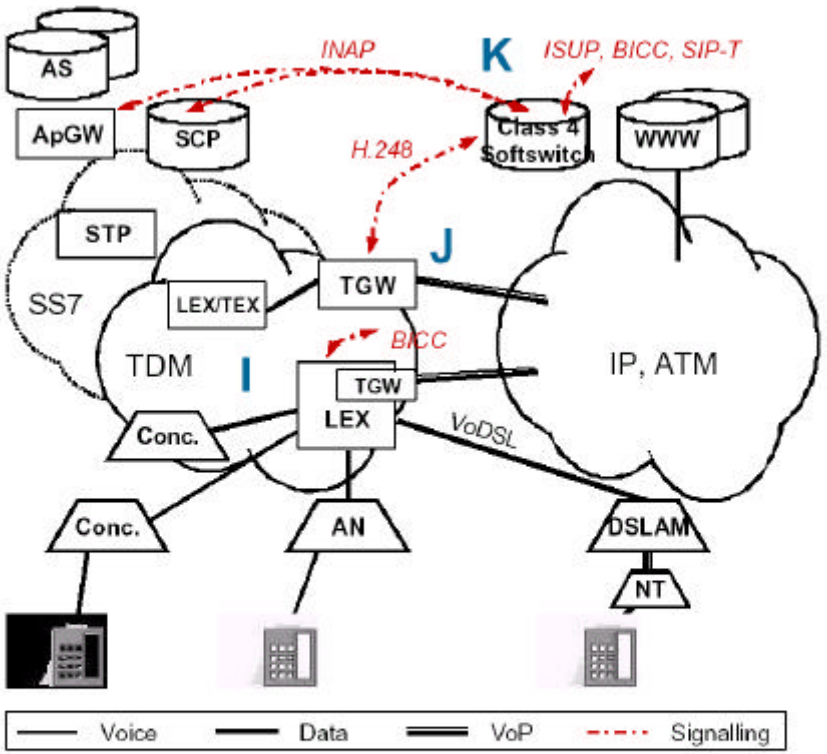



**Step 1 : PSTN for Voice and Internet**

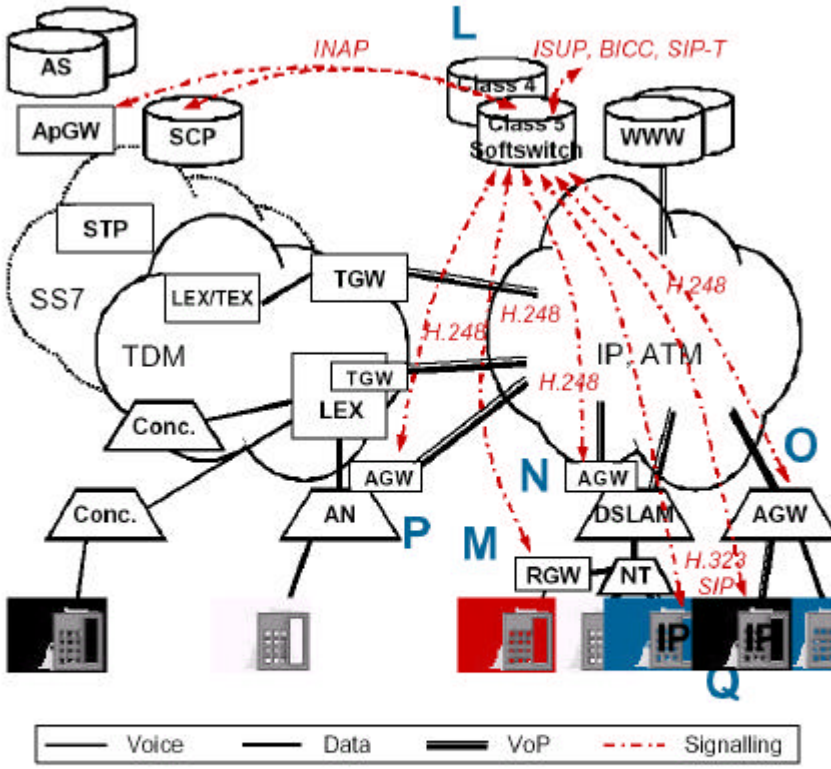



**Step 2 : PSTN Consolidation**

# Evolution steps to NGN

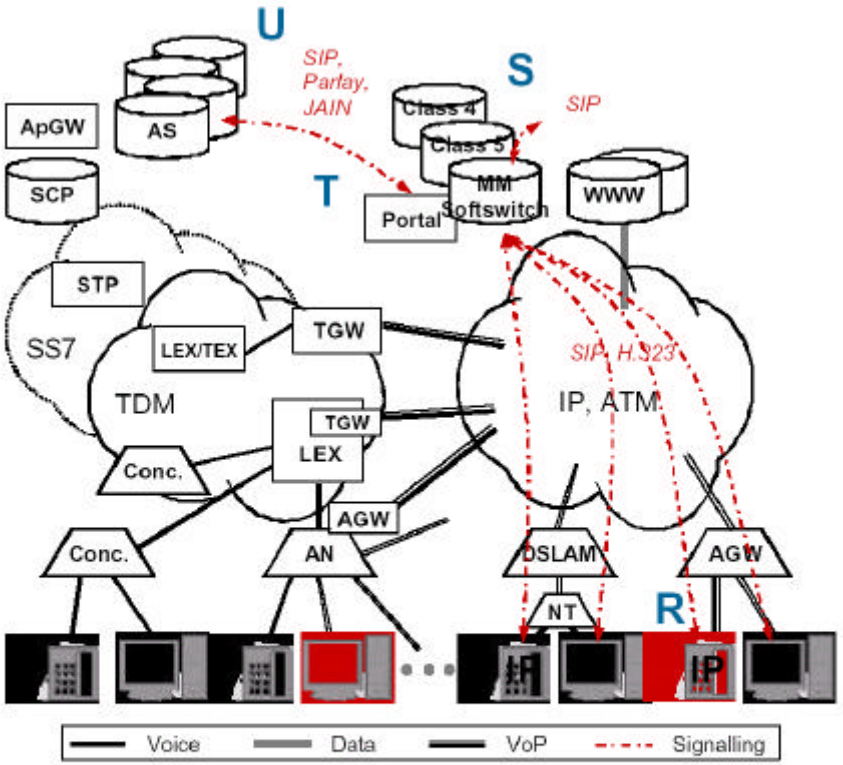



Step 3: Voice over Packet for Trunking

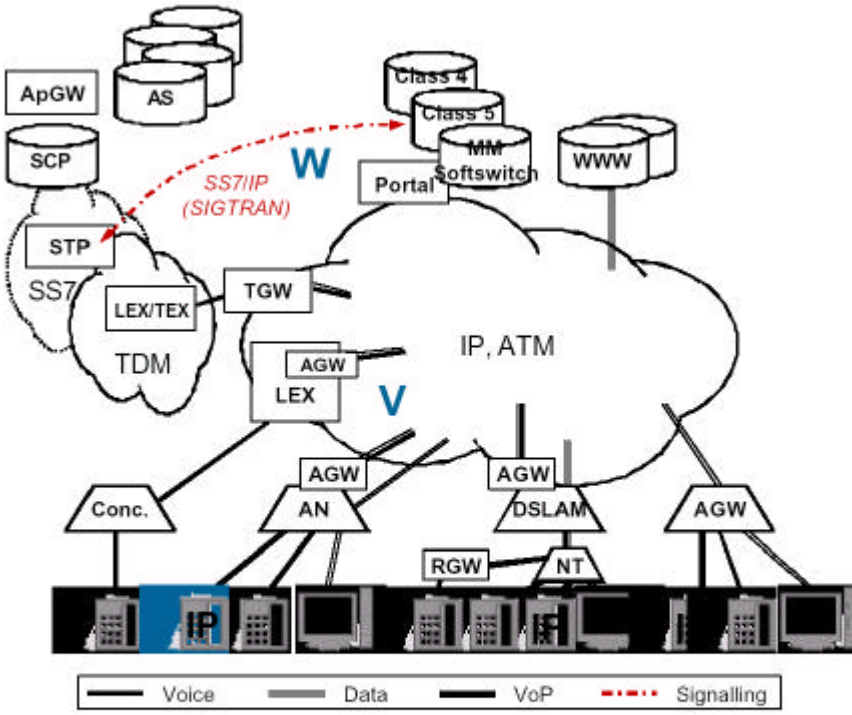



Step 4: Voice over Packets in access and CPE

# Evolution steps to NGN



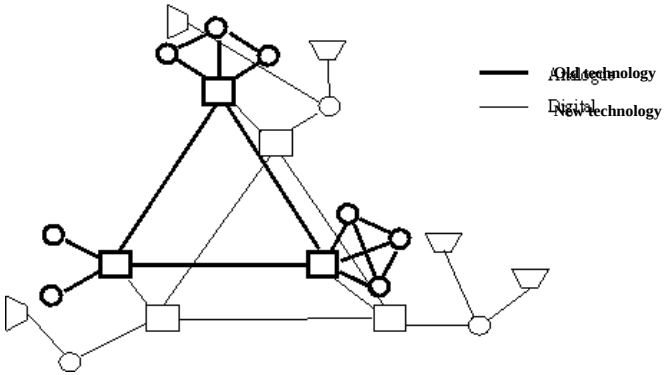

Step 5 : Multimedia

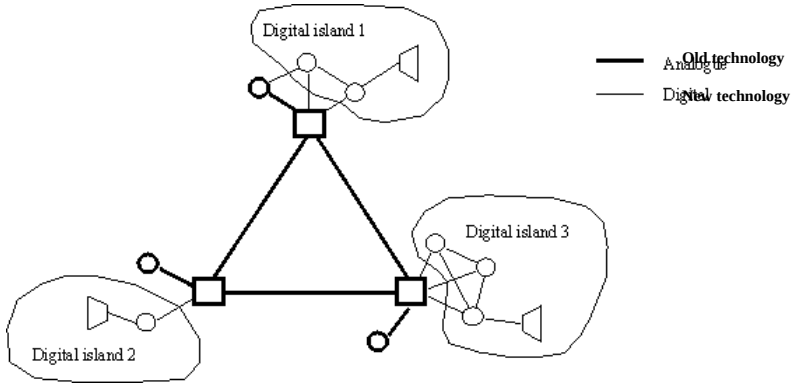



Step 6 : The full NGN

# Strategies for coexisting of the present and future technology

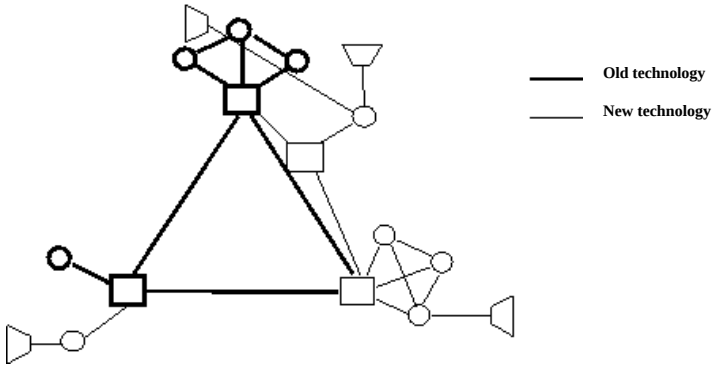
**Overlay** strategy



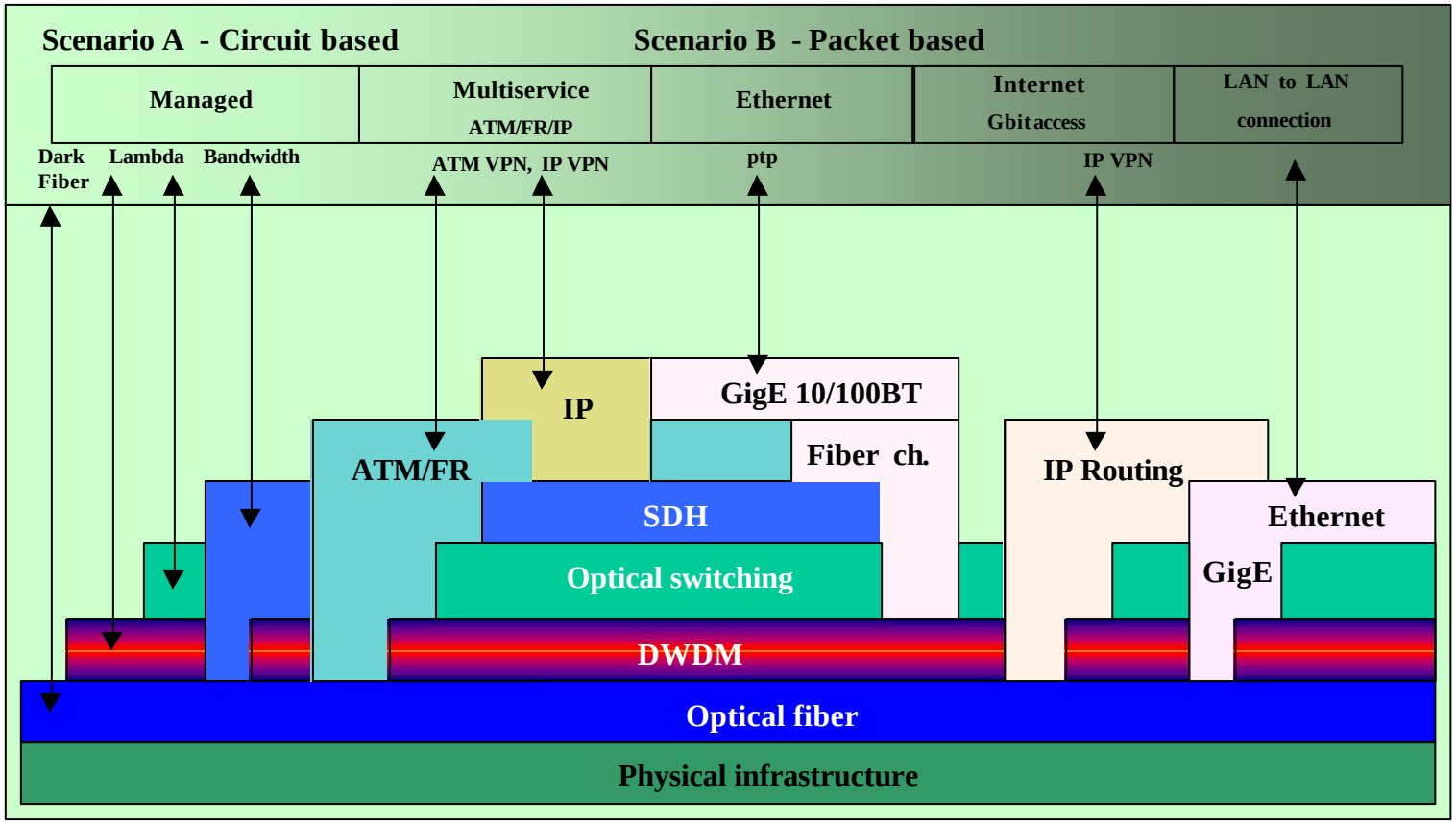




**Island** strategy

**Pragmatic** strategy



# Technological alternatives for NGN



# Subscribers potential

## Highly developed countries:

| Country | Population (in thousands) | Teledensity [%] | Average house-hold size | Teledensity per house-hold [%] | Residential lines [%] |
|---|---|---|---|---|---|
| Australia | 19,157 | 52,46 | 2,64 | 101,2 | 73,0 |
| Canada | 30,750 | 67,65 | 2,65 | 98,2 | 63,4 |
| France | 58,892 | 57,93 | 2,46 | 94,0 | 74,0 |
| Germany | 82,260 | 61,05 | 2,16 | 95,5 | 77,0 |
| Italy | 57,298 | 47,39 | 2,71 | 96,9 | 67,1 |
| Japan | 126,919 | 58,58 | 2,70 | 116,8 | 73,9 |
| New Zealand | 3,831 | 49,99 | 2,91 | 103,0 | 70,8 |
| Republic of Korea | 47,300 | 46,37 | 3,04 | 105,5 | 74,6 |
| Spain | 40,600 | 42,12 | 3,25 | 100,8 | 74,5 |
| Sweden | 8,881 | 68,20 | 2,22 | 98,7 | 65,3 |
| Switzerland | 7,204 | 72,67 | 2,02 | 99,6 | 68,0 |
| United Kingdom | 59,766 | 58,86 | 2,38 | 93,0 | 70,1 |
| United States of America | 275,130 | 69,97 | 2,58 | 94,1 | 65,8 |

- *ratio residential to business 3 to 1*

*teledensity per house-hold 100%*

# Subscribers potential :

## Central and East European and CIS countries :

| Country | Population(x1000) | Teledensity | Household size | Household Teledensity |
|---|---|---|---|---|
| Albania | 3,910 | 3.91 | 3,99 | 14.2 |
| Armenia | 3,520 | 15.15 | 4,17 | 57.0 |
| Azerbaijan | 7,734 | 10.36 | 5,34 | 49.1 |
| Belarus | 10,236 | 26.88 | 3,32 | 74.8 |
| Bosnia | 3,972 | 10.29 | - | - |
| Bulgaria | 8,225 | 35.04 | 2,83 | 84.6 |
| Croatia | 4,473 | 36.49 | 3,16 | 85.8 |
| Czech Republic | 10,244 | 37.79 | 2,67 | 71.9 |
| Estonia | 1,439 | 36.33 | 2,23 | 65.0 |
| Hungary | 10,197 | 37.25 | 2,72 | 87.7 |
| Kazakhstan | 16,223 | 11.31 | 4,50 | 45.2 |
| Kyrgyzstan | 4,880 | 7.71 | 4,40 | 27.5 |
| Latvia | 2,424 | 30.31 | 2,58 | 63.8 |
| Lithuania | 3,699 | 32.11 | 2,74 | 74.1 |
| Macedonia | 2,024 | 25.49 | 3,61 | 81.4 |
| Moldova | 4,380 | 13.33 | 3,25 | 37.5 |
| Poland | 38,765 | 28.24 | 2,95 | 63.9 |
| Rumania | 22,327 | 17.46 | 3,06 | 47.2 |
| Russia | 146,934 | 21.83 | 2,83 | 48.7 |
| Slovak Republic | 5,405 | 31.42 | 2,80 | 63.4 |
| Slovenia | 1,986 | 38.63 | 2,96 | 90.9 |
| Tajikistan | 6,127 | 3.57 | 5,85 | 16.5 |
| Turkmenistan | 4,459 | 8.17 | 4,67 | 34.2 |
| Ukraine | 50,456 | 20.65 | 3,09 | 52.7 |
| Uzbekistan | 24,655 | 6.71 | 5,50 | 30.7 |
| Yugoslavia | 10,640 | 22.61 | 3,09 | 61.9 |

# Subscribers potential :

**Average household size of Central and East European and CIS countries – from 2,2 to 5,8**

**Calculated subscriber potential for some Central and East European and CIS countries :**

- **Bulgaria : 3,86 Million (47 %) potential teledensity**
- **Hungary : 4,99 Million (49 %) potential teledensity**
- **Russia : 64 Million (43 %) potential teledensity**
- **Uzbekistan : 5,96 Million (24 %) potential teledensity**

# Information technology :

## Density statistics for Information technology :

| | Internet hosts per 10000 inhabitants | Internet users per 10000 inhabitants | PCs per 100 inhabitants |
|---|---|---|---|
| | | | |
| Low Income | **0,98** | **62,21** | **0,59** |
| Lower Middle Income | **4,32** | **264,94** | **2,45** |
| Upper Middle Income | **78,69** | **992,66** | **8,24** |
| High Income | **1 484,20** | **3 992,87** | **37,31** |
| | | | |
| Africa | **3,38** | **84,89** | **1,06** |
| Americas | **1 332,97** | **2 164,28** | **26,57** |
| Asia | **28,73** | **433,97** | **2,18** |
| Europe | **191,47** | **1 804,54** | **17,94** |
| Oceania | **885,26** | **2 771,59** | **39,91** |
| WORLD | **232,66** | **820,81** | **7,74** |

# Information technology :

## Central and East European and CIS countries :

| Country | Total Population (M) | Internet Users (10'000) | PCs (100 ) |
|---|---|---|---|
| Armenia | 3,79 | 142,05 | 0,79 |
| Azerbaijan | 7,78 | 32,13 | ... |
| Moldova | 4,39 | 136,67 | 1,59 |
| Tajikistan | 6,13 | 5,22 | ... |
| Ukraine | 50,30 | 119,29 | 1,83 |
| Uzbekistan | 25,26 | 59,39 | ... |
| Albania | 3,97 | 25,19 | 0,76 |
| White Russia | 10,25 | 411,87 | ... |
| Bosnia | 4,07 | 110,65 | ... |
| Bulgaria | 8,11 | 746,27 | 4,43 |
| Kazakhstan | 16,09 | 61,64 | ... |
| Latvia | 2,35 | 723,10 | 15,31 |
| Lithuania | 3,68 | 679,16 | 7,06 |
| Rumania | 22,39 | 446,63 | 3,57 |
| Russia | 146,76 | 293,00 | 4,97 |
| Macedonia | 2,04 | 342,47 | ... |
| Turkmenistan | 4,84 | 16,55 | ... |
| Yugoslavia | 10,68 | 561,80 | 2,34 |
| Croatia | 4,66 | 558,91 | 8,59 |
| Czech Republic | 10,27 | 1 362,66 | 12,14 |
| Estonia | 1,43 | 3 004,59 | 17,48 |
| Hungary | 9,97 | 1 484,01 | 10,03 |
| Poland | 38,63 | 983,72 | 8,54 |
| Slovak Republic | 5,40 | 1 203,26 | 14,81 |

# Technology - % digital :

## Central and East European and CIS countries :

| Country | Main lines (thousands) | Density | Digital ( %) | Residential (%) |
|---|---|---|---|---|
| Armenia | 529,3 | 13,97 | 20,9 | 90,3 |
| Azerbaijan | 865,5 | 11,13 | 30,4 | 88,7 |
| Moldova | 676,1 | 15,40 | 34,0 | 86,5 |
| Tajikistan | 223,0 | 3,63 | 7,5 | 79,0 |
| Ukraine | 10 669,6 | 21,21 | 7,9 | 82,4 |
| Uzbekistan | 1 663,0 | 6,58 | 33,8 | 84,2 |
| Albania | 197,5 | 4,97 | 78,9 | 91,0 |
| White Russia | 2 857,9 | 27,88 | 35,8 | 83,7 |
| Bosnia | 450,1 | 11,07 | 41,6 | 83,2 |
| Bulgaria | 2 913,9 | 35,94 | 12,0 | 88,2 |
| Kazakhstan | 1 834,2 | 11,31 | 29,3 | 88,8 |
| Latvia | 724,8 | 30,83 | 52,2 | 81,7 |
| Lithuania | 1 151,7 | 31,29 | 46,5 | 84,2 |
| Rumania | 4 094,0 | 18,28 | 54,8 | 88,2 |
| Russia | 35 700,0 | 24,33 | 27,1 | 79,0 |
| Macedonia | 538,5 | 26,35 | 71,2 | 88,5 |
| Turkmenistan | 387,6 | 8,02 | 20,4 | 80,3 |
| Yugoslavia | 2 443,9 | 22,88 | 53,0 | 88,5 |
| Croatia | 1 700,0 | 36,52 | 76,0 | 82,6 |
| Czech Republic | 3 846,0 | 37,43 | 85,7 | 68,8 |
| Estonia | 503,6 | 35,21 | 71,2 | 80,1 |
| Hungary | 3 730,0 | 37,40 | 85,8 | 86,6 |
| Poland | 11 400,0 | 29,51 | 77,6 | 76,7 |
| Slovak Republic | 1 556,3 | 28,80 | 70,0 | 74,2 |

# Telecom Indicators for CEE and CIS countries :

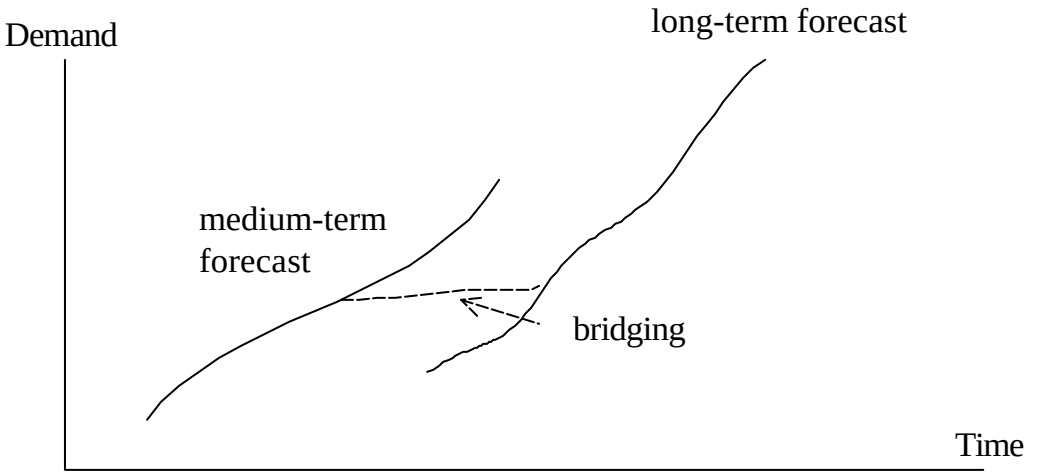
- **Subscribers potential-**
  **very high for many of the countries**

- **Information technology -**
  **below 10 % for most countries**
  **- about 40 % for high income countries**

- **Still plenty of analogue equipment mostly in rural areas -**
  **from only 7 % to 85 % digital**

# Evolving Network Architectures : Network Planning Strategies

- **Long term network planning (Target network)**



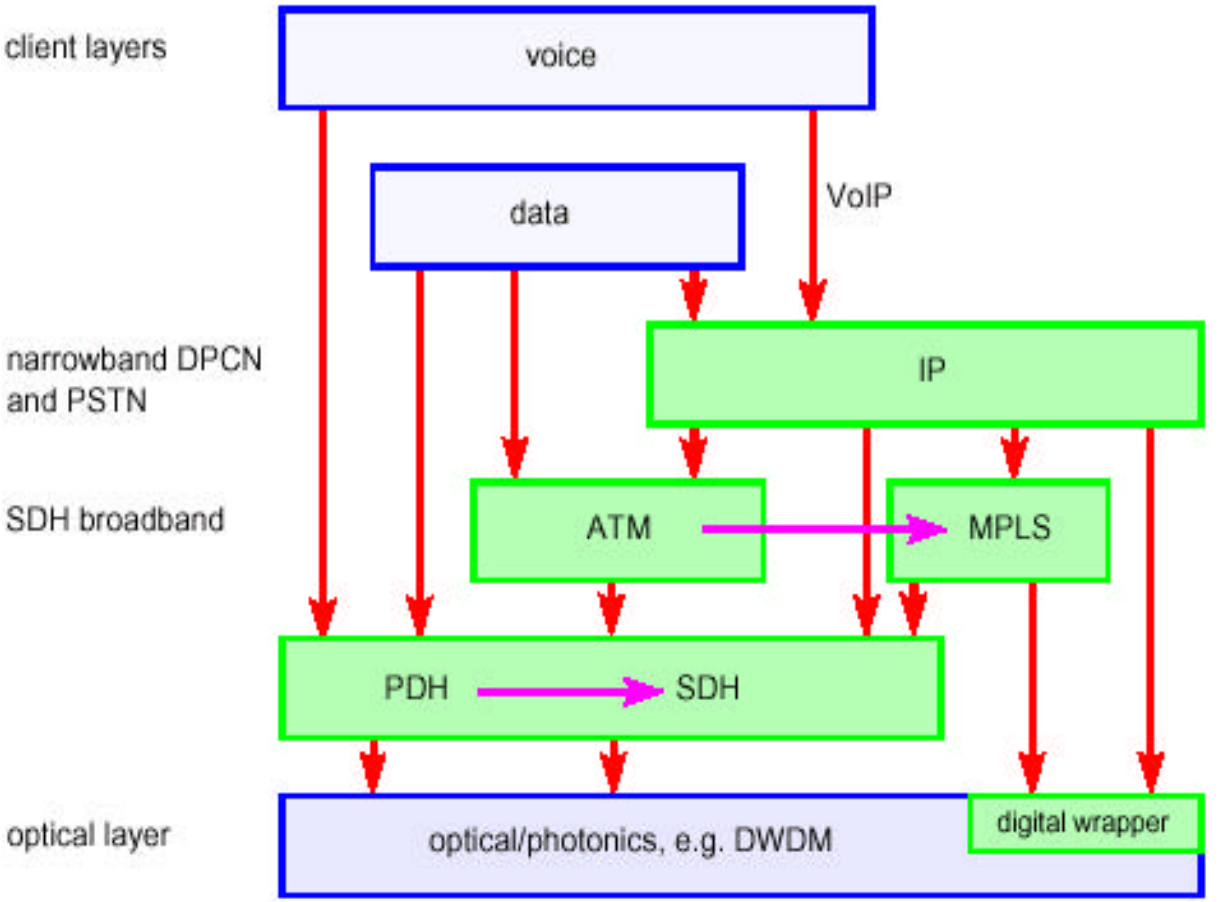

- **Medium term network planning**

- **Short term network planning**

# Network optimization

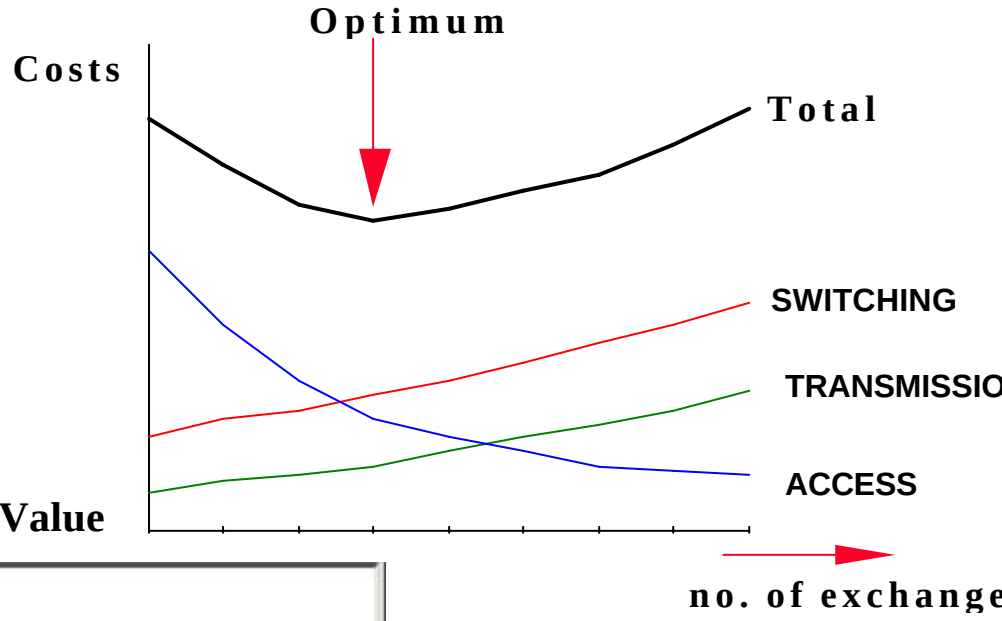
**Service/ routing layer**

**Transport layer**



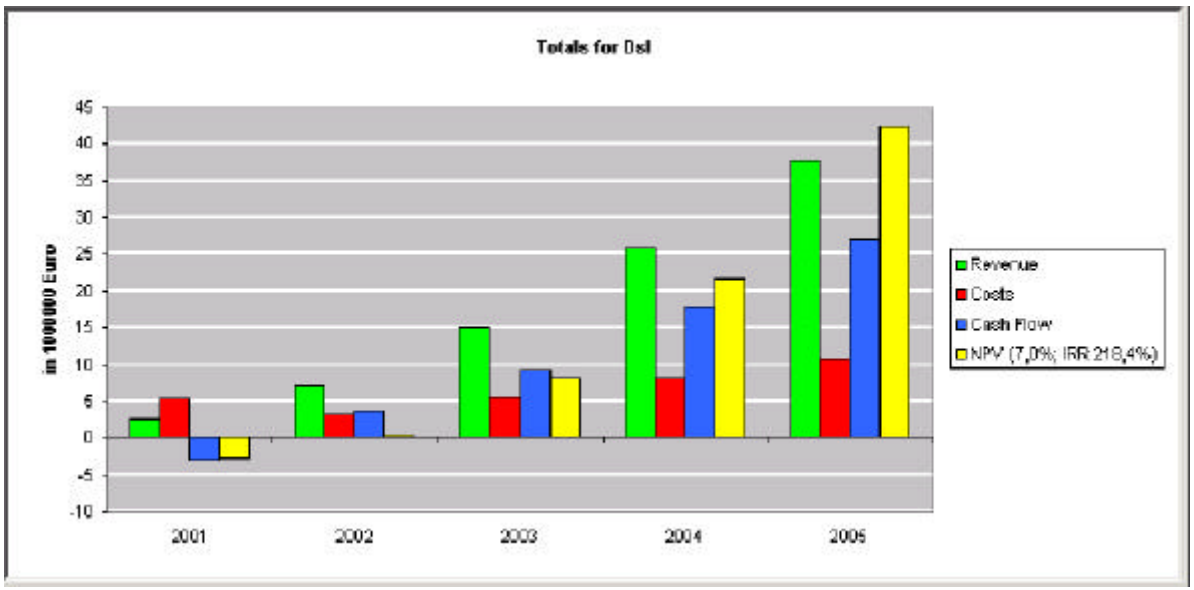
# Network costing

**Cost components of telecom network**

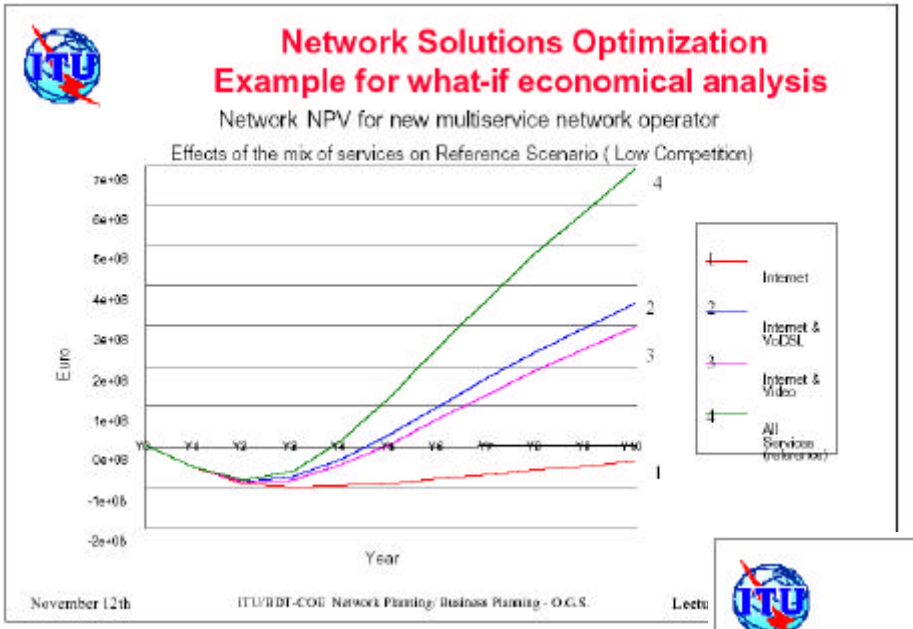



## Overall economic results –

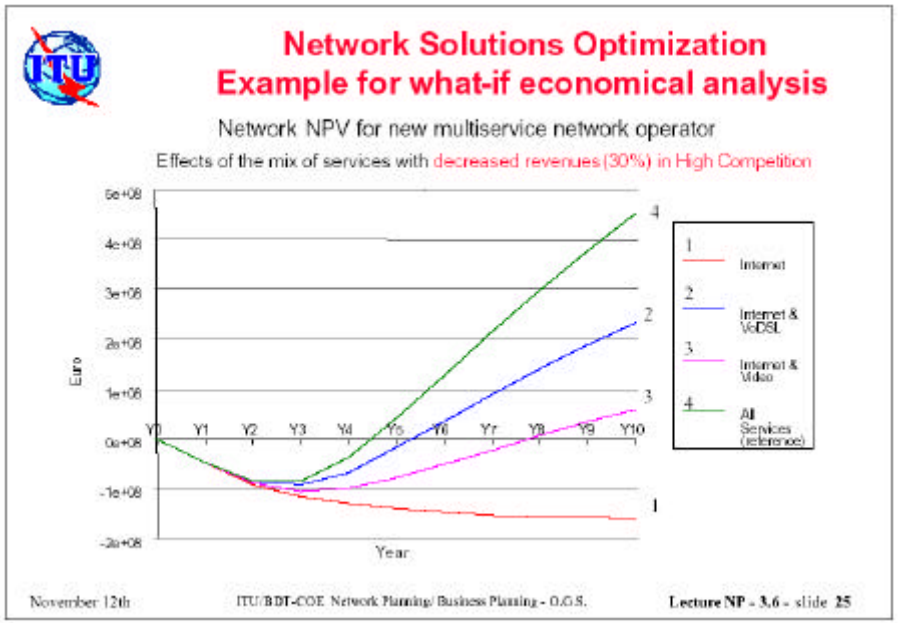
**Revenues, Cost, Cash-flow and Net Present Value**



# Economical analysis

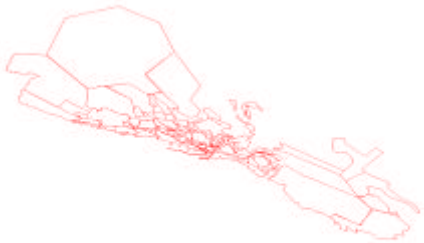



## Multiservice network operator



# Service forecasting

## Models for subscribers:

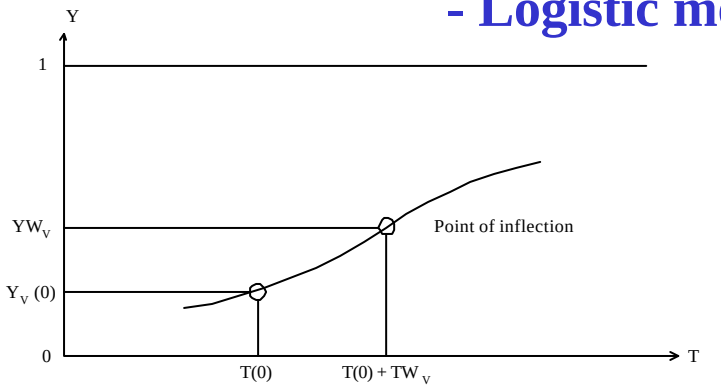



**Subscriber zones / areas**

**Subscriber nodes / sites**

**Methods for forecasting of subscribers**

**- Logistic model**

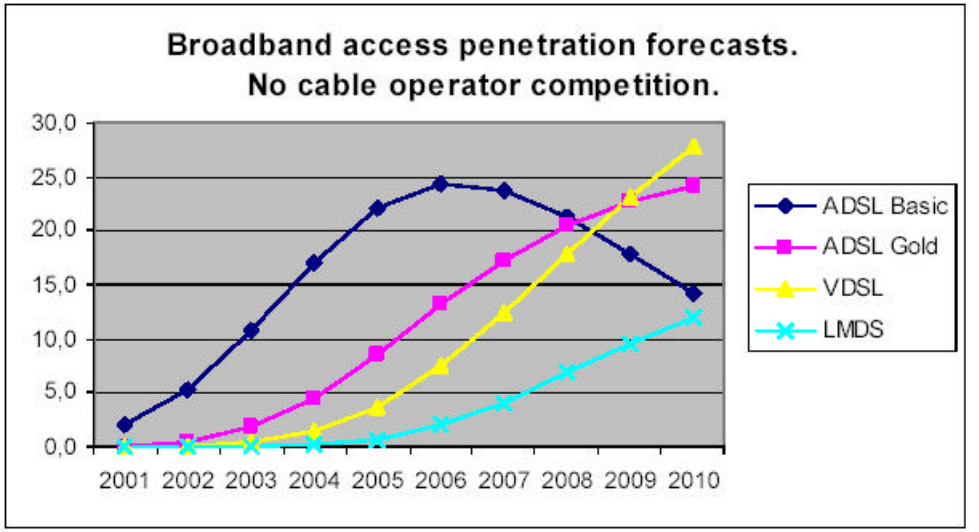


# Subscriber categories

***Subscriber categories defined with Customer Classes***

***Services -*** services offered to the customers :

E.g. ADSL Basic, ADSL Gold, VDSL, SDSL-Medium Enterprises and SDSL-Small Enterprises.




***Customer Classes –*** groups of customer using the same services (one or more) :

E.g. Residential ADSL Basic, Residential ADSL Gold, Small Enterprises (SDSL), Medium Enterprises (SDSL), Residential VDSL

# Traffic forecasting

## Models for traffic

INTERNATIONAL TELECOMMUNICATION UNION

**ITU-T**

**E.716**

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(10/96)

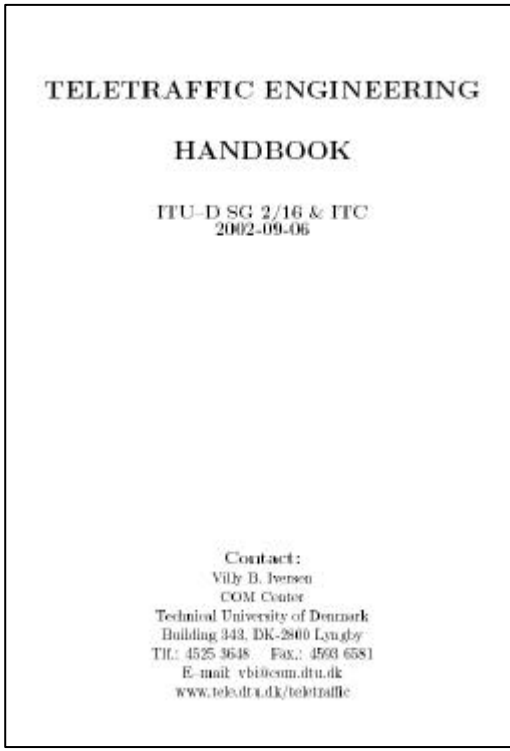
SERIES E: TELEPHONE NETWORK AND ISDN

Quality of service, network management and traffic engineering – Traffic engineering – ISDN traffic engineering

**User demand modelling in Broadband-ISDN**

scope of teletraffic engineering

❖ITU Recommendations


TELETRAFFIC ENGINEERING

HANDBOOK

ITU-D SG 2/16 & ITC
2002-09-06

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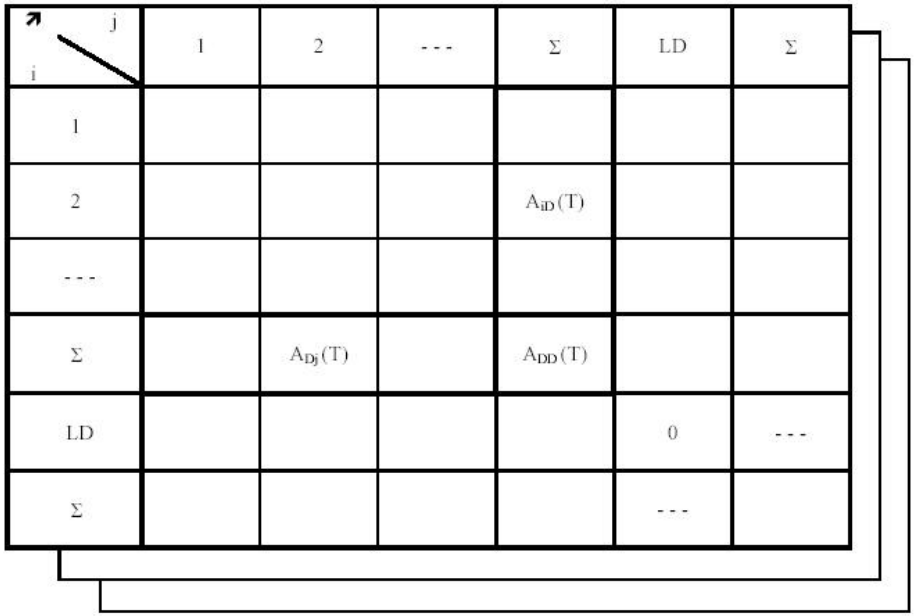
❖ TTE Handbook

# Traffic matrix

**The bases for effective network planning is the traffic data between each two nodes of the network**




| MM | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 487.78 | 65.04 | 45.53 | 650.37 | 67.75 | 85.63 | 51.49 | 54.20 | 65.04 | 525.71 | 590.75 |
| B | 65.04 | 8.67 | 6.07 | 86.72 | 9.03 | 11.42 | 6.86 | 7.23 | 8.67 | 70.10 | 78.77 |
| C | 45.53 | 6.07 | 4.25 | 60.70 | 6.32 | 7.98 | 4.81 | 5.06 | 6.07 | 49.07 | 55.14 |
| D | 650.37 | 86.72 | 60.70 | 867.16 | 90.33 | 114.18 | 68.65 | 72.26 | 86.72 | 700.95 | 787.67 |
| E | 67.75 | 9.03 | 6.32 | 90.33 | 9.41 | 11.89 | 7.15 | 7.53 | 9.03 | 73.02 | 82.05 |
| F | 85.63 | 11.42 | 7.99 | 114.18 | 11.89 | 15.03 | 9.04 | 9.51 | 11.42 | 92.29 | 103.71 |
| G | 51.49 | 6.86 | 4.81 | 68.65 | 7.15 | 9.04 | 5.43 | 5.72 | 6.86 | 55.49 | 62.36 |
| H | 54.20 | 7.23 | 5.06 | 72.26 | 7.53 | 9.51 | 5.72 | 6.02 | 7.23 | 58.41 | 65.64 |
| I | 65.04 | 8.67 | 6.07 | 86.72 | 9.03 | 11.42 | 6.86 | 7.23 | 8.67 | 70.10 | 78.77 |
| J | 525.71 | 70.10 | 49.07 | 700.95 | 73.02 | 92.29 | 55.49 | 58.41 | 70.10 | 566.60 | 636.70 |
| K | 590.75 | 78.77 | 55.14 | 787.67 | 82.05 | 103.71 | 62.36 | 65.64 | 78.77 | 636.70 | 715.46 |
| L | 189.69 | 25.29 | 17.70 | 252.92 | 26.35 | 33.30 | 20.02 | 21.06 | 25.29 | 204.44 | 229.74 |
| M | 65.04 | 8.67 | 6.07 | 86.72 | 9.03 | 11.42 | 6.86 | 7.23 | 8.67 | 70.10 | 78.77 |
| N | 785.86 | 104.78 | 73.35 | 1047.81 | 109.15 | 137.96 | 82.95 | 87.32 | 104.78 | 846.98 | 951.76 |
| O | 48.78 | 6.50 | 4.55 | 65.04 | 6.77 | 8.56 | 5.15 | 5.42 | 6.50 | 52.57 | 59.08 |
| P | 69.37 | 9.25 | 6.47 | 92.50 | 9.64 | 12.18 | 7.32 | 7.71 | 9.25 | 74.77 | 84.02 |
| Q | 61.24 | 8.17 | 5.72 | 81.66 | 8.51 | 10.75 | 6.46 | 6.80 | 8.17 | 66.01 | 74.17 |
| R | 405.48 | 54.20 | 37.94 | 541.97 | 56.46 | 71.36 | 42.91 | 45.16 | 54.20 | 438.09 | 492.29 |
| S | 54.20 | 7.23 | 5.06 | 72.26 | 7.53 | 9.51 | 5.72 | 6.02 | 7.23 | 58.41 | 65.64 |

**Usually set of traffic matrices with one matrix for each services**

# Switching/node planning

## *Location problem*

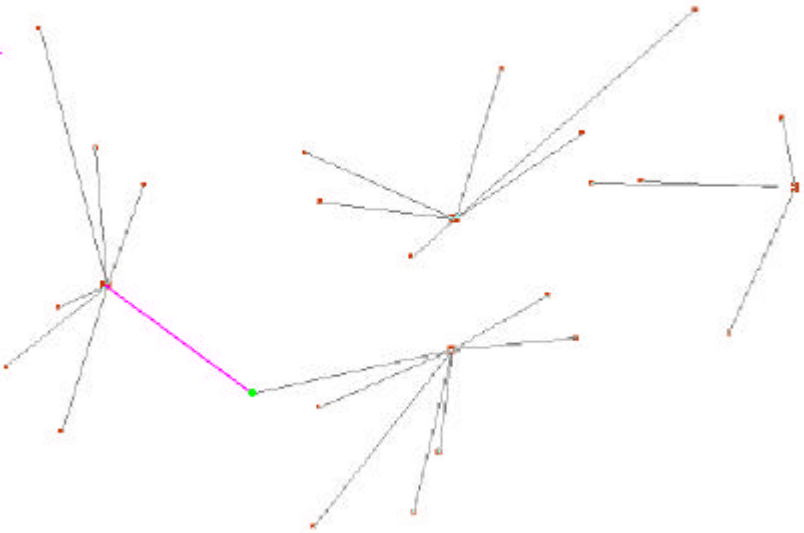
Graph model (subscribers in nodes)

= >

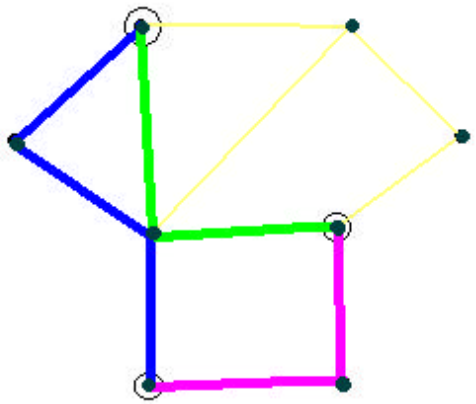
# Routing planning

***Dual homing (load sharing) -*** overflowing traffic is divided with predefined coefficient *a*

***Disjoint Routing Problem of Virtual Private Networks (VPN)*** – demands must be routed through a network so that their paths do not share common nodes or links



***Combinatorial optimization***

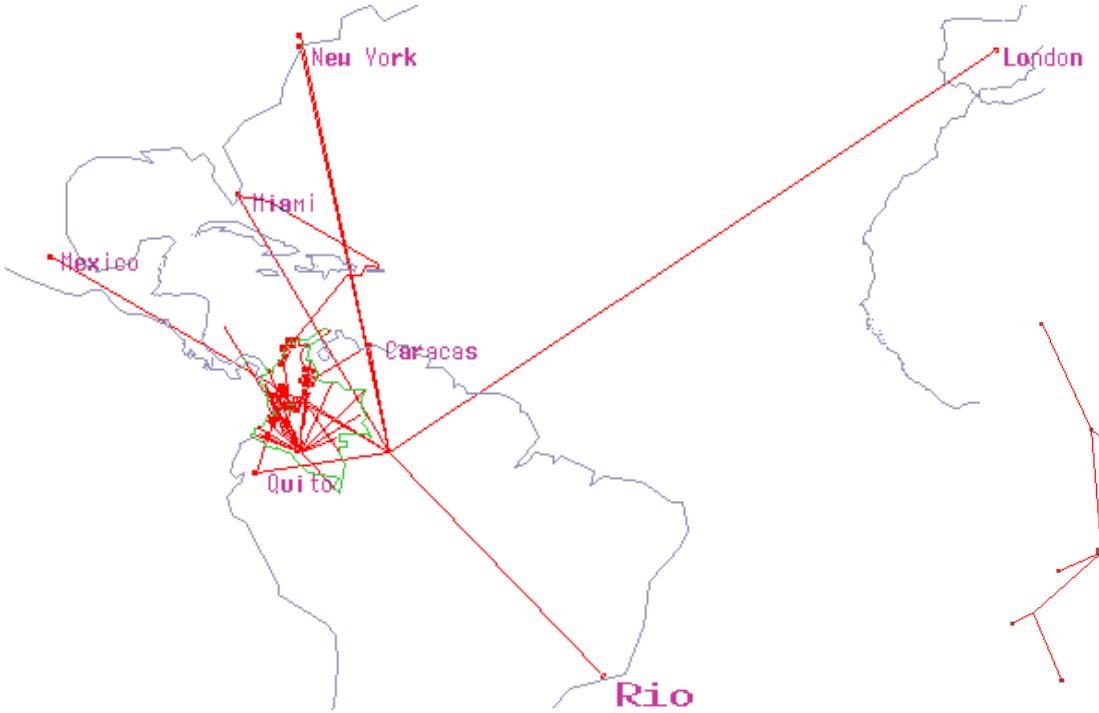


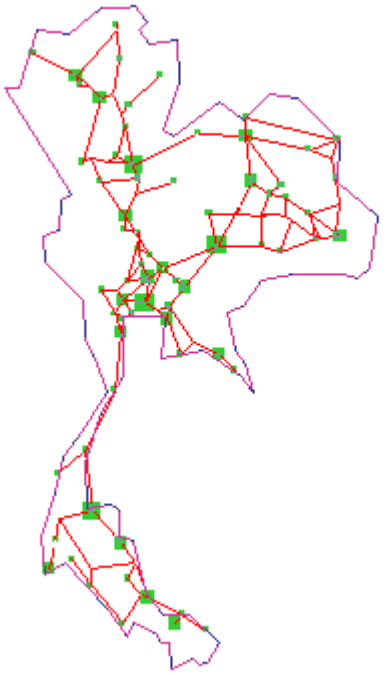
***disjoint routing***

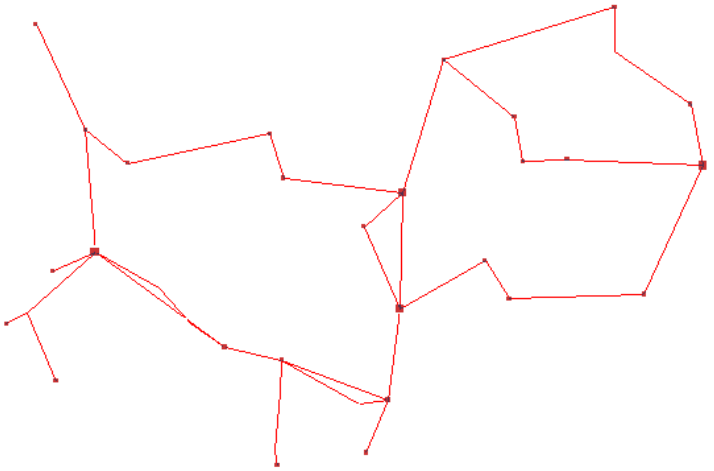
methods for ***non-hierarchical routing*** optimize routing and simultaneously optimally dimension link capacities

# Transmission planning

***Based on circuit/bandwidth matrix and transmission node/link data***





# Network Planning Strategies for Evolving Network Architectures

## CONCLUSION

**Evolution towards next generation network have to be considered very carefully on the bases of intensive network planning**