



# ITU / BDT regional seminar Network Planning for the CEE, CIS and Baltic

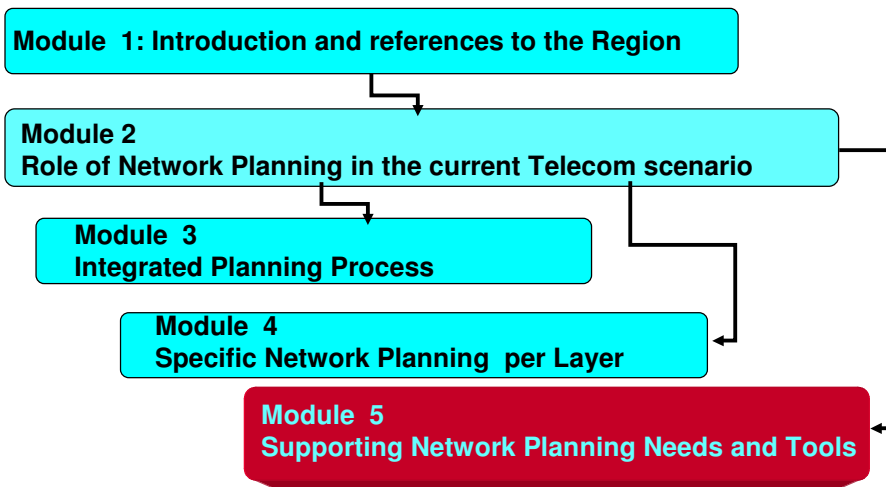
Belgrade, Serbia and Montenegro, 20–24 June 2005

## Supporting Network Planning Tools

Oscar González Soto  
ITU Consultant Expert  
Strategic Planning and Assessment



## BDT workshop on Network Planning



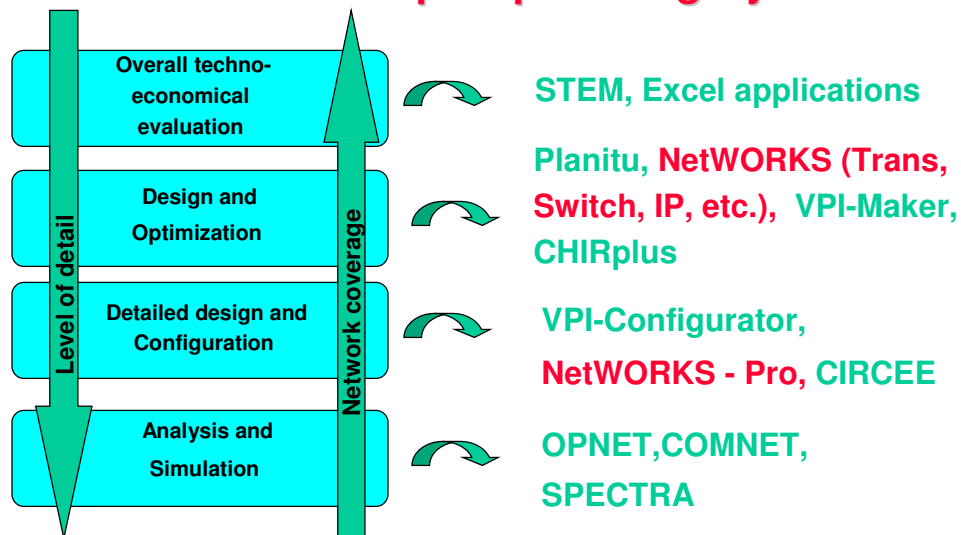


## Network Planning Tools Content

- Objectives and classification for the different tool types
  - Overall techno-economical evaluation
  - Network design and optimization
  - Network evaluation and simulation
  - Tool mapping per class



## Network Planning Tools: Tool examples per category





## Network Planning Tools: NetWORKS

Telecom  
Network  
Planning

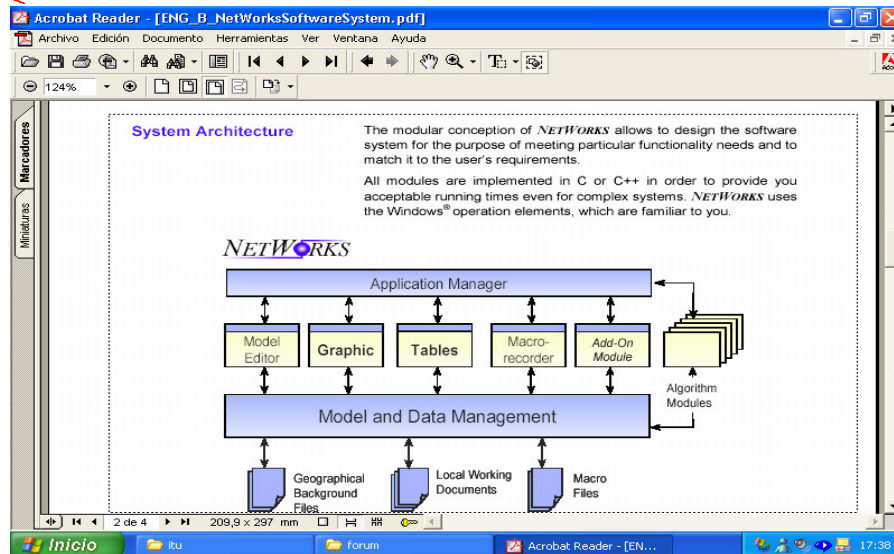


**Objective :** NetWORKS by  
Detecom (Germany) is a Telecom  
network planning tool to design,  
optimize, dimension and  
document several network layers  
and technologies as: Switching,  
Transmission, Cable, Mobile, IP,  
Signalling, etc.

[networks.info@detecon.com](mailto:networks.info@detecon.com)

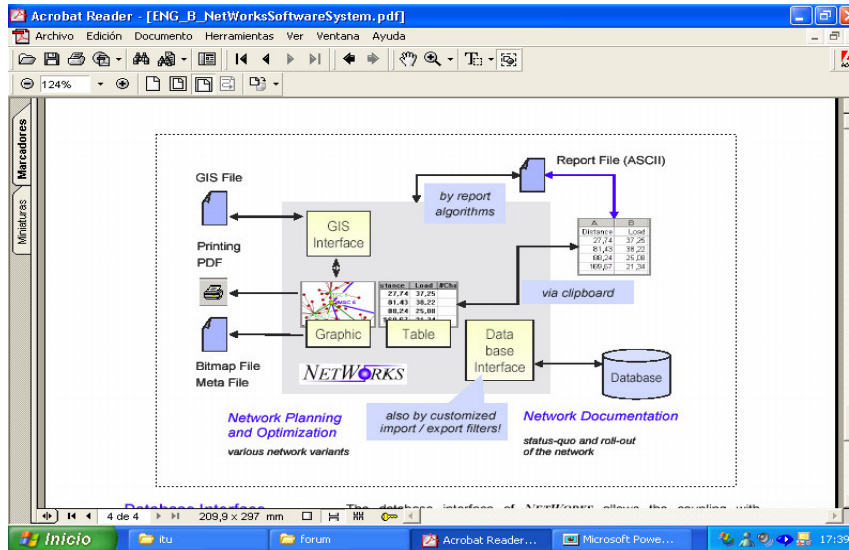


## Network Planning Tools: NetWORKS





# Network Planning Tools: NetWORKS



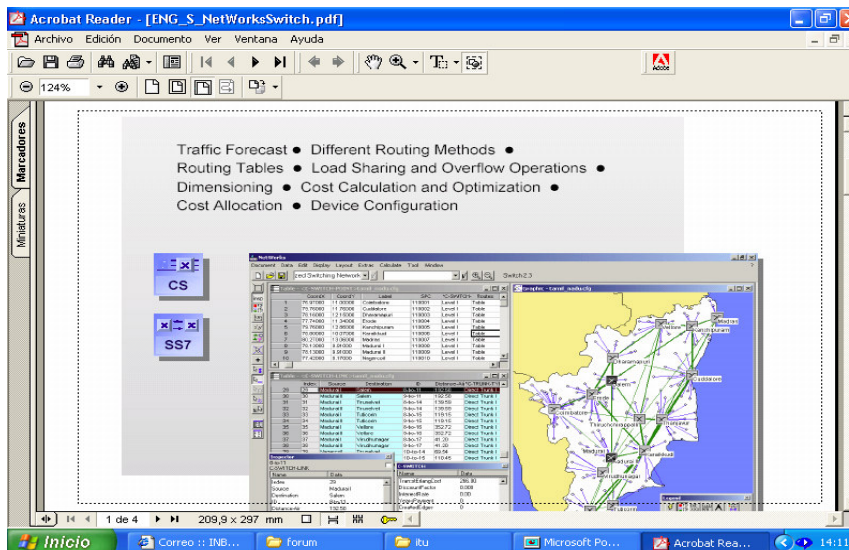
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# Network Planning Tools: NetWORKS



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# Network Planning Tools: NetWORKS

Acrobat Reader - [ENG\_S\_NetWorksSwitch.pdf]

Network Model

The network model used in *NetWORKS-Switch* comprises three layers. The upper layer uses the technical resources of the lower layer. The picture shows essential components of the model (without signalling network).

TRAFFIC  
Teletraffic  
(Services)

SWITCH  
Switching  
Systems

TRANS  
Transmission  
Systems

ERL-TRAFFIC-POINT

ERL-TRAFFIC

Traffic Relation  
C-SWITCH-TRAFFIC

Configuration

Assignment

C-SWITCH-POINT

C-SWITCH-LINK

C-ACCESS-POINT

C-INTERC-POINT  
Network Gateway

Assignment

Bandwidth Demand  
TRANS-CONNECTION

TRANS-POINT

TRANS-ROUTE

TRANS-LINK

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# Network Planning Tools: NetWORKS

Acrobat Reader - [ENG\_S\_NetWorksSwitch.pdf]

Presentation

- ⇒ Edition
- ⇒ Calculation
- ⇒ Optimization
- ⇒ Documentation

Calculate

- Traffic Engineering
- Access Network
- Non-hierarchical Network
- Hierarchical Network
- SS7 Network
- Transport Network
- Teletraffic Theory
- Universal
- Settings

*NetWORKS-Switch* supports you in these steps during the planning process for hierarchical and non-hierarchical switching networks. It also allows the planning of signalling networks (SS7). The focus is on

- Editing of traffic data for planning
- Forecasting of traffic matrices
- Building of transit switches for hierarchical networks
- Calculation of loads and capacities including dimensioning with considering load sharing or traffic overflows
- Calculation of end-to-end blockings
- Optimization of trunks of an overflow structure
- Dimensioning of network gateways
- Estimation of signaling traffic
- Determination of the demand for signaling channels between the signaling nodes
- Detailed allocation of the 64kbit/s-channels (with payload, signaling traffic, semi-permanent connections,...)
- Configuration of switching nodes with modules and ports
- Estimation of costs
- Generation of routing tables for switches and reports for dimensioning the trunks
- Finding out of the demand for transmission channels for the underlying transmission network.

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# Network Planning Tools: NetWORKS

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### Network Model

The network model used in *NETWORKS-Switch* comprises three layers. An upper layer uses the technical resources of a lower layer.

- TRAFFIC - Layer that contains traffic sources and traffic relations.

The SWITCH layer differs between non-hierarchical and hierarchical networks. In non-hierarchical networks all exchanges are of equal status. The direct trunks form (almost) a full-meshing, the overflow routes are not more than 2 hops long. In hierarchical networks two network levels are created. The traffic overflow is implemented in the order Direct trunk -> Second trunk -> Final trunk / Mesh trunk.

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# Network Planning Tools: NetWORKS

Acrobat Reader - [TRANS-E.PDF]

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### Application Trans

## NETWORKS

### Planning and Optimization of SDH and PDH Transmission Networks

*NETWORKS-Trans* is an application for specialists who are mainly confronted with PDH and SDH transport networks and who have to deal with complex problems regarding

- Optimization of partly meshed and ring-like network structures.
- Consideration of a given infrastructure (fiber-optic cables, ducts).
- Routing of end-to-end connections by various criterions, with protection if required.
- Calculation of loads and capacities needed for protection facilities.
- Dimensioning of rings.

- Design* - considering sites and links, demand (end-to-end relations), its paths over sites and links, and the loads and capacities of sites and links (both cable points / links and duct points / links can be considered optionally)
- Configuration* - considering devices, fibers/microwave channels, transmission systems at different mapping levels and splitted demand (end-to-end connections) and its path over devices and fibers / microwave channels

#### Network Model

The network model used in *NETWORKS-Trans* comprises three layers. An upper layer uses the technical resources of a lower layer.

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## Network Planning Tools: NetWORKS

**Application Trans**

Planning and Optimization of SDH and PDH Transmission Networks

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■ *Configuration* - considering devices, fibers/microwave channels, transmission systems at different mapping levels and splitted demand (end-to-end connections) and its path over devices and fibers / microwave channels

**Network Model**

The network model used in *NETWORKS-Trans* comprises three layers. An upper layer uses the technical resources of a lower layer.

- TRANS - Layer that contains devices, fibers.

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## Network Planning Tools: NetWORKS

⇒ **Presentation**

⇒ **Edition**

⇒ **Calculation**

⇒ **Optimization**

⇒ **Documentation**

*NETWORKS-Trans* supports you in these steps during the planning process for PDH, SDH and WDM transport networks. The focus is on

- Comparison of different network structures (e.g. partly-meshed and ring-like network structures)
- Consideration of a given infrastructure (e.g. fiber-optic cables, microwave systems, ducts)
- Routing of end-to-end connections by various criteria over disjoint paths
- Possible protective strategies
- Calculation of loads and capacities including dimensioning of rings
- Detailed allocation and grouping of containers
- Configuration of devices (multiplexers, cross-connectors etc.) in the network nodes
- Estimation of costs
- Analysis of utilization of network capacities and finding out the bottlenecks
- Generating reports on routing, dimensioning, configuration and demand for devices and modules
- Calculation of end-to-end availabilities.

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# Network Planning Tools: NetWORKS

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Design of Ring-like and Partly-meshed Networks • Various Routing Methods • Protective Strategies • Dimensioning • Calculation and Optimization of Costs • Cost Allocation • Allocating and Grouping • Device Configuration

PDH  
SDH  
WDM

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# Network Planning Tools: NetWORKS

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Bandwidth Demand Configuration

TRANS-POINT TRANS-CONNECTION TRANS-LINK

TRANS Transmission Systems

CABLE-POINT CABLE-LINK CABLE-PATH Assignment

CABLE Cables / Microwave Systems

DUCT-POINT DUCT-LINK DUCT-PATH Assignment

DUCT

DTXCON Telecommunications Engineering and Management Consultancy

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## Network Planning Tools: NetWORKS

Access and Core Networks • Traffic Planning for Different Services • Different Routing Approaches • Routing Tables • Dimensioning • Cost Calculation • Cost Allocation • Device Configuration

GSM  
GPRS  
UMTS

1 de 4 209,9 x 297 mm

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## Network Planning Tools: NetWORKS

→ Presentation  
→ Edition  
→ Calculation  
→ Optimization  
→ Documentation

**NETWORKS-Mobile** supports you in these steps during the planning process for 2G- and 3G-mobile fixed-line networks. The focus is on:

- Traffic planning for different services
- Cost and capacity-oriented design of the access areas (the connections BTS-BSC, BSC-MSC, NodeB-RNC, RNC-MSC) with taking into account the differences of the logical and physical structures
- Determination of loads and capacities including dimensioning under consideration of load sharing or traffic overflow among the MSCs and with reference to the gateways in the core network
- Configuration of locations with devices including modules and ports
- Estimation of costs
- Generation of the routing tables for the MSCs
- Generation of reports
- Determination of the demand for transmission channels for the underlying transmission network.

In many cases there is a decentralized planning of the access networks by the subsidiaries of a network operator. For doing so, an important basis are the dumps from a network database. The application **Mobile Access** shows you the whole planning process in a clear and flexible way.

Planning the core network (with MSCs and gateways), however, has to be done by the operator's headquarter. Also in this case the access to a network database is useful. By using the application **Mobile Core**

2 de 4 209,9 x 297 mm

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# Network Planning Tools: NetWORKS

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Network Model

The complex network model used in *NETWORKS-Mobile* comprises three vertical layers, the upper one of which is divided again into three horizontal layers. The upper layer uses the technical resources of the lower layer.

Due to the high complexity of 2G-/3G-mobile fixed-line networks, there are many different groups of objects (nodes, edges, relations, paths, sets, meta data) in the layers. The following picture is an example for showing the connection of the nodes of the 2G-/3G-access network to the core network in the MOBILE layer. The majority of these nodes rest on underlying FR, IP or ATM nodes (terminals, routers, switches) and SDH nodes (terminals, multiplexers).

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# Network Planning Tools: NetWORKS

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and SDH nodes (terminals, multiplexers).

For GSM and GPRS there are separate structures in the core network. The UMTS traffic is also handled in 3G-R3 over them. The network model already provides object groups for a UMTS core network based on packet switching. This enables to do strategic calculations for the medium-term planning.

Additionally, there are several functionalities of *NETWORKS-ATM* and *NETWORKS-Trans* made available by the integration of appropriate planning modules.

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# Network Planning Tools: NetWORKS

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Minisaturas

Marcadores

**NETWORKS - ATM**

for the Planning of Networks with ATM Technology

Traffic Planning • Network Design • Capacity Planning • Cost Calculation • Cost Allocation • Documentation of Allocation (VCI, VPI) • Device Configuration

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# Network Planning Tools: NetWORKS

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Minisaturas

Marcadores

⇒ Presentation

⇒ Edition

⇒ Calculation

⇒ Optimization

⇒ Documentation

**NETWORKS-ATM** supports you in doing these steps during the planning process for ATM technology networks. The focus is on

- Displaying different services resting on ATM and describing them with traffic parameters,
- Finding appropriate network topologies,
- Determining the required resources in case of a given QoS,
- Defining routing strategies, addressing schemes and network levels,
- Assigning identifiers for VC (*virtual channels*) and VP (*virtual paths*),
- Configuring the ATM network elements (switches).

**Network Model and Planning Ways**

The network model defines an ATM layer which can be related to adjacent layers. There are three phases of the planning process with **NETWORKS-ATM**:

**Design**

With taking into account the device locations, the transmission secti-

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# Network Planning Tools: NetWORKS

The diagram illustrates the network architecture between ATM and TRANS (PDH/SDH) transport networks. It shows the flow of bandwidth demand from the TRANS network through various links (TRANS-CONNECTION, ATM-DEVICE-LINK, VPI, VP-LINK, VPC-DEMAND, VPC-LINK, VCC-DEMAND) to the ATM network. Key components include ATM-DEVICE-POINT, VCI (virtual channel identifier), and VPI (virtual path identifier).

Source	Destination	Routing	Service Type	Line/Contract	Class	Class 1	Class 2	Class 3
Tototocaplan	Janday	AAL2	VCB	VCB	Class 1	3.00	1.50	
Puerto Barrios	Tototocaplan	AAL2	VCB	VCB	Class 1	3.00	1.50	
Colem	Puerto Barrios	EFM	EFM	EFM	Class 2	2.00	2.00	
Zucap	Metapan	EFM	EFM	EFM	Class 2	2.00	2.00	



# Network Planning Tools: NetWORKS

**Algorithms and other Application Functions**

Many application functions of *NETWORKS-ATM* are *algorithms* which you can setup to and run on your given model. This enables you to follow your individual planning line according to your specific planning task.

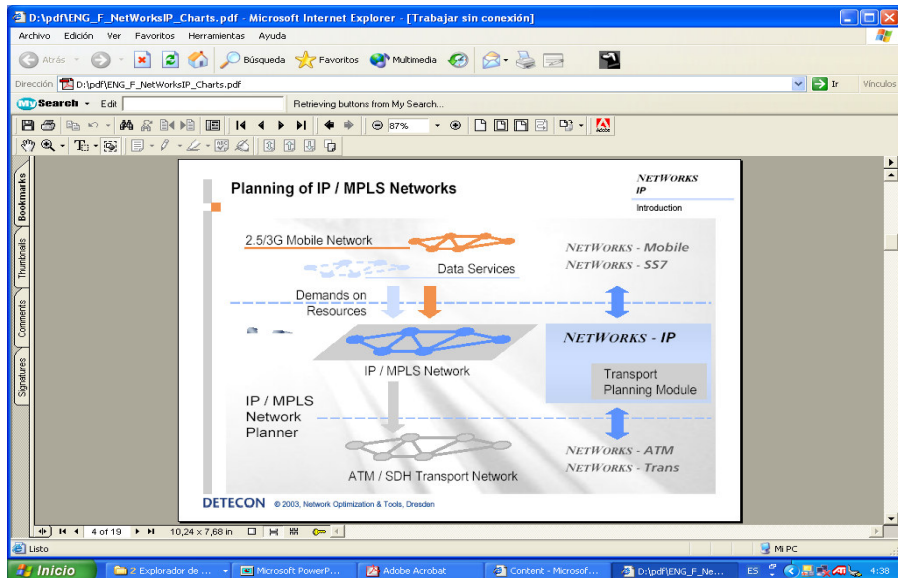
*NETWORKS-ATM* also extends the graphical and tabular functions considerably. Some typical *application functions* are:

- Planning of ATM traffic contracts (see dialog example)
- Definition of the routing in specific routing dialogs for each individual VCC or VPC
- Tracing the allocation of the physical containers and displaying their utilization
- PNNI configuration
- Device catalog and configuration view for the nodes
- Customized import and export filters for the coupling with databases.

**Display of utilization of a physical link (ATM-DEVICE-LINK) by VCC and VPC**



# Network Planning Tools: NetWORKS



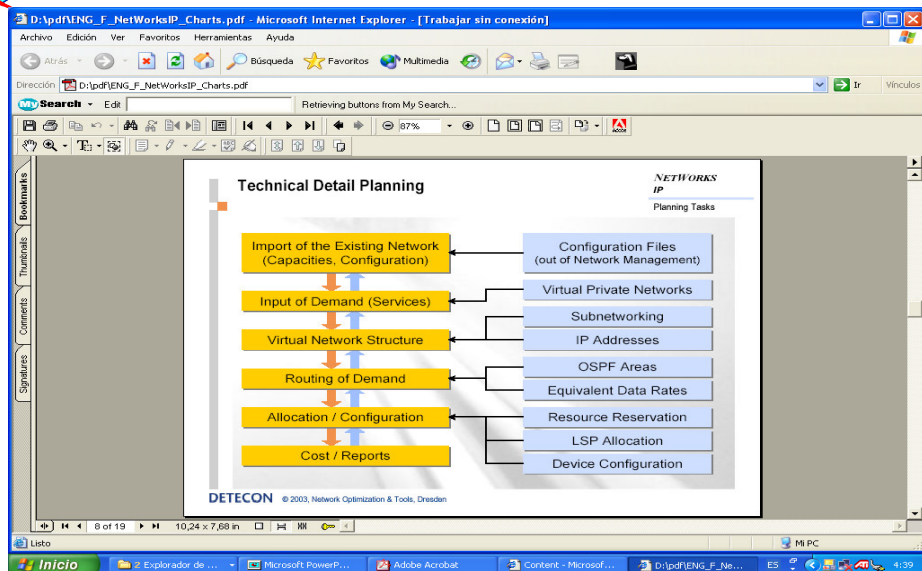
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# Network Planning Tools: NetWORKS



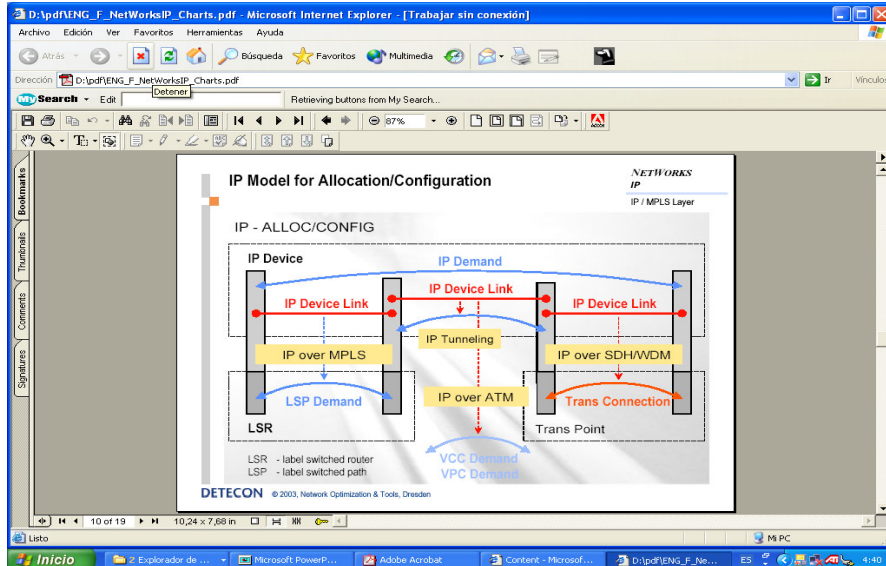
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# Network Planning Tools: NetWORKS



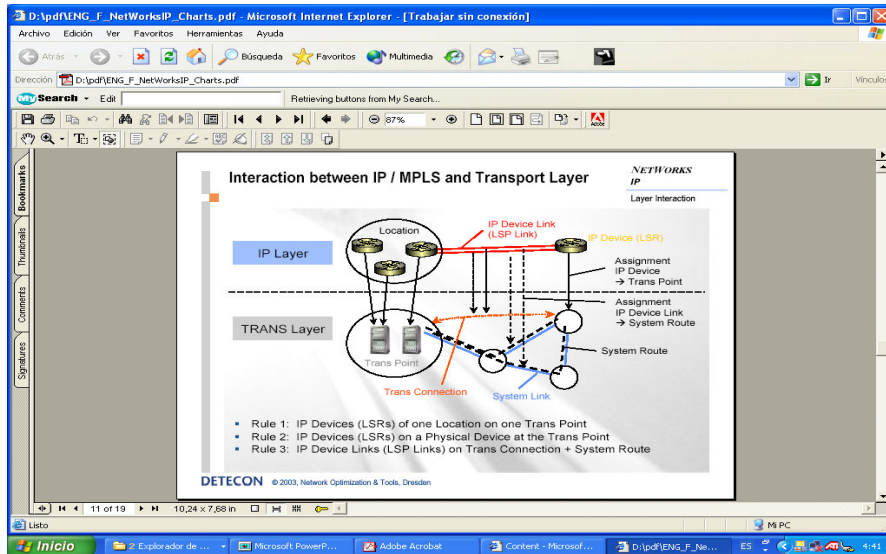
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# Network Planning Tools: NetWORKS



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# Network Planning Tools: NetWORKS

The screenshot displays the NetWORKS software interface with several windows open:

- Table -> IP\_DEVICE (26) -> demo.cfg:** A table listing network devices with columns for Index, Name, Country, ID, Label, Type, Level, and Position. It lists devices for various cities like Cologne, Frankfurt, Hamburg, Munich, Leipzig, and Berlin.
- Table -> Interface (26) -> demo.cfg:** A table listing network interfaces with columns for Name, IP Address, Priv., Type, and Description. It includes interfaces like FastEthernet0/0, Serial2/2/0, Serial2/1/0, Serial2/2/1, Serial2/0/0, Serial2/3/1, Serial1/0/0, and Serial2/3/0.
- Schematic Display -> demo -> ipcfir2:** A network diagram showing nodes and connections with utilization values. A legend indicates:
  - IP-LEVEL: Customer Edge (blue), Provider (green), Provider Edge (red), Server (yellow)
  - DISPLAY: Utilization ( $u < 0.8$ ) (green), Utilization ( $0.8 < u < 1$ ) (orange), Overbooked ( $u > 1$ ) (red)
- Map:** A map of Europe with nodes placed on various cities.

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# Network Planning Tools: NetWORKS

The screenshot shows a presentation slide for NetWORKS - Pro software. The slide content includes:

- NETWORKS - Pro**
- Flexible Algorithms for Different Network Types and as a Platform for Applications**
- Generation and Optimization of Node and Edge Structures**
- Traffic Forecast and Distribution**
- Routing**
- Dimensioning**
- Cost Calculation and Optimization**
- Reliability Analysis**
- Universal Algorithms**

The slide also features a small inset image of the software interface and a Windows taskbar at the bottom showing the 'Inicio' button and several open applications.

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# Network Planning Tools: NetWORKS

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## Flexible Algorithms for Planning and Optimization Various Telecommunications Networks

*NETWORKS-Pro* is an application for high demands on flexibility in planning and optimization of telecommunications networks regarding

- various technologies (PDH, SDH, ATM, GSM, circuit and packet switching).
- various network architectures (access networks, backbone networks; variable number of network levels, several network layers).
- various network structures (star, tree, chain, mesh, ring).
- various dimensioning rules (multiplexing, formulas of teletraffic theory, cost-relevant dependencies).
- various routing approaches (non-hierarchical, quasi-hierarchical, hierarchical; with gateways, with hubs).
- various cost functions (linear, partly linear, variable formulas).

Each more or less complex planning step has been consequently implemented as an separate algorithm. So you get the possibility to follow your own planning way according to a special planning task. The tool does not force you to use it in a certain order.

In addition each algorithm has access to all data elements defined in the model (items, parameter, matrices) both as input and output values for an algorithm (see below the example of a routing algorithm).

### Methods of Operations Research

The following methods of graph theory, queuing theory and reliability theory as well as integer and heuristic optimization are implemented in algorithms of *NETWORKS-Pro*:

- Shortest paths in graphs (Dijkstra, Floyd, LC-FIFO with hop number restriction).
- Shortest disjoint paths in graphs (Hackbath, Suurballe).

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# Network Planning Tools: NetWORKS

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- Presentation
- Edition
- Calculation
- Optimization
- Documentation

*NETWORKS-Pro* supports you in doing these steps during the planning and optimization process for different highly flexible telecommunications networks. The focus is on:

- various technologies (PDH, SDH, WDM, IP, ATM, GSM, GPRS, UMTS).
- various network architectures (access networks, backbone networks; variable number of network levels, various network layers).
- various network structures (star, tree, chain, mesh, ring).
- various dimensioning rules (multiplexing, formulas of teletraffic theory, cost-relevant dependencies).
- various routing approaches (non-hierarchical, quasi-hierarchical, hierarchical).
- various cost functions (linear, piecewise linear, variable formulas).

*NETWORKS-Pro* is characterized by

- completely free modeling, even with physical and logical layers in one model,
- a comprehensive algorithm pool which can be arranged individually,
- user-definable planning cycles which can be matched to the relevant problem,
- editable menus for determining standard planning cycles for recur...

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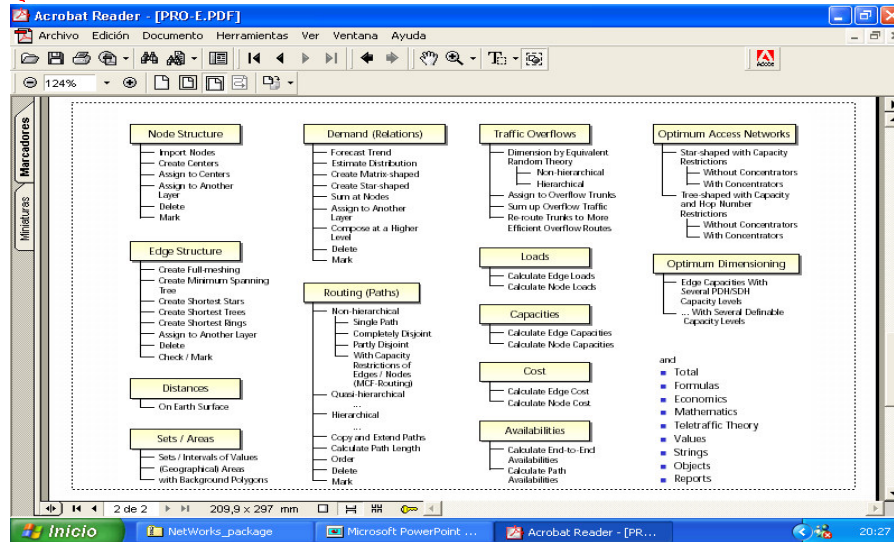
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## Network Planning Tools: NetWORKS



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## Network Planning Tools: NetWORKS

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