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Adalah benar telah melakukan presentasi makalahnya yang berjudul **"Joint Optimization Of Data Network Design and Faculty Selection by Using Linear Programming Method"** di University of Malaya, Malaysia pada tanggal 27 Maret 1997 dalam rangka Technical Exchange Program di Malaysia (25 s.d 30 Maret 1997).

Demikian surat keterangan ini diberikan kepada yang bersangkutan untuk digunakan sebagaimana mestinya.

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JOINT OPTIMIZATION OF DATA NETWORK DESIGN AND FACILITY SELECTION BY USING LINEAR PROGRAMMING METHOD

by

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JOINT OPTIMIZATION OF DATA NETWORK DESIGN AND FACILITY SELECTION BY USING LINEAR PROGRAMMING METHOD

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ABSTRACT

The goal of optimal network design and facility engineering is to arrive at network topologies that minimize total network cost while selecting facility types, allocating capacity, and routing traffic to accommodate demand and performance requirements. This research describes a data network design model based on a Mixed Integer/Linear Programming (MILP) formulation, as do most other approaches, separate link capacity and facility selection from routing and topological design, it fully integrates these processes to capture the very important couplings that exist between them.

We show that our formulation leads to a natural decomposition of the optimal design problem into two subproblems solvable sequencially. We present a linki reduction algorithm that efficiently design single or multifacility networks. This algorithm is based on a special-purpose monotonic greedy drop heuristic procedure.

INTRODUCTION

The goal of optimal network design and facility engineering is to generate network topologies that minimize total network cost while selecting facility types, allocating capacity, and routing traffic to accommodate demand and performance requirements. Performance constraint, like average network delay for data networks or end-toend blocking probabilities for circuit-switched networks and link/node cost function, introduce nonlinearities into optimum design models.

Due to the complexity of the optimal network design problem, Gerla and Kleinrock originally decomposed it into three nonlinear subproblem: optimal capacity assignment, optimal routing, and optimal topological design; however these problem are coupled. We extend the scope of the problem by including transmission facility selection into the model.

Our research describes an Mixed Integer/Linear Programming (MILP) model data network design that does not rely on direct decomposition of the problem, but integrates routing, capacity assignment, facility selection and topological design. This MILP problem is naturally decomposed into two subproblems which can be solved sequentially. The first subproblem is MILP-Reduction (MILP-R) and the second subproblem is optimal capacity assignment.

MATHEMATICAL MODEL

Now formulated our mathematical model for joint optimal topological design, capacity assignment, routing, and facility selection based on tradeoff between cost and performance.

Optimization Problem Formulation

The MILP problem is formulated as:

Minimize

$$\bar{C} = \sum_{t,mn} \left(A^t_{mn}\,\eta^t_{mn} + B^t_{mn}\,\alpha^t_{mn} \right) + \sum_{n} o_n\,\beta_n$$

Subject to

$$0 \le \beta_n \le \hat{\beta}_n$$

$$0 \le \alpha^t_{mn} \le \hat{\alpha}^t_{mn}\;\eta^t_{mn}$$

$$f^t_{mn} \le \rho^t_L\,\alpha^t_{mn} \quad and\, f_m \le \rho_N\,\beta_n$$

$$D^* \le D_0$$

$$\sum_{n,t} \eta^t_{mn} \ge M$$

given that,

$\eta^t_{mn} = 1$ if facility t on link mn of the garph G is activated

$= 0$ otherwise

The following reduced Mixed Integer-Linear Programming problem (MILP-R) for minimum-cost joint topological design, facility selection, and routing

Minimize,

$$\bar{C} = \sum_{t,mn} \left(\mathbf{A}^t_{mn}\,\eta^t_{mn} + (B^t_{mn} / \rho^t_L)\,\mathbf{f}^t_{mn} \right) + \sum_{n} (\mathbf{O}_n / \rho_N)\,\mathbf{f}_n \;.$$

Subject to,

$$f^t_{mn}/\rho^t_L \le \hat{\alpha}^t_{mn}\;\eta^t_{mn}$$

$$f_m \le \hat{\beta}_m\,\rho_N$$

$$D^* \le D_0$$

$$\sum_{S} h^k_s = \lambda^k \quad \text{dan } h^k_s \ge 0$$

$$\sum_{t,n} \eta^t_{mn} \ge M$$

$$\sum_{t} \eta^t_{mn} = 0\;,\;1$$

DISCUSSION

This research describes a data network dåsign model based on a MILP, and solution of this problem utilize the link reduction algorithm. We present a fast link reduction algorithm that efficiently design **Single and Multifacility** network. This algorithm is based on a special-purpose greedy drop heuristic procedure

The routing problem, we develop three standard algorithms for shortest path problem: **Bellman-Ford, Dijkstra**, and **Floyd-Warshall** algorithm.

PROGRESS RESEARCH REPORT

In this paper we report the progress research report, comprise:

A. Link Reduction algorithm for Single Facility as follows:

We define a topology T^V and its associated cost C^V at iteration v of the algorithm. A new topology $T_{mn}{}^V$ with cost $C_{mn}{}^V$ is constructed by deleting candidate link mn. For each candidate link mn pre-eliminated, we evaluate a $\Delta C_{mn}{}^V$ to reflectt the cost diffrential of this pre-elimination. We denote by ΔC^V the set { $\Delta C_{mn}{}^V$} of pre-elimination candidates. At each iteration v, the elimination step basically reduces the network of the pre-elimination candidate with maximum $\Delta C_{mn}{}^V$. It generates topologies, verifies a set of constraint, and perform cost comparisons as follows:

Step 0. Initialize T^0 with starting graph G, B_{mn}/ρ_L **dan** O_n/ρ_N **incrementtal cost metric,** C^0, h_s^{k0}**,** iteration v = 1.

Step 1. Pre-elimination of link mn: generates topology T_{mn}^v by eliminating a new link mn in T^V**.**

Step 2. Evaluate T_{mn}^v with respect to reliability and connectivity constrains:: if not met go to Step 1.
Else include T_{mn}^v in T^V, the set of retained topologies for iteration v

Step 3. Shortest path routing fori T_{mn}^v, compute $\Delta C_{mn}^t = C^v - C_{mn}^v \rightarrow \Delta C^v$, if every feasible link mn reduced then go to Step 4. else go to Step 1.

Step 4. Link elimination procedure:
get cost set DC^V for topologies in $\{T^V\}$, find $\max_{kl}$ $\Delta C_{kl}^v \rightarrow (\Delta C_{mn}^v, T_{mn}^v)$; if $C^v < C^{v-1}$ or $(C^v \geq C^{v-1}$ and $\sum_{mn} \eta_{mn} \geq [(\sum_k \lambda^k) D_0 - N\rho_N/(1-\rho_N)](1-\rho_L)/\rho_L)$ then $T^v = T_{mn}^v$
this defines new reference topology for the next iteration by deleting link mn, v = v + 1; Go to Step 1; else stop with solution T^{v-1} .

B. Routing Problem

The routing probelm, we can only report Bellman-Ford algorithm

Suppose that node 1 is the " destination" node and consider the problem of finding a shortest path from every node to node 1. Assume that there exist at least one path from every node to destination. To simplify the presentation, let us denote $d_{ij} = \infty$ if (i,j) is not an arc of the graph

A shortest walk from a given node i to node 1, subject to the constrain that the walk contains at most h arcs and goes through node 1 only once, is referred to as a shortest ($\leq h$) walk and its length is denoted by $d_i^{(h)}$. By convention, we take

$$D_i^h = 0 \quad \text{for all h}$$

We will prove shortly that D_i^h can be generated by the iteration

$$D_i^{h+1} = \min_j [d_{ij} + D_j^h] \quad \text{for all } i \neq 1$$

starting from the initial conditions,

$$D_i^0 = \infty \quad \text{for all } i \neq 1$$

The Bellman-Ford Algorithm, illustrated in Fig. 1

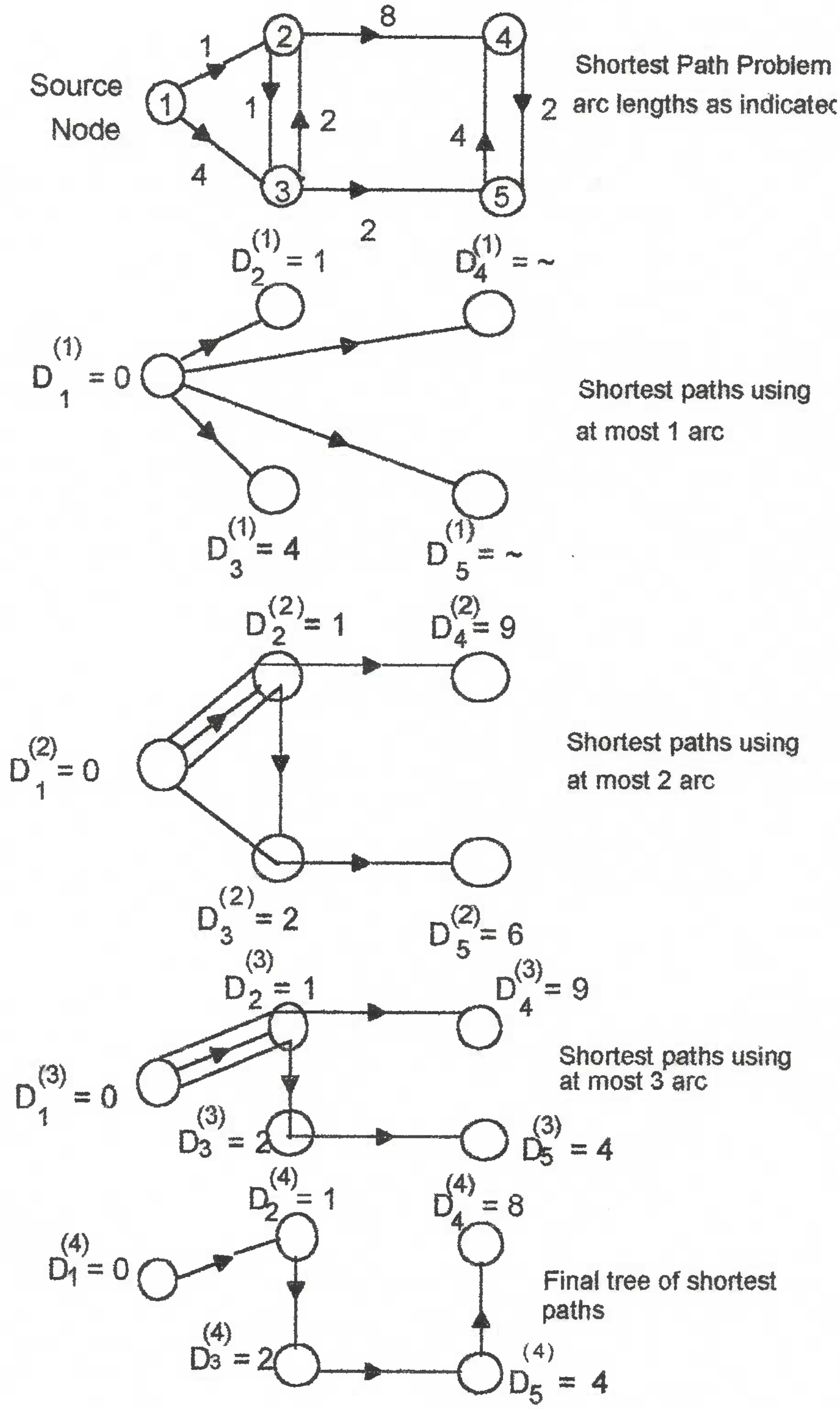

Figure 1 Succesive iteration of the Bellman-Ford method

NEXT PROGRESS OF RESEARCH ACTIVITY

In the next progress of research activity, we report about:

1. Link Reduction algorithm for Multifacility Case
2. Routing problem by Dijkstra and Floyd-Warshall algorithm.

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