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SHORTEST PATH IN STOCHASTIC COMMUNICATION NETWOKS

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ABSTRACT
The project presents a Methodology to compute shortest path in a stochastic communication network. In this stochastic communication network shortest path from source node to sink node is calculated by considering all possible paths, in which all nodes are capable of source node to sink node is calculated by considering all possible paths, in which all nodes are capable of receiving and transmitting messages. Here the messages are assumed to be travel between the pair of nodes with specified speed which varies for different pairs of nodes and the travel times between the nodes are allowed to be an exponentially distributed random variables. The problem is formulated as a chance constrained programming in stochastic communication network with the objective of minimizing the distance between the source and sink nodes. The results of the proposed methodology for this stochastic communication network under consideration are documented and compared with that of an existing methodology.

Keywords:
Shortest path, Maximize, Minimize, Net work, Nodes.

INTRODUCTION

A sub graph of a graph (G) with N - 1 links that has no circuits is called a spanning tree of G with N nodes. It has been extensively researched to generate all spanning trees of G without flow. For instance, 1–5. The system resilience of a computer network has been determined using these spanning trees without flow (6–8). A proposed spanning tree with flow9 employs an algorithm that consists of two main steps: To determine the spanning trees with flow, first create spanning trees without flow using the Cartesian product of all pathways.

PROPOSED METHODOLOGY

Consider a Communication Network G (n, a) with nodes (n) as stations capable of receiving and transmitting messages and arcs (a) as one why communication links connecting the pairs of nodes. The messages are assumed to be travel between the pairs of nodes (i, j) with specified speed, which varies for different pairs of nodes, and the messages transmitting time t, to node j from i is Random Variable. In order to compute expected length from source node to sink node The problem can be formulated as a chance constrained programming problem as follows.

$$\text{Minimize} \quad Z = \sum_i t_{ij} \sum_j x_{ij}$$

$$\text{Subject to } P\{ \sum_i t_{ij} \sum_j x_{ij} \le l_m \} \ge (I - \alpha_m)$$

i.e., $\sum_i \sum_j t_{ij} x_{ij} \le l_m$ is realized with a minimum probability of $(1-\alpha_m)$

Where l_m is Maximum allowable path length

m1,2,3……N

$0<\alpha_m<1$

Here the separable convex programming technique is used to solve this approximate model. Now consider the separable functions as follows.

$$f_{12}(X_{12}) = 10x_{12}$$

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$f_{13}(X_{13}) = 12x_{13}$
$f_{14}(X_{14}) = 13x_{14}$
$f_{23}(X_{23}) = 25x_{23}$
$f_{34}(X_{34}) = 23x_{34}$
$f_{35}(X_{35}) = 11x_{35}$
$f_{45}(X_{45}) = 6x_{45}$

$g^1{}_{12}(x_{12}) = 10^{x_{12}}$; $g^1{}_{23}(x_{23}) = 25^{x_{23}}$; $g^1{}_{35}(x_{35}) = 11^{x_{35}}$

$g^2{}_{13}(x_{13}) = 12^{x_{35}}$; $g^2{}_{35}(x_{35}) = 11^{x_{35}}$

$g^3{}_{14}(x_{14}) = 13^{x_{14}}$; $g^3{}_{45}(x_{45}) = 6^{x_{45}}$

$g^4{}_{13}(x_{13}) = 12^{x_{13}}$; $g^4{}_{34}(x_{34}) = 23^{x_{34}}$; $g^4{}_{45}(x_{45}) = 6^{x_{45}}$

The range of the variables are obtained from the constraints by substituting all variables to zero, except a variable whose range we want to determine.

$0 <= x_{12} <= 2.5000$
$0 <= x_{13} <= 2.0833$
$0 <= x_{14} <= 1.923$
$0 <= x_{23} <= 1$
$0 <= x_{34} <= 2.2727$
$0 <= x_{45} <= 4.1667$

$0 <= y_1 <= 29.9043$
$0 <= y_2 <= 27.5421$
$0 <= y_2 <= 25$
$0 <= y_4 <= 34.5733$
$0 <= y_5 <= 32.2206$

To obtain more accurate results the variables are partitioned into more number of ranges. following partitions However we partitioned the existing variables into the following partitions.

Variable (x ij)	Partitions
X_{12}	3
X_{13}	2
X_{14}	2
X_{23}	1
X_{34}	1
X_{35}	3
X_{45}	4
Y_1	6
Y_3	5
Y_4	8
Y_5	7

Due to the above number of partitions the new ranges of the variables are given follows.

$0 \leq Xk12 \leq 0.8333$ for k =1,2,3
$0 \leq Xk13 \leq 1.0416$ for k =1,2

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$0 \leq Xk14 \leq 0.9615$	for	k =1,2
$0 \leq Xk23 \leq 1.0$	or	k =1
$0 \leq Xk34 \leq 1.0869$	for	k =1
$0 \leq Xk35 \leq 0.7575$	for	k =1,2
$0 \leq Xk45 \leq 1.0416$	for	k =1,2,3,4
$0 \leq Xk1 \leq 4.984$	for	k =1,2,3,4,5,6
$0 \leq Xk2 \leq 4.5903$	for	k =1,2,3,4,5,6
$0 \leq Xk3 \leq 5.0$	for	k =1,2,3,4,5
$0 \leq Xk4 \leq 4.3216$	for	k =1,2,3,4,5,6
$0 \leq Xk5 \leq 4.6029$	for	k =1,2,3,4,5,6

iii. for i = 1 ; k = 1 :-

for j = 1:

$$\rho^1 4 = \frac{g^1 1(a_{11}) - g^1 1(a_{01})}{a_{11} - a_{01}}$$

$$= \frac{g^1 1(6) - g^1 1(0)}{6-0}$$

But $g^1 1(y_1) = 0.836\, y_1$

$g^1 1(6) = 0.836x6 - 5.016$

$g^1 1(0) = 0$

$\frac{5.016-0}{6-0} 11 = \rho^1$

$\boxed{\rho^1 11 = 0.836}$

a. for j = 7 :

$$\rho^7 4 = \frac{g^7 11(a_{11}) - g^7 1(a_{01})}{a_{11} - a_{01}}$$

$$= \frac{g1^7(6) - g1^7(0)}{6-0}$$

But $g^7 1(y_1) = -y^2 1$

$g^7 1(6) = -(6)^2 = -36$

$g^7 1(0) = 0$

$\frac{-36-0}{6-0} = \rho^7 11$

$\boxed{\rho^1 11 = -6}$

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$\frac{5.016-0}{6-0}11 = \rho^1$

$\rho^1 11 = 0.836$

b. for j = 7 :

$$\rho^7 4 = \frac{g^7 11(a_{11}) - g^7 1(a_{01})}{a_{11} - a_{01}}$$

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But $g^7 1(y_1) = -y^2 1$

$g^7 1(6) = -(6)^2 = -36$

$g^7 1(0) = 0$

$\frac{-36-0}{6-0} = \rho^7 11$

$\rho^1 11 = -6$

The remaining calculated values are shows in following table

For i=(1,2):

K	a_{ki}	ρ_{ki}	ρ^1_{ki}	ρ^5_{ki}	ρ^6_{ki}	ρ^7_{ki}	ρ^{11}_{ki}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	10	10	10	10	100	100	X_{112}
2	2	10	10	10	10	300	300	X_{212}
3	3	10	10	10	10	500	500	X_{312}

For i=(1,3):

K	a_{ki}	ρ_{ki}	ρ^2_{ki}	ρ^4_{ki}	ρ^6_{ki}	ρ^8_{ki}	ρ^{10}_{ki}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	12	12	12	12	144	144	X_{113}
2	2	12	12	12	12	432	144	X_{213}

For i=(1,4):

K	a_{ki}	ρ_{ki}	ρ^2_{ki}	ρ^4_{ki}	ρ^6_{ki}	X_{ki}
0	0	-	-	-	-	-

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1	1	13	13	13	169	X_{114}
2	2	13	13	13	507	X_{214}

For i=(1,3):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{4}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{10}	ρ_{ki}^{11}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	23	23	23	23	529	529	X_{134}

For i=(1,4):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{1}	ρ_{ki}^{2}	ρ_{ki}^{6}	ρ_{ki}^{7}	ρ_{ki}^{8}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	11	11	11	11	121	121	X_{135}
2	2	11	11	11	11	121	121	X_{235}

K	a_{ki}	ρ_{ki}	ρ_{ki}^{1}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{7}	ρ_{ki}^{11}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	25	25	25	25	625	625	X_{123}

For i=(1,3):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{4}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{10}	ρ_{ki}^{11}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	23	23	23	23	529	529	X_{134}

For i=(1,4):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{1}	ρ_{ki}^{2}	ρ_{ki}^{6}	ρ_{ki}^{7}	ρ_{ki}^{8}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	11	11	11	11	121	121	X_{135}
2	2	11	11	11	11	121	121	X_{235}

K	a_{ki}	ρ_{ki}	ρ_{ki}^{1}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{7}	ρ_{ki}^{11}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	25	25	25	25	625	625	X_{123}

For i=(1,3):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{4}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{10}	ρ_{ki}^{11}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	23	23	23	23	529	529	X_{134}

For i=(1,4):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{1}	ρ_{ki}^{2}	ρ_{ki}^{6}	ρ_{ki}^{7}	ρ_{ki}^{8}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	11	11	11	11	121	121	X_{135}
2	2	11	11	11	11	121	121	X_{235}

K	a_{ki}	ρ_{ki}	ρ_{ki}^{1}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{7}	ρ_{ki}^{11}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	25	25	25	25	625	625	X_{123}

For i=(1,3):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{4}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{10}	ρ_{ki}^{11}	X_{ki}

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0	0	-	-	-	-	-	-	-
1	1	23	23	23	23	529	529	X_{134}

For i=(1,4):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{1}	ρ_{ki}^{2}	ρ_{ki}^{6}	ρ_{ki}^{7}	ρ_{ki}^{8}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	11	11	11	11	121	121	X_{135}
2	2	11	11	11	11	121	121	X_{235}

K	a_{ki}	ρ_{ki}	ρ_{ki}^{1}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{7}	ρ_{ki}^{11}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	25	25	25	25	625	625	X_{123}

For i=(1,3):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{4}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{10}	ρ_{ki}^{11}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	23	23	23	23	529	529	X_{134}

For i=(1,4):

K	a_{ki}	ρ_{ki}	ρ_{ki}^{1}	ρ_{ki}^{2}	ρ_{ki}^{6}	ρ_{ki}^{7}	ρ_{ki}^{8}	X_{ki}
0	0	-	-	-	-	-	-	-
1	1	11	11	11	11	121	121	X_{135}
2	2	11	11	11	11	121	121	X_{235}

K	a_{ki}	ρ_{ki}	ρ_{ki}^{3}	ρ_{ki}^{4}	ρ_{ki}^{5}	ρ_{ki}^{6}	ρ_{ki}^{9}	ρ_{ki}^{10}	ρ_{ki}^{11}	X_{ki}
0	0	-	-	-	-	-	-	-	-	-
1	1	6	6	6	6	6	36	36	36	X_{145}
2	2	6	6	6	6	6	108	108	108	X_{245}
3	3	6	6	6	6	6	180	180	180	X_{345}
4	4	6	6	6	6	6	252	252	252	X_{445}

By using calculated slopes, the system of equations are modified into the following equations.

	$114x_{113} + 432x_{213} + 121x_{135} + 121x_{235} – 6y_{12}$……………..=0
	$169x_{114} + 507x_{214} + 36x_{145} + 108x_{235} + 180x_{345}$………….=0
	$144x_{113} + 144x_{213} + 529x_{134} + 36x_{145} – 108x_{245}$….……..=0
	$100x_{112} + 300x_{212} + 500x_{312} + 625x_{123} + 529x_{134}$……………..=0

The above system of equations are solved by using UPPER BOUNDING TECHINIQUE and values are calculated with the Aid of TORA package.

$x_{112} = 0.22$ $x_{212}= 0.11$ $x_{312} = 0.08$

$x_{113} = 0.24$ $x_{213} = 0.17$

$x_{114}= 0.13$ $x_{214} = 0.08$

$x_{123} = 0.1$

$x_{123} = 0.08$

$x_{135} = 0$; x235 = 0.11

$x_{145} = 0.32$ $x_{245} =0.18$ $x_{345} = 0.06$ x445 = 0.06

$y_{11} = 0.8$ $y_{23} = 0.9$ $y_{31}= 0.85$ $y_{41} = 0.67$ $y_{51} = 0.92$ $y_{61} = 0.87$

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$y_{12} = 0.7$: $y_{22} = 0.75$ $y_{12} = 0.72$ $y_{42} = 0.74$ $y_{12} = 0.69$ $y_{62} = 0.63$
$y_{13} = 0$ $y_{2} = 0.96$ $y_{33} = 0.89$ $y_{43} = 0.97$ $y_{53} = 0.95$

CONCLUSION

In this project a methodology is presented to compute the expected least path length in a stochastic communication network. By formulating the problem as a chance constrained programming. In this stochastic communication network shorted path from source node to sink node is calculated by considering all possible paths in which all nodes are capable of receiving and transmitting messages. Here the messages are assumed to be travel between the pair of nodes and the travel times between the nodes are allowed to be exponentially distributed random variable. In the proposed methodology, the message travel speeds can also be allowed as random variables, instead of travel times between nodes to compute the shorted path. The methodology can also be applied to the vehicle routing, air craft flying operations and travelling sales man problem. The results of the proposed methodology for this stochastic communication network under consideration are documented and compared with that of an existing methodology.

RESULTS AND DISCUSSION

In this project a methodology is presented to compute the expected least path length in a stochastic communication network . By formulating the problem as a chance constrained programming. In this stochastic communication network shorted path from source node to sink node is calculated by considering all possible paths in which all nodes are capable of receiving and transmitting messages. Here the messages are assumed to be travel between the pair of nodes and the travel times between the nodes are allowed to be exponentially distributed random variable. In the proposed methodology, the message travel speeds can also be allowed as random variables, instead of travel times between nodes to compute the shorted path. The methodology can also be applied to the vehicle routing, air craft flying operations and travelling sales man problem. The results of the proposed methodology for this stochastic communication network under consideration are documented and compared with that of an existing methodology.

Path	Maximum length	Probability
1-2-3-5	13.6483	0.8
1-3-5	11.6286	0.85
1-4-5	11.200	0.90
1-3-4-5	13.5026	0.70
1-2-3/4-5	16.7766	0.75

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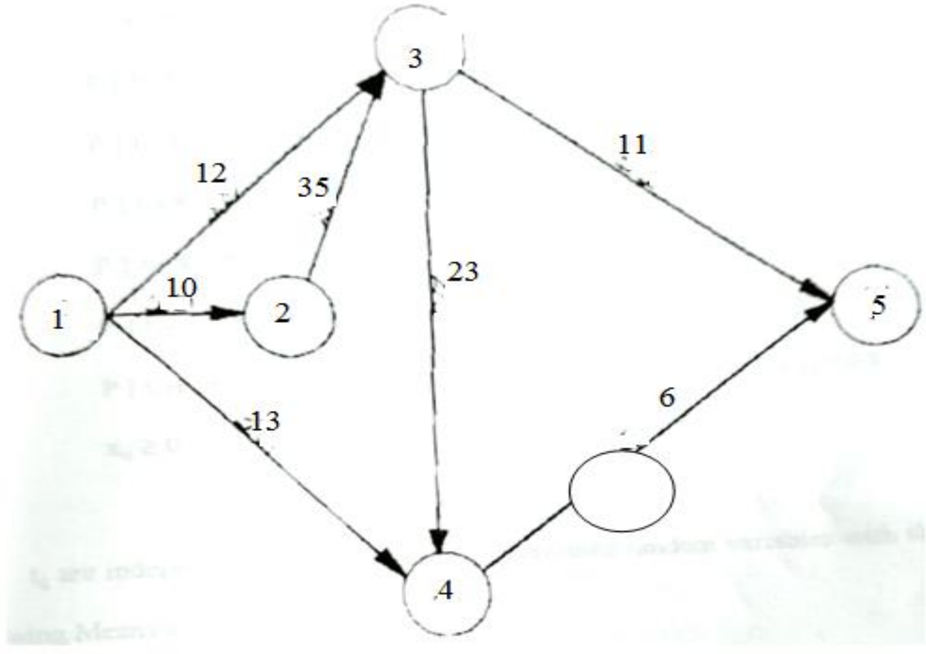

Fig:1 Net Work Path Diagram

For this stochastic communication network. Proposed methodology shows **1-4-5 path** as the shorted path with **11.2 units** as minimum length between source and sink nodes. Where as for the same stochastic communication network existing kulkarni‘s method shows the same **1-4-5 path** as shorted path, but with **11.357 units** as minimum length between source and sink nodes.

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