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SYSTEMATIZATION OF RELIABLE OPEN ENDED NETWORKS

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ABSTRACT

The key of network begins after the need for sharing files. Sharing in local networks was later extended as Internet. In recent years, number of Internet users increased rapidly. As this count increases, the network traffic also becomes serious and a need arises to create new network topologies and to calculate corresponding reliability. The aim of this paper is to study and compare the reliability of open ended networks using Wiener index. The calculation of the overall reliability of the networks becomes an important problem. This paper presents the Topology invariant which calculates the reliability of the newly constructed open ended networks by introducing new nodes. The simulated experimentation of the proposed Topology invariant for the new open ended networks have been done and compared with existing open ended networks.

Keywords: reliability, wiener index, open ended networks.

1. INTRODUCTION

The ICT, which is the present days' need, plays a vital role almost in every aspect of the modern lives. For successful implementation and the increase in performance, the ICT in addition to the others, requires highly reliable communication networks. Thus an important aspect of the communication network design is to analyse the reliability and introduce the new network topology so the overall throughput, delay, reliability are improved. The analysis of the reliability focuses on following two factors as

(i) Constructing new open ended networks by introducing new nodes without forming cycle.

(ii) Estimation of the reliability of the newly constructed open ended networks using Reliability Wiener Index in terms formula constructed using hops matrix.

(iii) Comparing the reliabilities of the new open ended networks and existing open ended networks.

There are different measures of reliability. All-terminal network reliability (also called overall network reliability) is calculated from the probability that each and every node in the network is connected to each other. One of the more useful reliability measures is the source-to-terminal (s-t) reliability, which is the probability that a given source node can communicate with a given terminal node. Related to this is the notion of K-terminal reliability, which is the probability that all nodes in a given set K can communicate.

Numerous algorithms and evaluation techniques have been described in the literature for the computation of above mentioned reliability measures. But all such methods are computationally intractable for networks of even moderate size. For any network with reliability as a parameter, its design and modification is a difficult task. The selection of optimal network topology with reliability constraint is an NP-hard combinatorial problem as these methods grow exponentially with network size. So, for networks of large size Genetic-algorithm based approaches are used as a new solution method for optimal design of networks considering reliability. In [14] Kumar, Pathak and Gupta developed a genetic algorithm considering distance, diameter and reliability to design and expand computer networks. Dengiz, Altiparmak and Smith in [9] focused on large backboned communication network design considering all terminal network reliability and used a genetic algorithm, but customized it appreciably to the all-terminal design problem to give an effective, efficient optimization methodology.

The objective of this paper is to present the new open ended networks from existing open ended networks by introducing new node and edges and comparing the reliability of old and new open ended networks.

2. COMMUNICATION NETWORKS

The main focus is on global reliability of communication networks. In a communication network the weights of the edges quantify the volume or the quality of the information transmitted by the nodes. In such a case, the strength of a path called reliability of the path can be calculated as the product of the weights of the edges belonging to their paths.

Various measurable properties of the networks are usually expressed by means of numbers. Inorder to link network topology to any real network property, one must first convert the information contained in the network into numerical characteristics. Every number uniquely determined by the structure of a graph called graph invariant.

Those graphs invariants are used for study of the structural properties of networks are usually called topological indices. Among the most extensively used indices we cite Wiener index.

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3. RELIABILITY WIENER INDEX

Now we are interested in the study of the global reliability of networks. We will not discuss here how to assign weights to edges, as we assume that the literature provides appropriate measures for the various applications of weighted Topologies. For instance, suppose that, in a communication network, the weights (w) of the edges reflect the quality of the information transmitted or the trust between nodes:

i. The probability that a bit transmitted by node i is erroneously received by node j is a simple way to quantify the quality of transmission between node i and node j. This probability can be viewed as the weight w(i,j) of edge (i, j).

ii. The level of trust between node i and node j in a social network can be quantified as a weight w(i,j) ∈ [0,1] proportional to how much node i trusts node j. Extreme cases are no trust (w(i,j) = 0) and maximum trust (w(i,j) = 1). The Wiener index W(G) of a Topology G with vertex set $\{v_1, v_2, \ldots, v_n\}$ defined as the sum of distances between all pairs of vertices of G, is the first mathematical invariant reflecting the topological structure of a molecular Topology.

$W(G) = \frac{1}{2}\sum_i \sum_j d_{ij}$ where d_{ij} is the distance between the vertices v_i and v_j is the first mathematical invariant reflecting the topological structure of a molecular Topology.

The out-reliability $R_1^+(i)$ of a vertex i in a digraph G of n nodes by $R_1^+(i) = \sum_{j=1}^{n} \overline{F}_{ij}$ where $\overline{F}_{ij}$ number of the hops in the most reliable path from i to j.

The local index R_1^+ imposes a good ranking according to the capacity of transmitting reliable "information" to all other nodes, where the information is transmitted through the most reliable path.

The out-reliability Wiener index [12] of G is defined as $W_{R_1^+}(G) = \sum_{v \in V(G)} R_1^+(v)$. The out reliability Wiener index of G is a measure of the capacity of the vertices of G of Transmitting information in a reliable form, where the information is transmitted through the reliable path.

4. P^K_{MN} NETWORK

4.1 Construction of topology

P^K_{MN} NETWORK is the combination of two bus with n number of nodes in Bus horizontal bus and m number of nodes in Vertical Bus with common Vertex at k. The class of trees $P^k_{n,m}$ is obtained by taking two paths P_n and P_m and merging one pendant vertex of P_m on to any interior vertex v_k of P_n.

There are n-2 possible trees $P^k_{n,m}$ for any given path P_n and P_m by merging path P_m at n-2 positions. In $P^k_{n,m}$, there are exactly three pendant vertices and only one vertex of degree three. There are n+m-1 vertices and n+m-2 edges in $P^k_{n,m}$.

For this tree we calculate Wiener index and analysis has been done on Wiener indices for different values of m and n. The analysis results the arithmetic progression with certain common difference.

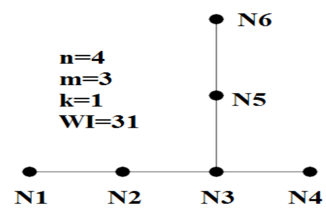

Figure-1.

The Wiener index for $P^k_{n,m}$ is

$$W(P^k_{n,m}) = m(m-1)(n-1) + \frac{(n-1)(m-1)(m-2)}{2} + \frac{(n-(k+1))(n-k)(m-1)}{2} + \frac{(k-1)(k-2)(k-1)}{2} + W(P_n) + W(P_m),\ k = 2,3,4,\ldots,(n-1)$$

Algorithm

Input: Number of nodes in horizontal bus and vertical bus.

Output: A P^k_{mn} Network with n number of nodes in horizontal bus and m number of nodes in horizontal bus. The vertical bus is placed at various position of Horizontal bus and Wiener Index is calculated for each iterations.

```
Start
    for position←1 to n
    for i←1 to n
        plot_points
        draw_horizontal_bus
    end;
    for i←1to m
        plot_points
        draw_vertical_bus
    end;
    k←position
    wpn←(n*n*n-n)/6;
    wpm←(m*m*m-m)/6;
    p1←m*(m-1)*(n-1);
    p2←(n-1)*(m-1)*(m-2)/2;
    p3←((n-(k+1))*(n-k)*(m-1))/2;
    p4←(m-1)*(k-2)*(k-1)/2;
      WI←p1-p2+p3+p4+wpm+wpn;
    end;
Stop
```

P^K_{MN} network is one in which two bus topologies are combined at a particular node K. The vertical bus is placed at various nodes of the horizontal bus. The combination which gives higher reliability is considered as final.

The nodes N3, N5, N6 are placed at nodes N1, N2, N3 and N4. For each placement, Wiener Index is calculated. The node placement which gives lowest Wiener Index is a said to be higher reliable.

4.2 MATLAB programs to construct

To construct Tensor Product topology $C_3 \wedge C_n$

```
r=4;
m=input('Get vertices: ');
   % INITIALIZATION
   x1=zeros(m,1);
   x2=zeros(m,1);
   x3=zeros(m,1);
   y1=zeros(m,1);
   y2=zeros(m,1);
   y3=zeros(m,1);
   n=3*m;
      % CIRCLE
      x=linspace(0,2*pi,n+1);
      x=r*sin(x);
      y=linspace(0,2*pi,n+1);
      y=r*cos(y);
      plot(-x,y,'*','Color','r','LineWidth',2,'MarkerSize',9);
      hold on
% First set of points
     i=1;
     j=1;
  while i<n
     x1(j)=-x(i);
     y1(j)=y(i);
     i=i+3;
     j=j+1;
  end
lot(x1,y1,'*','Color','b','LineWidth',2,'MarkerSize',9);
 % Second set of points
     a=3;b=1;
   while a<=n
        x2(b)=-x(a);
        y2(b)=y(a);
        a=a+3;b=b+1;
end
plot(x2,y2,'*','Color','g','LineWidth',2,'MarkerSize',9);
% Third set of points
     p=5; q=1;
  while p<n
      x3(q)=-x(p);
      y3(q)=y(p);                    if(p==n-1)
           x3(m)=-x(2);                      y3(m)=y(2);
break;                          end
     p=p+3;         q=q+1;
end
plot(x3,y3,'*','Color','r','LineWidth',2,'MarkerSize',3);
%CONDITION #1 E1
line([x1(1) x2(m)],[y1(1) y2(m)]);
pause(0.3)
line([x2(m)x3(m-1)],[y2(m)y3(m-1)]);
pause(0.3)
line([x3(m-1)x1(m)],[y3(m-1) y1(m)]);
pause(0.3)
%CONDITION #2 E2
 f=3;
while f<=m
line([x1(f)x2(f-1)],
    [y1(f)y2(f-1)]);
pause(0.3)
line([x2(f-1)x3(f-2)],
     [y2(f-1) y3(f-2)]);
pause(0.3)line([x3(f-2)
x1(f-1)],[y3(f-2) y1(f-1)]);
pause(0.3)
f=f+1;
end
%CONDITION #3 E3
pause(0.7)
line([x1(2) x2(1)],[y1(2) y2(1)]);
pause(0.6)
line([x2(1) x3(m)],[y2(1) y3(m)]);
pause(0.6)
line([x3(m) x1(1)],[y3(m) y1(1)]);
pause(0.6)
%CONDITION #4 E4
line([x1(1) x2(2)],[y1(1) y2(2)]);
pause(0.3)
 line([x2(2) x3(3)],[y2(2) y3(3)]);
pause(0.3)
line([x3(3) x1(2)],[y3(3) y1(2)]);
pause(0.3)
%CONDITION #5 E5
h=2;
while h<=m-2
if(h==0)
break;
end
line([x1(h)x2(h+1)],[y1(h) y2(h+1)]);
pause(0.3)
line([x2(h+1)x3(h+2)],[y2(h+1) y3(h+2)]);
pause(0.3)
line([x3(h+2)x1(h+1)],[y3(h+2) y1(h+1)]);
pause(0.3)
line([x1(h+1)x2(h+2)],[y1(h+1) y2(h+2)]);
pause(0.3)
h=h+1;
end
pause(0.3)
%CONDITION #6 E6
       line([x2(m) x3(1)],[y2(m) y3(1)]);
```

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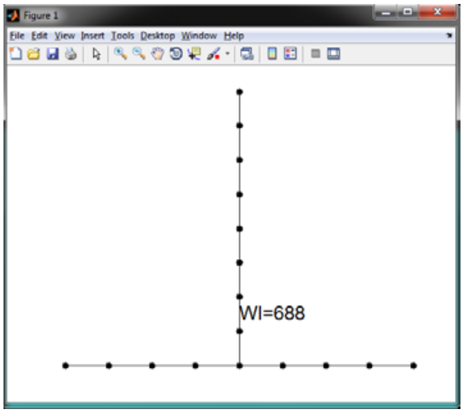


Table-1.

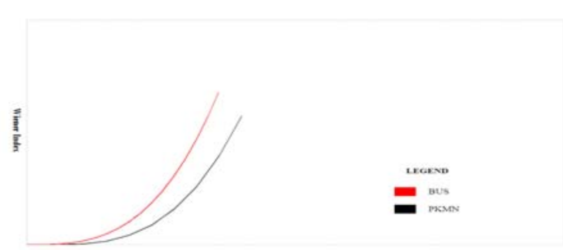
PKMN NETWORK
Comparison of Node Positioning

Value of N	Value of M	Value of K	Wiener Index[WI]	No. of Nodes
9	9	1	816	17
9	9	2	760	17
9	9	3	720	17
9	9	4	696	17
9	9	5	688	17
9	9	6	696	17
9	9	7	720	17
9	9	8	760	17
9	9	9	816	17

4.3 Graphical comparison between P^K_{MN} and BUS

A graphical comparison is made by taking number of nodes in X-AXIS and Wiener index in Y-AXIS. The graph is constructed in HTML5. The MATLAB program calls a java program to open the link in Web- Browser. The link is concatenated with number of nodes sent from MATLAB input. This is taken by PHP server as GET Request and graph is constructed by additional Wiener Index Calculation.

In JavaScript, two curves are plotted based on calculation of Wiener Index. One curve include the plot made between Number of nodes and its equivalent Wiener Index in Bus Topology and other include Number of nodes and its equivalent Wiener Index in P^k_{mn} Network. In Fig 4.3, we can see that P^K_{MN} network has lower Wiener Index compared to same number of nodes in Bus topology.



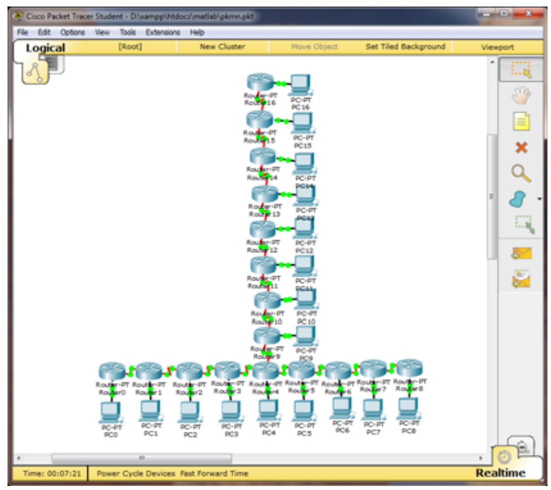
P^K_{MN} network has lower Wiener Index compared to same number of nodes in Bus topology. Hence it can be concluded as P^k_{mn} Network is Reliable than Bus Topology.

5. CISCO PACKET SIMULATION

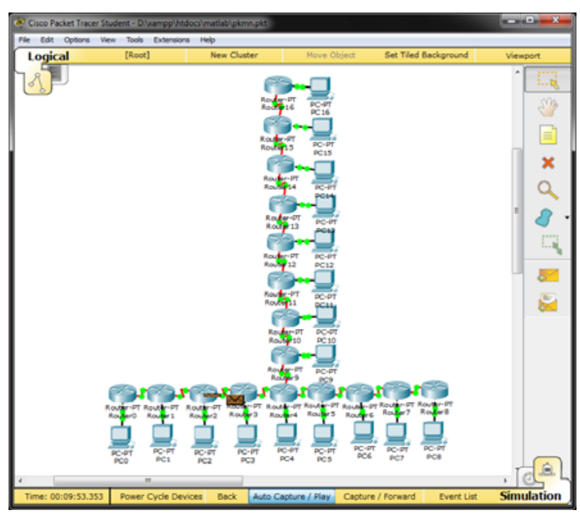
In cisco Packet simulation, virtual network is constructed and packets are transferred from starting and ending nodes and various parameters such as packet loss, number of hops and latency are calculated.

We can see that comparing bus topology and this network, P^K_{MN} network is highly reliable and efficient. There is low packet loss, less number of hops to reach destination, lower latency and hence higher reliability.

5.1 Network construction for P^k_{mn} structure



5.2 Data transfer in p^k_{mn} network send data from pc0 to pc16



Receive acknowledgement from PC16 to PC0

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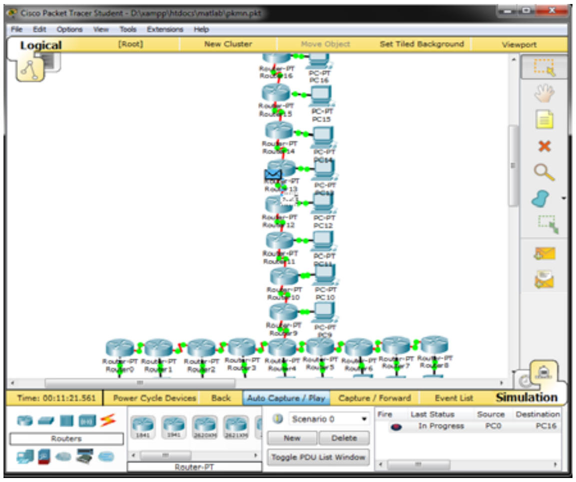
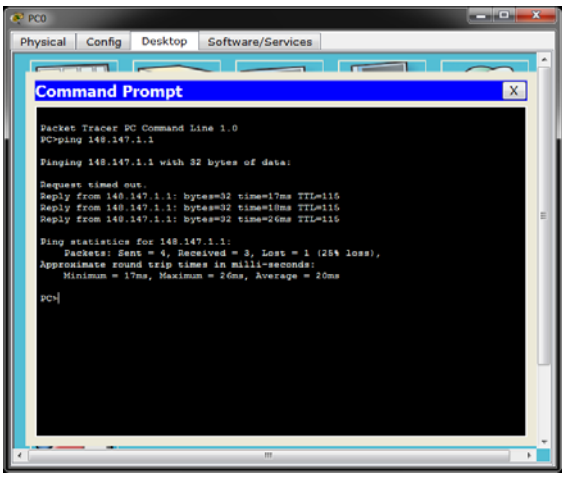
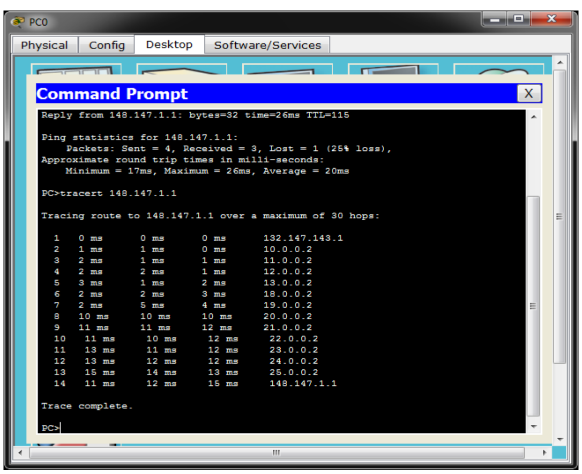


5.3 Ping command in P^k_{mn} network



5.4 Trace route command in P^k_{mn} network



5.5 Comparison between P_{kmn} and Bus interms of data transfer

A tabular comparison is made between P^k_{mn} and Bus network in terms of Data Transfer in Network. Table-2 depicts that P^k_{mn} is best network when comparing it with Bus Topology.

Table-2.

Parameters	BUS	P^K_{MN}
Data transfer rate	25ms	20ms
Packet loss	25%	25%
No of hops	17	14
Risk factor	15	11
Wiener index	High	Low
Reliability	Low	High

6. CONCLUSIONS

We presented a new methodology for constructing topologies with existing topologies. The generalization developed in this paper makes more reliable method since now the construction of topologies is not restricted to the selection of an integer n. The generalization developed in this paper makes more flexible method since now the construction of topologies is not restricted to the selection of an integer n. The reliability of newly constructed topology in table1 and table 2 show that the P^K_{MN} topology is more reliable than bus topology as this topology takes less time for data transfer, less number of hops and lower risk factor.

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