# NETWORK FRACTIONAL ROUTING

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*Abstract* — **A Network is a set of devices connected by communication links. Network must be able to meet a certain number of criteria. In a network, message can be transmitted from source to sink nodes. The messages are drawn from a specified alphabet. The proposed research work focus on fractional coding for networks in the special case of routing. The routing capacity is the supremum of ratios of message dimensions edge capacity for which a routing solution exists and also we will prove that the routing capacity of every network is achievable and rational. An alternative method to find fractional routing solution is to be developed. When the variety of related properties of fractional routing is used to solve a network, the dimension of the messages need not be same as the capacity of the edges. We will prove fractional routing capacity for some solvable network using cost matrix model.**

***Keywords*** **— Fractional Routing, capacity, Cost matrix, Flow**

## I. INTRODUCTION

A meaningful objective of this Problem is to determine the maximum flow of item from a given source node to a given destination node. The maximum flow problem can be solved by capacity matrix method. An alphabet is a finite set. A network is a finite directed acyclic graph with source messages from fixed alphabet and message demands at sink nodes. A network is solvable if it has a solution for some alphabet. A solution is linear solution if the output of every edge function is a linear combination of its inputs. Messages are vector if dimension k each edge in a network carries a vector of at most n alphabet symbols. The ratio k/n in a (k, n) fractional routing solution is called an achievable routing rate of a network. The routing capacity of a network is the quantity ε = sup {all achievable routing rates. If a network has a routing solution, then the routing capacity of the network is at least 1. The maximum flow problem is a special case of more complex network flow problem such as the circulation problem. The maximum value of a source to sink flow is equal to the minimum capacity of a source to sink.

## II. RELATED WORK

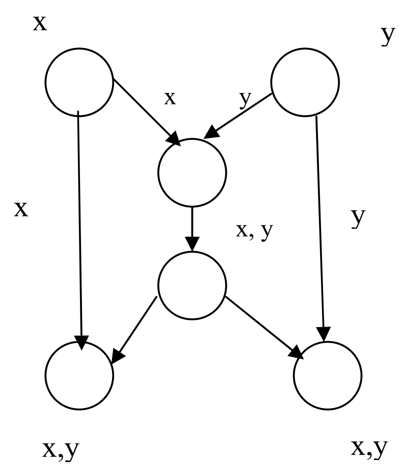



Fig. 2.1.The multicast network N whose routing capacity is 1/2.

Statement:

Each of the two sources emits a message and both messages are demanded by the two sinks.

Proof:

Convert Fig 2.1 in to adjacency matrix

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 2 | 0 | 0 | 1 | 0 | 0 | 1 |
| 3 | 0 | 0 | 0 | **1** | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 1 | 1 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 |

Sink nodes

There must be sufficient capacity along the edge (3, 4) to accommodate both messages. Hence, the requirement $2k \le n$, where k be the dimension of the messages and n be the capacity of the edges, $k/n \le ½$, ($\varepsilon = k/n$). Thus $\varepsilon = ½$, this is a fractional routing solution.

## III. PROPOSED ALGORITHM

Step 1: Select the path from source to sink.

Step 2: Construct the Capacity matrix an initial flow f in C. where f is a flow and C is a capacity matrix (or) construct adjacency matrix where adjacency means A(I,J) = 0 where i=j=n (let n=1,2,…..n)

Step3: Find Q values using select the path from 1 to N. where Q = min (from source to intermediate node and from intermediate node to sink node).

Step 4: If select the forward arc using negative sign then backward arc using positive sign.

Step 5: Now Q values are added to the +ve sign and subtracted from the –ve sign using capacity matrix.

Step 6: Find the new capacity matrix, check the sink columns all entries zero. If all entries are zero then nom need one more iteration otherwise repeat step 3, 4 and 5.

Step 7: Find the maximum flow = Capacity matrix – capacity closure matrix. Where capacity closure matrix means sink columns all entries zero or last iteration.

Step 8: The final flow matrix using select the path only entered the values.

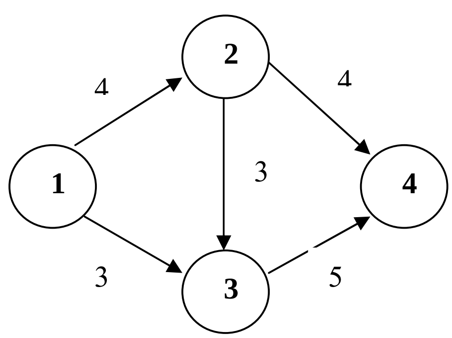
Step 9: Now construct the Max-flow diagram using the final matrix and Max-flow equal to sum of the Q values. (Where Q = $Q_1, Q_2, Q_3, \ldots\ldots\ldots Q_n$ values)

Step 10: Find the Network Fractional Routing using the formula.

Network Fractional Routing = Flow/ Capacity

i.e. [0, 1]. The intervals between 0 and 1.

## IV. FRACTIONAL ROUTING EXAMPLE NETWORK




**ITERATION 1:**

Step1:

Select the path from source to sink.

a) $1 \rightarrow 2 \rightarrow 4$

b) $1 \rightarrow 2 \rightarrow 3 \rightarrow 4$

c) $1 \rightarrow 3 \rightarrow 4$

Step 2:

Construct the capacity matrix or form the adjacency matrix.

C =

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 4 | 3 | 0 |
| 2 | 0 | 0 | 3 | 4 |
| 3 | 0 | 0 | 0 | 5 |
| 4 | 0 | 0 | 0 | 0 |

Where C is the capacity matrix

Step 3: Find Q values using select the path.

Consider **a)** $1 \rightarrow 2 \rightarrow 4$

$Q_1 = \min (1 \rightarrow 2, 2 \rightarrow 4)$

$= \min (4, 4)$

$Q_1 = 4$

Step 4: Select the forward ($\longrightarrow$) using Negative sign and Backward ($\longleftarrow$) are using Positive sign.

| -ve | +ve |
|---|---|
| $1 \rightarrow 2$<br>$2 \rightarrow 4$ | $2 \rightarrow 1$<br>$4 \rightarrow 2$ |

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 4(-) | 3 | 0 |
| 2 | 0(+) | 0 | 3 | 4(-) |
| 3 | 0 | 0 | 0 | 5 |
| 4 | 0 | 0(+) | 0 | 0 |

Step 5: Q values are added to the positive (+ve) sign and subtracted from the negative sign (-ve) using capacity matrix.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0(4-4) | 3 | 0 |
| 2 | 4(0+4) | 0 | 3 | 0(4-4) |
| 3 | 0 | 0 | 0 | 5 |
| 4 | 0 | 4(0+4) | 0 | 0 |

Step 6: sink columns are not fully zero. So, find one more iteration.

**ITERATION 2:**
Select the path
b) 1 ⟶ 2 ⟶ 3 ⟶ 4
Calculate Q values
Q = min ( 1⟶ 2, 2⟶ 3, 3⟶ 4)
= min (0, 3, 5)
Q = 0 Therefore, Not consider the path.

Once again do the iteration 2:
Step 1:
Select the path
c) 1 ⟶3 ⟶4

Find Q values using select the path
$Q_2$ = min (1 ⟶3, 3 ⟶4)
= min (3, 5)
$Q_2$ = 3

Step 2:
Select the forward arc using –ve sign and backward arc using +ve sign.

| -ve | +ve |
|---|---|
| 1 ⟶3<br>3 ⟶4 | 3 ⟶ 1<br>4 ⟶ 3 |

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 3(-) | 0 |
| 2 | 4 | 0 | 3 | 0 |
| 3 | 0(+) | 0 | 0 | 5(-) |
| 4 | 0 | 4 | 0(+) | 0 |

Step 3:
Q values are added to the +ve sign and subtracted from the –ve sign.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0(3-3) | 0 |
| 2 | 4 | 0 | 3 | 0 |
| 3 | 3(0+3) | 0 | 0 | 2(5-3) |
| 4 | 0 | 4 | 3(0+3) | 0 |

= C*

Sink columns are not fully zero but all paths are selected (i.e. No need iteration)

Step7:
Find the maximum flow.
f = Capacity matrix (C) - Closure matrix (C*)

f =

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 4 | 3 | 0 |
| 2 | 0 | 0 | 3 | 4 |
| | 0 | 0 | 0 | 5 |
| 4 | 0 | 0 | 0 | 0 |

( - )

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 4 | 0 | 3 | 0 |
| 3 | 3 | 0 | 0 | 2 |
| 4 | 0 | 4 | 3 | 0 |

Finally,

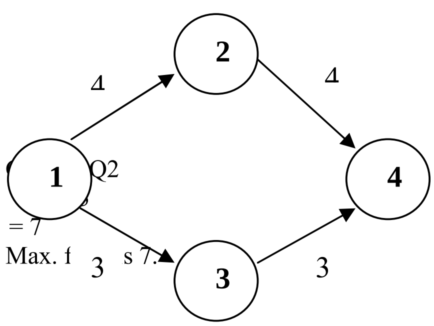
The flow is

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 4 | 3 | 0 |
| 2 | -4 | 0 | 0 | 4 |
| 3 | -3 | 0 | 0 | 3 |
| 4 | 0 | 0 | -3 | 0 |

Step 8:

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | | 4 | 3 | |
| 2 | | | | 4 |
| 3 | | | | 3 |
| 4 | | | | |

Step 9: Construct the max- flow diagram.




Q2

= 7

Max. f s 7.

Step 10:

Find the network fractional routing using the formula. = flow/capacity.

Example:

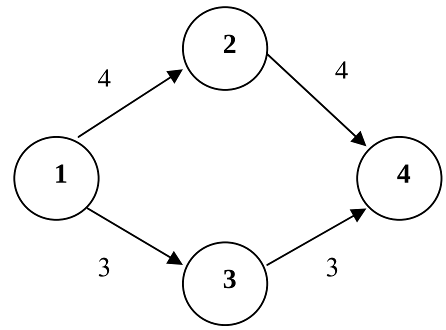



Fig. (a) Flow Diagram

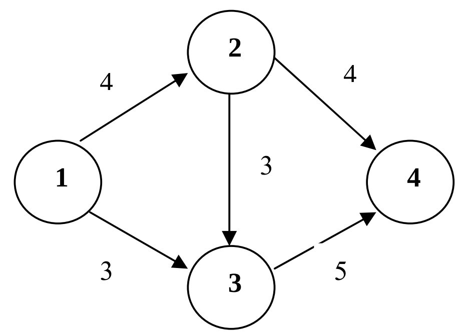
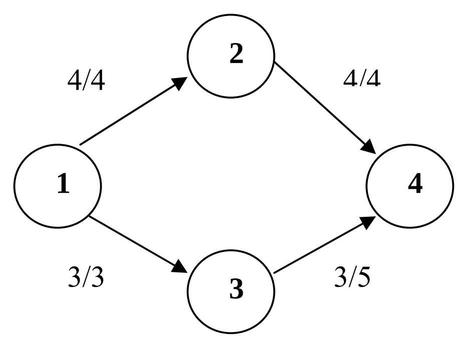
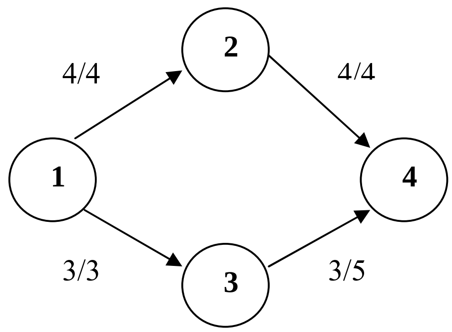



Fig. (b) capacity diagram

Finally,
Fractional Routing Diagram:




Now, modify the diagram




So, the interval between 0 and 1.

## V. RESULTS AND DISCUSSION

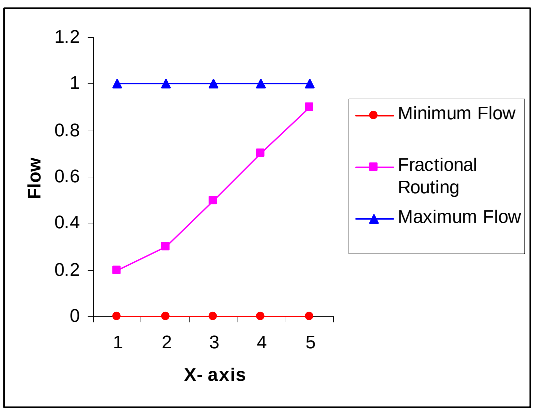



Fig 5.1. Fractional Routing Capacity

Fig. 5.1. Depicts the Fractional routing Capacity Values are lies between the intervals 0 and 1. Where 0 is the Minimum flow and 1 is the Maximum flow in the network.

## VI. CONCLUSIONS

The routing capacity of a network provides an indication of performance when only fractional routing is permitted. This paper formally defined the concept of the Fractional routing capacity of a network and it is proved by an example. Any non-degenerate network, there exists many fractional routing solutions using different values of k and n. Thus, it is enviable to differentiate the largest ratio of message dimension to edge dimension for which a fractional routing solution exists.

## VII. FUTURE WORK

Given a network N= (V, E) with a set of sources $S = \{S_1, S2 \ldots S_N\}$ and a set of sinks $T = \{t_1, t_2, \ldots t_m\}$ Instead of only one source and one sink. To find the maximum flow across N. We can transform the multi source multi-sink problem into a maximum flow problem by adding a super source connecting to each vertex in S and a super sink connected by each vertex in T with infinite capacity on each edge. We will briefly describe some of the algorithms for solving linear programming problems. Linear programming is important because it is so expressive: many, many problems can ne coded up as linear program. This especially includes problems of allocating resources and business supply – chain applications and Hamiltonian Circuit.

## VIII. REFERENCES

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