required is $UpperInteger\left(\frac{\hat{x}_{ijk} - \underline{x}_{ijk}}{18 * 2}\right)$ and their length is equal to Max $\{y_1, \hat{y}_{ijk}\}$ - Min $\{y_1, \underline{y}_{ijk}\}$ - 18. Similar computations apply for vertical backbone cable.

1.2.3 Apply a cable sizing and structure cost subroutine (not included here) to determine the number and cost of cables required at each point in the distribution network, and the total structure cost. This completes the computation of the distribution costs associated with SAI_{ijk}.

1.3 Find the coordinates of the point within the grid that is closest to the central office in L1 distance and label this point (x^F_{ij}, y^F_{ij}). It defines a provisional feeder entry point into the grid. Choose k_1 to minimize $D_{ijk} = Abs(x_{ijk}) + Abs(y_{ijk})$. This defines the SAI closest to the central office in L1 distance, which will become the first primary SAI. For notational convenience refer to the coordinates of this location as (x_1, y_1). The remaining SAIs in the grid can either be directly connected to the provisional feeder entry point, or they can be tethered to (x_1, y_1) which is then resized appropriately and connected to (x^F_{ij}, y^F_{ij}). For any set of 1-3 secondary SAIs that are tethered to (x_1, y_1) the cost of the necessary distribution plant is computed as follows. (The subscripts i and j defining the particular grid will be ignored in the following discussion.)

1.3.1 Define the smallest rectangle containing (x_1, y_1) and each additional secondary SAI. Designate the bottom-left and top-right coordinates as $(\underline{x}, \underline{y})$ and $(\hat{x}, \hat{y})$ respectively.

1.3.2 Construct a horizontal backbone cable along the line segment connecting $(\underline{x}, y_1)$ and $(\hat{x}, y_1)$. Connect each secondary SAI to this backbone by a vertical segment connecting (x_k, y_k) to (x_k, y_1).

1.3.3 A vertical segment connecting (x_k, y_k) to (x_k, y_1) must be sized to carry L_k lines. If technology t is used, the cost is therefore

$$(a_t + b_t * L_k) * Abs(y_1 - y_k).$$

1.3.4 At each point (x, y_1) on the horizontal backbone with $x \geq x_1$ the number of required lines is given by $\sum_{k:x_k \geq x} L_k$. If there are three such points (the maximum possible number) and $x_1 < x_2 < x_3 < x_4$, then $x_1 = \underline{x}$ and the cost of the entire horizontal backbone is given by

$$\left[a_t + b_t\left(L_2 + L_3 + L_4\right)\right]\left(x_2 - x_1\right) + \left[a_t + b_t\left(L_3 + L_4\right)\right]\left(x_3 - x_2\right) + \left[a_t + b_t L_4\right]\left(x_4 - x_3\right).$$

Similar computations apply if there are fewer than three tethered SAIs and if the horizontal backbone extends to the left of (x_1, y_1).

1.3.5 The cost of connecting the primary SAI, (x_1, y_1) and all of its tethered secondary SAIs to the provisional feeder entry point is given by

$$\left[a_t + b_t\left(L_1 + \sum L_k\right)\right] * \left[Abs\left(y^F - y_1\right) + Abs\left(x^F - x_1\right)\right]$$

1.4 For each configuration of one to four SAIs compute the total distribution cost assuming the cost minimizing use of primary and secondary SAIs. The minimum cost obtained defines the total distribution cost for the grid and the optimal number of primary and secondary SAIs. Store the relevant information for later use and discard all other provisional computations.

2. Feeder Plant

Based on the location of the central office and the fixed locations of all primary SAIs within a quadrant, choose the optimal angular feeder and horizontal or vertical subfeeder routes to connect each primary SAI to the CO. The end result is a value of $FeederCost_{ijk}$ for each primary SAI location.

2.1 In the following discussion, quadrant 1 will refer to the area between 315 degrees and 45 degrees on a coordinate system with the central office as the origin. Quadrants 2, 3, and 4 are consecutively numbered in a counter-clockwise direction. The feeder and subfeeder network will consist of one or two main feeder routes in each quadrant. If there is one main feeder, let

$$\alpha = \text{ArcTan}\left(\frac{\sum_{i,j,k} L_{ijk}\, D_{ijk}\, y_{ijk}}{\sum_{i,j,k} L_{ijk}\, D_{ijk}\, x_{ijk}}\right)$$

where (x_{ijk}, y_{ijk}) are the coordinates for primary SAI_{ijk}. Thus, α is the angle of a weighted average SAI location with weights equal to the product of the number of lines and the L1 distance. (This is a simple heuristic that seeks to minimize total subfeeder distance. An alternative regression based approach may be substituted later.)

2.2 Given α, which defines the main feeder route for a quadrant, design the subfeeder routes as follows. Construct at most one subfeeder route for each vertical (in quadrants 1 and 3) or horizontal (in quadrants 2 and 4) block of grids. For each such block j, let x^j (respectively y^j) be the line-weighted average x_{ijk} (y_{ijk}) coordinates for all SAIs in that block. The subfeeder will run along this line. Each SAI will be connected to the subfeeder by a perpendicular sub-sub-feeder. The total feeder plus subfeeder distance for SAI_{ijk} located in a vertical block j is therefore given by

$$D_{ijk} = \left(Abs(x_{ijk} - x^j) + y_{ijk} - x^j \operatorname{Tan}(\alpha) + \frac{x^j}{\operatorname{Cos}(\alpha)} \right)$$

2.3 If there are two main feeder routes in a quadrant, define α_1 and α_2 as above but summing over the upper and lower halves of the quadrant respectively. Subfeeder and sub-sub-feeder is determined as before except that subfeeder coming off of a main feeder can now be both horizontal and vertical. In quadrant 1, if $y_i \geq x_i \operatorname{Tan}(\alpha)$ the subfeeder is vertical, and distances are computed just as before. If $y_i < x_i \operatorname{Tan}(\alpha)$ (or $x_i > y_i \operatorname{Cot}(\alpha)$) then the subfeeder runs horizontally to the right, and total distance is given by

$$D_{ijk} = \left(Abs(y_{ijk} - y^i) + x_{ijk} - y^i \operatorname{Cot}(\alpha) + \frac{y^i}{\operatorname{Sin}(\alpha)} \right)$$

2.4 Determine feeder plant type based on Rules (0.3), taking account of the maximum distribution plus inside wiring distance served from the SAI. Apply the cable sizing subroutine and the structure cost subroutine in order to determine $FeederCost_{ijk}$.

3. Total Loop Investment

$$TotalLoopCost = \sum_{i,j,k} \left(DistributionCost_{ijk} + FeederCost_{ijk} \right)$$

HCPM: Hybrid Cost Proxy Model
Pseudocode for SAI Locations and Distribution Plant

Preliminary, Incomplete and Subject to Change

```
BEGIN
    Get_user_inputs;                { Read Constants, UserInputs, Tables from      }
                                    { BCPM data and/or other sources               }

    total_feeder_cost := 0.0;
    total_distribution_cost := 0.0;

    for Quadrants := 1 to 4 do
    begin
        quadrant_subfeeder_cost := 0.0;
        quadrant_distribution_cost := 0.0;
        for grids := 1 to ngrids   { for each grid in this quadrant }
        begin
            Get_grid_data;          { output from customer location module: }
                                    { includes info on microgrids and possible}
                                    { SAI locations.                        }

            Minimum_distribution_cost := infinity;

            for SAI_case := 1 to 4 do
            begin
                Assign_microgrids_to_SAI;

                Calculate_distribution_cost;

                If distribution_cost < minimum_distribution_cost then
                begin
                    Minimum_distribution_cost := distribution_cost;
                    Minimizing_configuration := configuration;
                end
            end; { for SAI_case }
```

```
            Quadrant_distribution_cost := quadrant_distribution_cost + distribution_cost;

            Calculate_subfeeder_cost;
            quadrant_subfeeder_cost := quadrant_subfeeder_cost + subfeeder_cost;

        end; { for grids }

        Calculate_quadrant_main_feeder_cost;

        total_feeder_cost := feeder_cost + quadrant_main_feeder_cost + quadrant_subfeeder_cost;

        total_distribution_cost := total_distribution_cost + quadrant_distribution_cost;

    end; { for quadrants }
END; { Program }
```

Psuedocode for Costing the Feeder/Sub-feeder Plant and Updating the Grid Costs

Preliminary, Incomplete and Subject to Change

```
Subroutine GetQuadrantFeederCost(QuadIndex, GridIndex, GridRecord,
                                 GridOutputRecord);
Var
  Feeder Record:
  Alpha, Aplha1, Alpha2, Sumx, SumY, SumX1, SumXY1, SUmX2, SumY2, Avx, AvX1, AvX2,
  SingleFeederCost, DualFeederCost: Real;
Begin
     {Get Single, Dual Feeder Angles}
     For i :=1 to NGrids
       UpdateSingleDualFeederAlpha(QuadIndex,GridIndex, GridRecord,
                   GridOutputRecord, SumX, SumY, SumX1, SumY1, SumX2, SumY2);
     end;
     GetAlphas(SumX, SumY,SumX1, SumY1, SumX2, SUmY2,AvX, AvX1, AvX2);

     {Get Single, Dual Feeder Cost}
     For i :=1 to NGrids
         UpdateSingleFeederCost(QuadIndex,GridIndex, GridRecord,
                                  GridOutputRecord, Feeder);
         UpdateDualFeederCost(QuadIndex, Grindex, GridRecord,
                                GridOutputRecord, Feeder);
     end;
     If Feeder.SingleFeederCost <= Feeder.DualFeederCost then SingleFeeder:=True
     else DualFeeder:=True;
```

```
    {Re-estimate Subfeeder cost and update final Grid Cost}
    For i:=1 to NGrids
        GetGridSubFeederCost(QuadIndex, GridIndex, GridRecord, GridOutputRecord, Feeder);
        Update GridCostQuadIndex, GridIndex, GridRecord, GridOutputRecord, Feeder);
    end;

 end;

End;{end of program}
```

Panum

Panum Telecom, LLC

Resume'

Vaikunth N. Gupta

QUALIFICATIONS

Knowledgeable in the Telecom Act of 1996 and its impact on local, long-distance and international networks and network/technologies.

Familiar with various facets of information technologies: Transport, Switching and Network Management e.g. Internet, Satellite Communications, ATM, SDH/SONET, Various Signaling Protocols.

Extensive experience in successfully building and managing profitable high-technology, telecommunications companies with international presence.

Familiar with many aspects of international commerce especially with respect to communications with international standards bodies e.g. ITU, ISO 9001 Quality Systems, P&L issues and negotiations with large international telecom carriers.

Summary of Select Accomplishments:

5/2/97-Present *President & CEO, Panum Telecom, LLC (formerly Networks Corporation), 7315 Wisconsin Ave., Suite 800W, Bethesda, MD 20814.*

10/96-5/2/97 *Engineering Consultant (Volunteer), Federal Communications Commission, 1919 M Street, Washington, D.C. 20554*

Responsibilities:

i **Common Carrier Bureau, Policy Division: (a) Review and advise on technical matters relating to various aspects of Telecommunications Act of 1996 e.g. Interconnection, 271 applications, Common Transport, Long-term Number Portability, Operational Support Systems, Cost Models and CEI Plans and (b) Participate in NANC meetings.**

ii **Wireless Telecom Bureau, Policy and Enforcement Divisions: Review and advise on technical matters involving (i) wireless interconnections and (ii) auctions networks.**

5/96-3/97 *Member, Board of Directors, CTel, a subsidiary of ECI Telecom, a company publicly traded on the NASDAQ (Symbol: ECILF) stock exchange.*

2/84-5/96 *President & CEO , CTel, 22240 Comsat Drive, Clarksburg, MD 20871*

Responsibilities:

i **Technology Specialization:** Switched Network performance Management with primary customer focus on major national & international local exchange, long-distance and cellular carriers e.g. AT&T, MCI, British Telecom, etc.

ii **Customer Base:** Major administrations in approximately 30 major industrially developed countries around the world.

iii **P&L Responsibility:** Founded the company and created an economic gain of 400,000% with an average annual compounded growth rate of approximately 200% and steadily increasing earnings.

iv **Organizational Structure:** Created a company with a global operation and offices in three continents: (a) Americas: Headquarters in Metropolitan Washington DC, U.S.A. (b) Europe/MiddleEast: London, UK and (c) Asia/Pacific: Hongkong.

v **Large company Affiliation:** Acquired by a publicly traded (NASDAQ symbol: ECILF), global multi-national company with current annual revenues of approximately $ 800 million and offices and presence around the world.

11/80 - 11/83 *Member of Technical Staff, COMSAT Laboratories, 22300 Comsat Drive, Clarksburg, MD 20871*

International Satellite Transmission Technology:

Responsible for voice compression technologies that became the basis for products that are currently deployed by almost all international carriers to carry switched voice, data and fax traffic. Managed many INTELSAT projects.

EDUCATION

8/77-8/80 Ph.D.(Eng.), Univ. of Kentucky, Lexington, KY 40506

1/75-8/77 M.S. (Eng.)., Univ. of Kentucky, Lexington, KY 40506

7/69-9/74 B.S. (Elec. Eng.)., BHUIT, Varanasi, India

OTHER ACCOMPLISHMENTS/ACTIVITIES/DATA

U.S. Patents:

(i) "In-service, non-intrusive monitoring device using common-channel signalling"

(ii) "Variable rate encoded speech using a backward prediction"

(iii) "A DSI System with ADPCM coding"

Professional Affiliations:

6/76 - 11/83 (i) Computer Consultant for NIDA on Computer applications to brain research

6/76 - 9/80 (ii) Computer Consultant for Univ. of Kentucky Radiology Center

8/84 - 1/85 (iii) Assoc. Adjunct Professor at George Washington Univ.

6/86-Present (iv) Member, Board of Directors, Suburban Maryland High Technology Council

Other Data:

SS#: 404-98-0591

Nationality: U.S.A.

Publications: Approximately 30 in various Journals, Conferences and Other Forums

Panum

Panum Telecom, LLC

COMPANY PROFILE

Panum Telecom, LLC (**Panum**) is a Management Consulting Company specializing in the telecommunications and information technology sectors of the high-tech. industry. The company principals possess broad practical experiences in global business development, technology research, product manufacturing and proven marketing strategies. These experiences are with clients such as:

U.S. Telecom Carriers: Bell South Communications, South Western Bell Telephone Company, MCI Telecommunications, AT&T, Sprint Communications, COMSAT Corporation, U.S. West Communications Corp., Ameritech, Inc., AirTouch Communications, and Cellular One.

International Telecom Administrations: British Telecom, France Telecom, Deutsche Telecom, Cable and Wireless, Mercury Communications, Teleglobe Canada, HongKong Telecom, Telstra and Telecom Australia, KDD Japan, Beijing Telecom, Korean and Taiwan Telecom Administrations and many others.

Equipment Providers: Western Electric (now Lucent Technologies), IBM, DSC Communications, Northern Telecom, ECI Telecom and many others.

Government & Laboratories: US Federal Government Agencies, INTELSAT, INMARSAT, Bell Labs. and COMSAT Labs.

SERVICES:

Business development: Due diligence and background research for Mergers and Acquisitions, competitive analysis, strategic planning and marketing research leading to product/service definition and development; association with ventures that produced growth of an average, 200% annual compounded growth over a ten-year period in both sales and profits with an overall economic gain of 400,000%.

Policy Formulation: Advisory association with the Federal Communications Commission (FCC) in the regulatory affairs dealing with competition in the local RBOCs markets. Involved with such issues as Telephone Number Portability, Interconnection, provision and approval of various Enhanced Services in the local telephone markets and entry by the RBOCs into the long-distance markets.

Core Emerging Technologies: Commercial and defense communications technologies that facilitate multimedia communications via advanced intelligent networks, broadband such as ATM/SDH/SONET/Frame Relay and SMDS, digital wireless, Internet and Intranet, satellite and switched international telecommunications, network management and test and measurement systems, and database and client/server applications.

Quality Management Systems: Experienced with the implementation of quality management systems such as the ISO 9001.

Contact: ***Please call + 301-299-6271 or fax + 301-299-4216 for further information.***

7315 Wisconsin Av., Suite 800W, Bethesda, MD 20814, U.S.A.
Tel: 301-299-6271. Fax: 301-299-4216. e-mail: Info@PanumTelecom.com

Operating History:

Panum Telecom, LLC (Panum) was registered in Maryland on June 4, 1997, pursuant to a reorganization of its predecessor, Panum Networks Corp.. The reorganization was aimed at providing maximum operating flexibility and optimal tax advantages to its members (shareholders).

Early Clients:

1. **Federal Communications Commission (FCC):** Pursuant to multiple, time-staged contracts, Panum is involved in investigating all forward-looking communications technologies, and integration thereof, for developing local exchange networks as part of the implementation of Sections 251 and 254 of the Telecom Act of 1996. Additionally, Panum is advising the FCC on various regulatory matters dealing with the competition in the local telephone networks.

2. **Lucent Technologies (Lucent):** Panum, under a two-year framework contract, is working with Lucent to assess markets and technologies dealing with Quality Enhancement and Signal Processing systems for voice/data/fax transmission for both narrow- and broad-band services.

3. **COMSAT Laboratories:** Panum has acquired the worldwide distribution rights for COMSAT's flagship products which are ATM-based and offer high performance for T1/E1 and T3/E3 applications to satellite and terrestrial networks.

Business Focus:

Panum is focusing its energies in the market competition resulting from the Telecom Act of '96. Its initial focus has been on services leading up to the definition of a definitive business and strategic operational plan. The current plan calls for creating partnerships with large companies (entities) dealing with cutting-edge technologies for the deployment of voice/data/fax services. Hence, its early partnerships with the FCC and Lucent Technologies.

Management:

Panum's day-to-day operations are managed by its Managing Member, Dr. Vaikunth N. Gupta. Panum is currently counseled by the law firm of Bregman, Berbert & Schwartz and the accounting firm of Cohen, Rutherford, Blum & Schott. Panum is currently in discussions with various industry leaders to elect and form its Board of Directors.

Offices:

Panum is conveniently located in Bethesda, a Maryland Suburb, only minutes away from the heart of the U.S. Capital, Washington, D.C.. It is currently sub-leasing its office facilities in a high-rise building across from the Bethesda metro center at 7315 Wisconsin Ave., Suite 800W, Bethesda, MD 20814 and will be be relocating to more permanent quarters in the suburban Maryland area by the end of 1997.