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## **5. Würzburger Workshop**

### **"IP-Netzmanagement, Netzplanung und Optimierung"**

# **Planning and Optimisation for Hybrid Fibre-VDSL Access Networks with Tabu Search**

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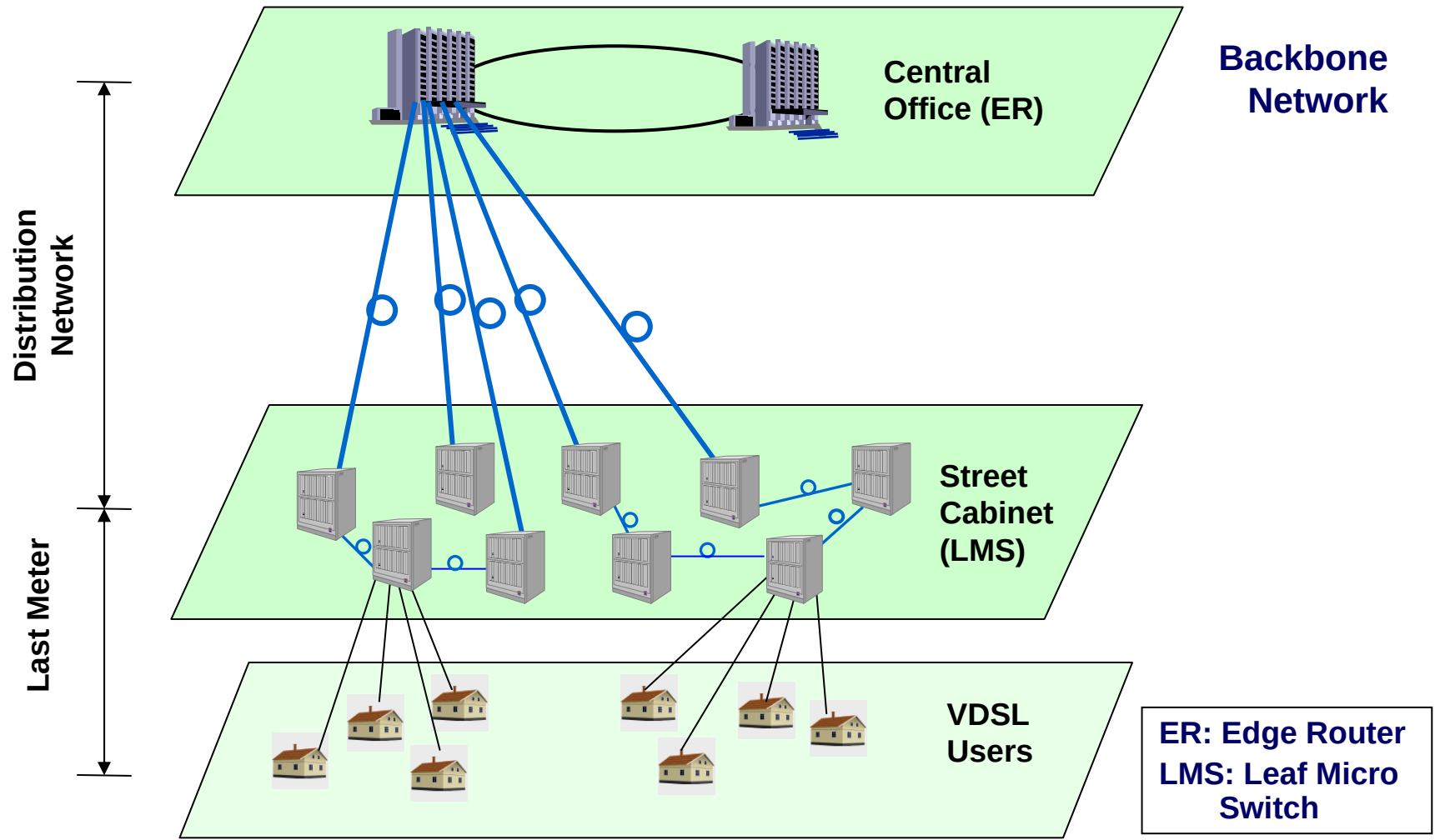


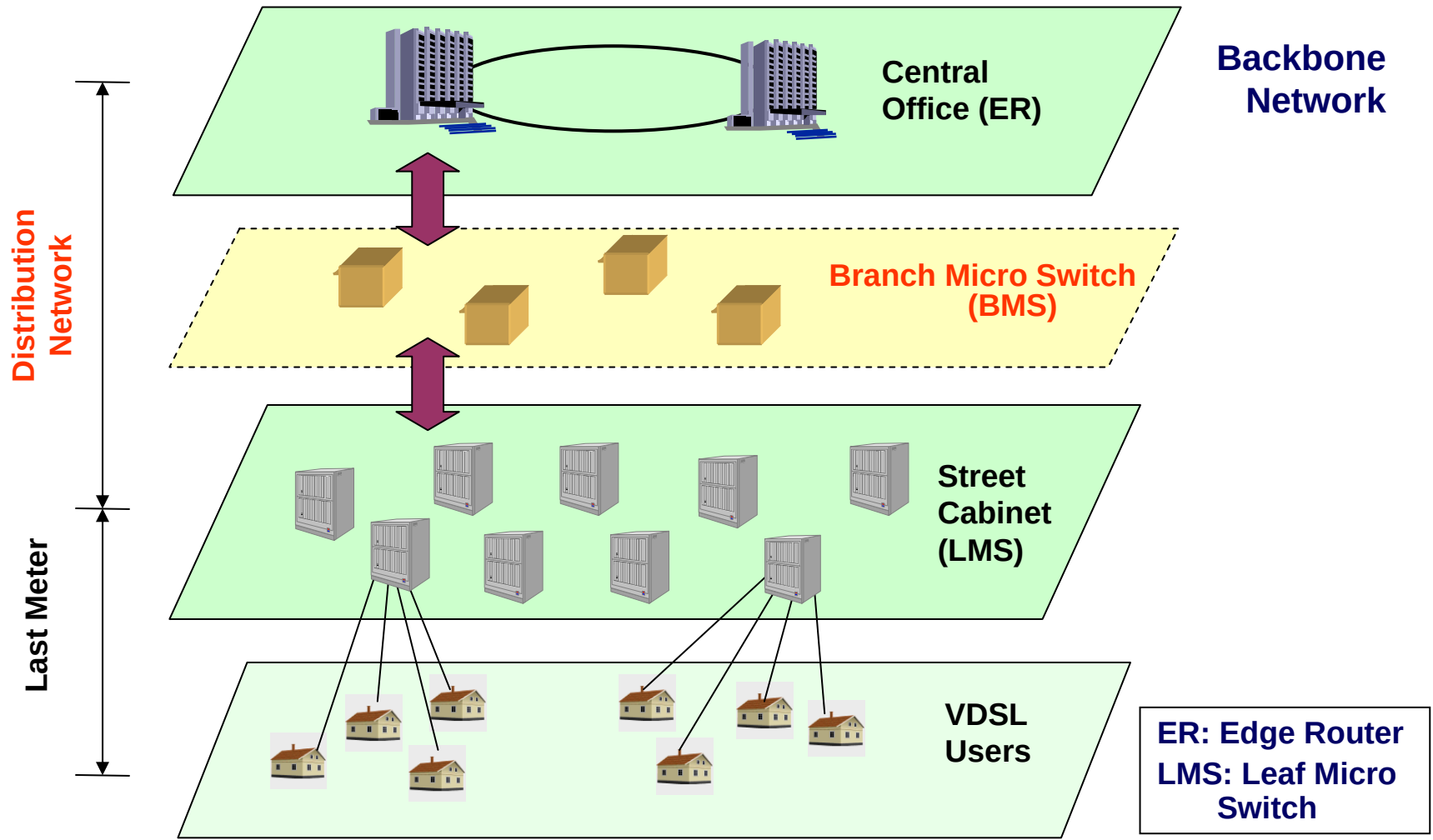
- Motivation
- Hybrid Fibre-VDSL access networks
- Statement of Problem
- Tabu Search
- Optimisation and results analysis
- Conclusions

- DSL (**D**igital **S**ubscriber **L**ine)
  - Based on the existing copper telephone line – “Last meter”
  - Bit rate: from 1 Mbps up to 52 Mbps
- DSL: the most popular broadband access technology (*from “DSL Forum”*)
  - By March 31, 2005: 107 million subscribers worldwide
  - Estimation: 500 million by 2010
- VDSL 2: the latest specification for standard DSL by *ITU-T (G.933.2)* on May 27, 2005
  - 25 Mbps up to 100 Mbps for Both up and downstream
  - Application for HDTV, Video on Demand, Video conference, etc.

# Hybrid Fibre-VDSL Access Networks (HFVAN)

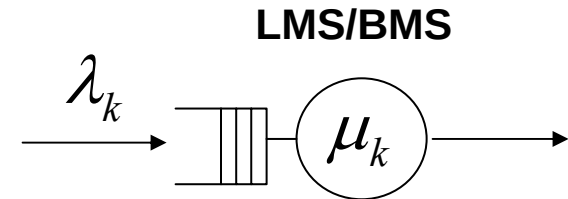
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- Mean delay for LMS or BMS (M/M/1)

$$E\{T_k\} = \frac{L}{\mu_k - \lambda_k}, \quad \begin{array}{l} \mu_k: \text{Service rate} \\ \lambda_k: \text{total arrival rate} \\ L: \text{packet length} \end{array}$$



- Mean end-to-end network delay of HFVAN

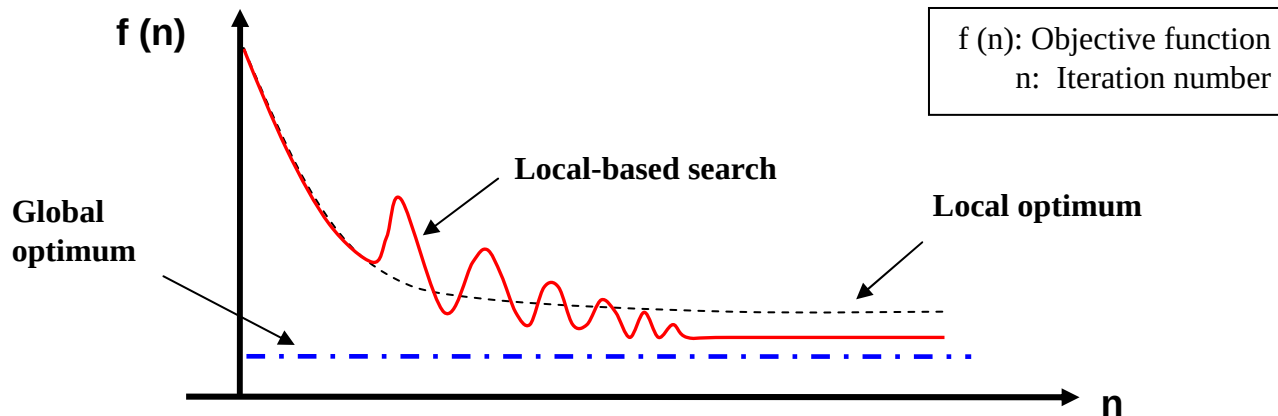
$$E\{T\} = \frac{1}{\gamma} \cdot \sum_{k=1}^K \frac{\lambda_k}{\mu_k - \lambda_k}, \quad \gamma: \text{network total traffic}$$

- Reliability: “*two-connected edges*”, as the simplified approach, solves single link failure subject to the constraints of network elements

- Analysis of modelling
  - Nodes (ER/BMS/LMS): e.g.  $N=50$ 
    - > Links:  $50 \cdot 49 / 2 = 1225$
    - > Potential topologies:  $\sim O(n^{1225})$
  - With multiple constraints for Up- and Downstream

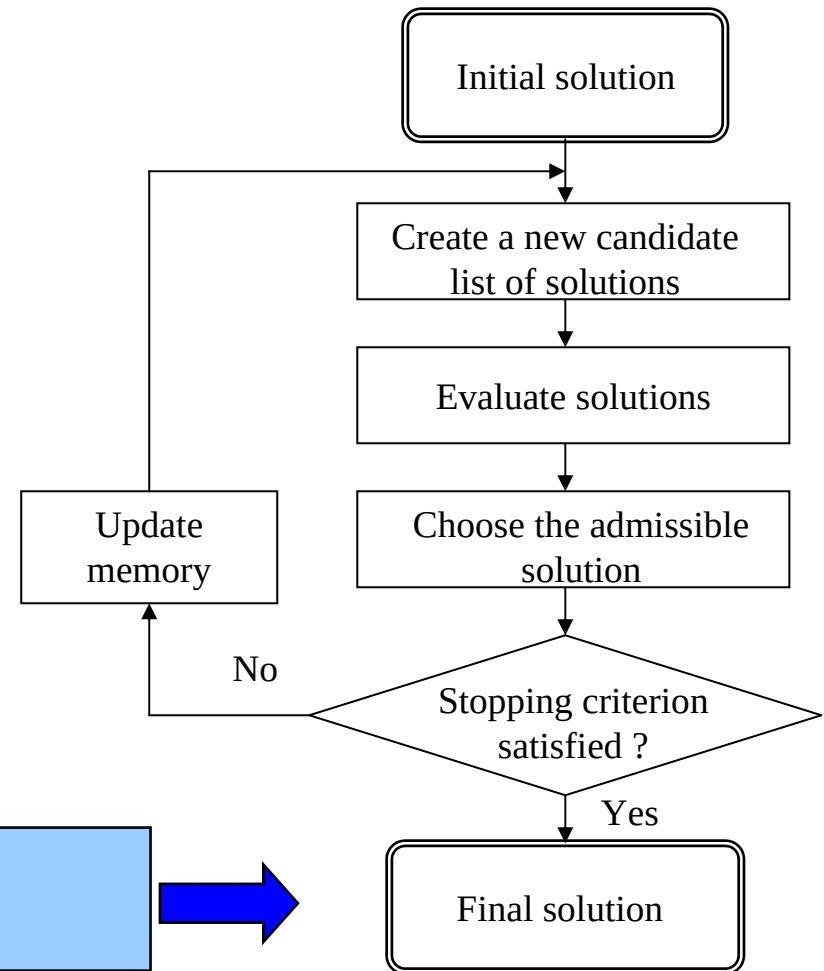
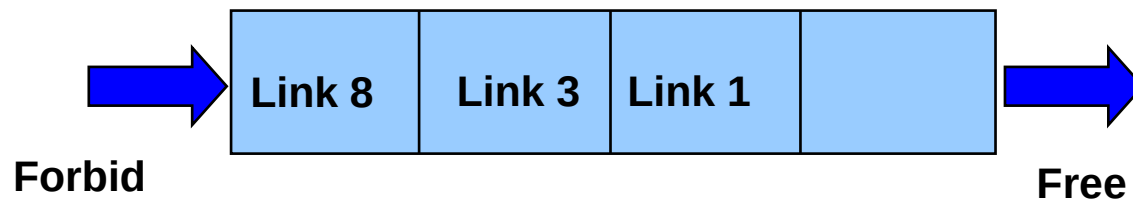
**Hierarchical planning and optimization of Hybrid Fibre-VDSL Access Networks is NP-hard Problem**

- Local-based Search
  - Simulated Annealing (SA)
  - **Tabu Search (TS)**
- Evolution and computational Intelligence
  - Genetic algorithm
  - Fuzzy systems
  - Neural networks
  - Particle swarm optimization, etc.

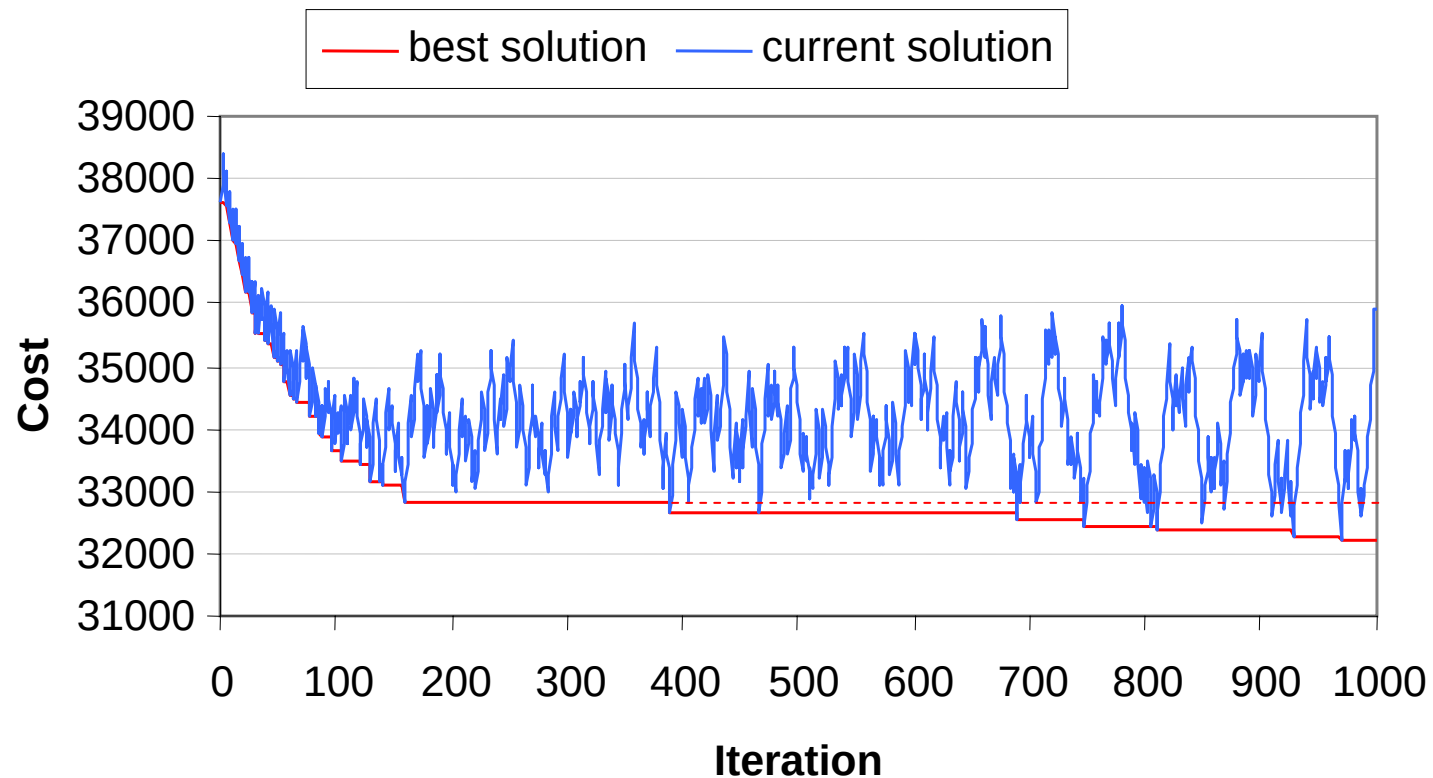




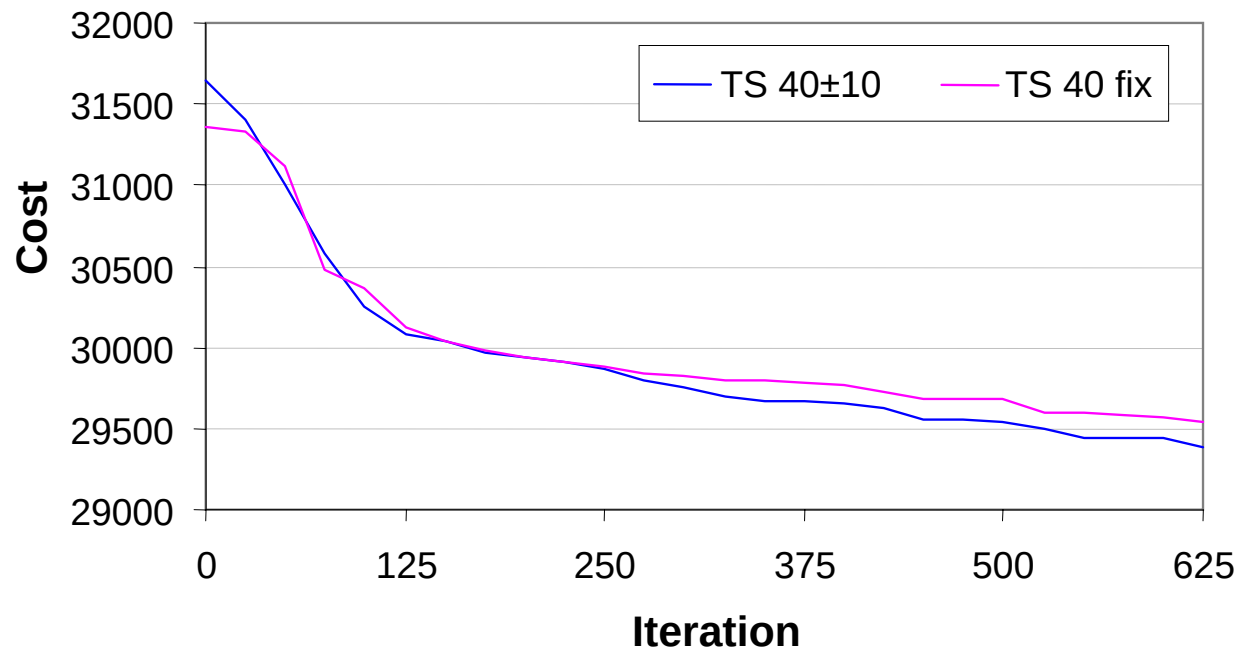
- Tabu Search:  
makes use of a Tabu List  
to forbid the previously  
visited search space
  - Tabu list (add/drop)
  - Tabu length
  - Candidate list
  - Enhanced criterion  
(intensification and  
diversification)



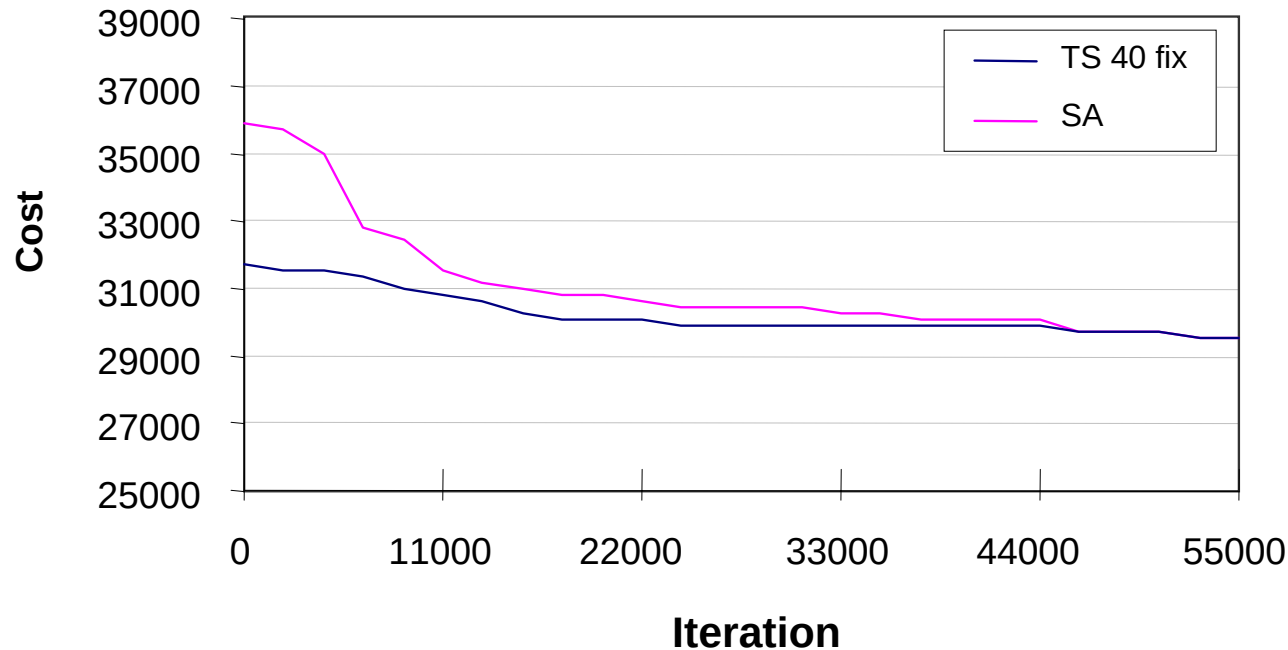
- Optimisation process with Tabu Search
  - Tabu length: 40

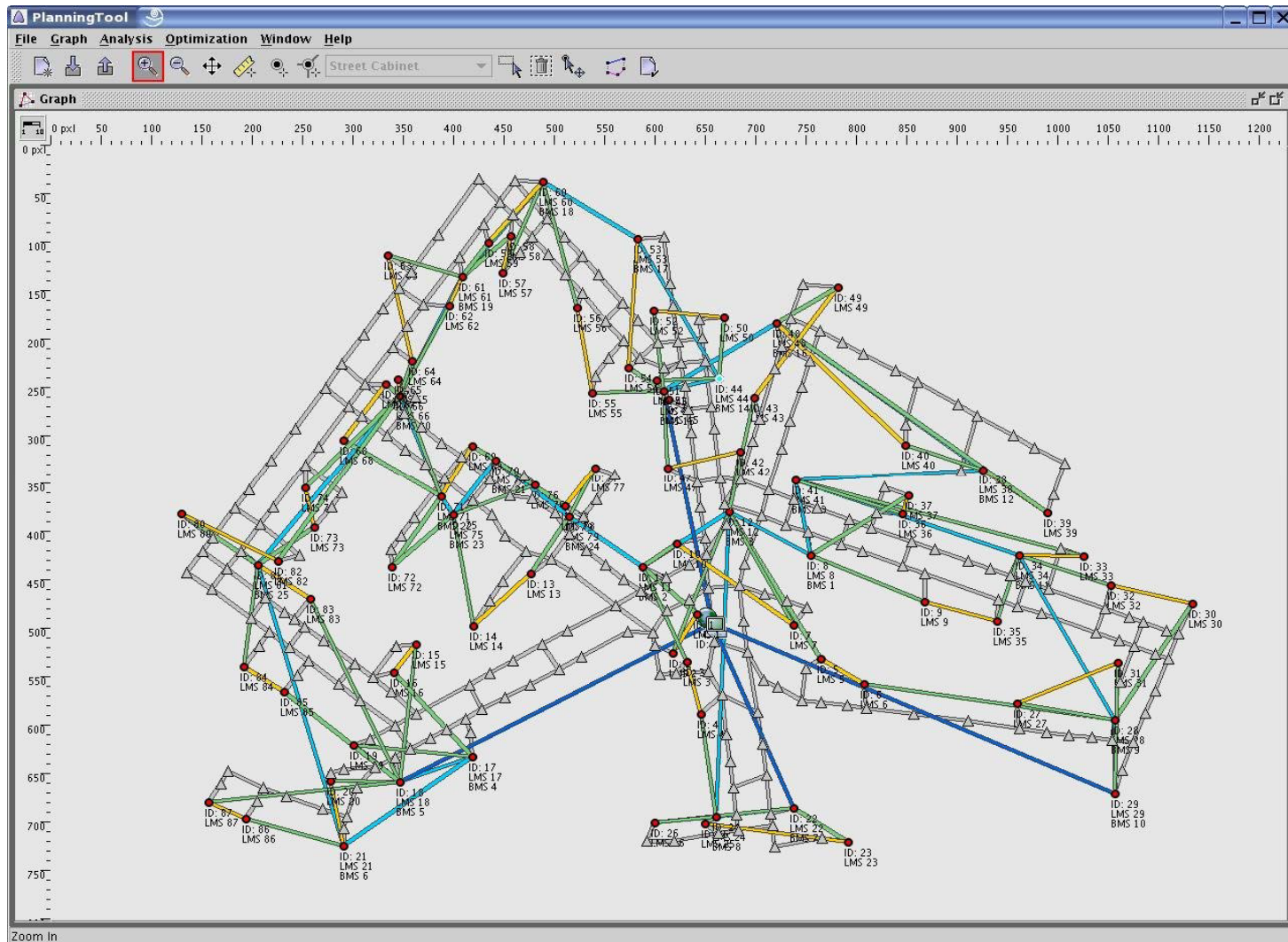


- Tabu Search with fix & adaptive Tabu list



- Tabu Search (TS) in comparison with Simulated Annealing (SA)





- Hybrid Fibre-VDSL access networks (HFVAN) is an efficient access solution with hierarchical structure
- Planning and optimisation of HFVAN is NP-Hard problem
- Mean delay and reliability are important factors for planning and optimisation of HFVAN
- Tabu Search adopting deterministic conditions accelerates the search process
- Tabu Search with adaptive Tabu length can improve the quality of optimisation
- Further investigation with reliability and other heuristic algorithms are meaningful

**Thank you!**

