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TOPOLOGICAL EFFECTS AND PERFORMANCE OF DABBAWALA GRAPH MODEL – A STUDY

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Abstract: -

Graph theory is widely applied in Engineering, Computer Science and Business studies. The aim of this research is to throw light on how graph theory could be applied in common real-world problems. One such problem that is considered to address in this paper is the working pattern of Dabbawala in Mumbai. The purpose of the paper is two-fold: to propose an innovative model graph model $D(G)$ and to attest the proposed graph model in relevance to existing theorems by procuring diversity of results.

Keywords: - *star graph, tree, distance, coloring, chromatic number, eccentricity, 2-centered graph*.

INTRODUCTION:

Mumbai, the business capital of India is one of the busiest cities hosting overflowing industries and corporates. Most of the corporates work round-the-clock where the employees work in shift. One of the main challenges faced by the employees is the lack of time to travel to their residence. Going home for lunch would benefit the employees with hot, hygiene, spouse-made and fresh lunch. Mumbai has the trend of '*Dabbawalas*' [1] , who play a vital role in overcoming this problem. Dabbawalas collect lunch boxes from the residence of employees in the late morning, delivers them at the workplaces, predominantly using bicycles and metro. The work of Dabbawala extend in collecting the empty boxes back at the residence of employee.

Most of the Dabbawalas are illiterate or poorly literate. They adapt an organized method to carry out this everyday task. Color code and/or symbols are used for easy proof of identity. It is to be noted that the dabbawalla who receive the lunch box at the residence of customer will not be the same to deliver it at the destined offices. The entire path from the point of collection to the point of destination has many changing junctions. Each Dabbawala's duty is to pass on the dabbas from one junction to another. To carry out this change inventively, the dabbawallas follow code-of-standard. The lunch boxes hold marking that include the destination and information of the station where the boxes need to be loaded and unloaded.

Organization:

A key to the dabbawala's operations is the Mumbai Suburban Railway, one of the most extensive, complex and heavily used urban commuter lines in the world. Its basic layout allows delivery people with bicycles and handcarts to travel short distances between the stations and customer's homes and offices. The daily schedule determines when certain tasks need to be done and the amount of time allotted for each. For instance, workers have 40 seconds to load the crates of dabbas onto a train at major stations and just 20 seconds at interim stops. If a worker is late in dropping-off his dabbas at a station, his felony is immediately obvious to every-one, and alternative arrangements have to be made for transporting his dabbas on another train.

Simple Codes:

To convey information, the dabbawalas rely on a system of very basic symbols. The lid of a dabba has three key marking on it. The first is a large, bold number in the center, which indicates the neighbourhood where the dabba must be delivered. The second is a group characters on the edge of the lid: a number for the dabbawala who will make the delivery, an alphabetical code (two or three letters) for the office building, and a number (Roman letter) indicating the floor. The third - a combination of color and shape, and in some instances, a motif indicates the station of origin. Customers supply small bags for carrying their dabbas, and the variations in the bag's shapes and colors helps workers remember which dabba belongs to which customer. The coding system contains enough information for people to know where to deliver the dabbas, and where to return it.

Unless mentioned otherwise, all graphs considered in this paper are simple, undirected and connected.

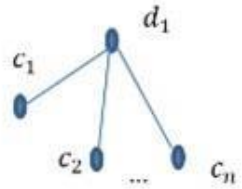
Basic Definitions:

Distance $d(u, v)$ between two vertices u, v of a graph G is defined as the length of the shortest $u - v$ path in G. The **Eccentricity of vertex** (u) is the largest distance from u to another vertex, $e(u) = max_{v \in V(G)} d(u, v)$. The **Radius** (G) of a graph is the minimum eccentricity of any vertex. The **Diameter** $iam(G)$ is the maximum eccentricity of any vertex. The center (G) is the subset of $V(G)$ of vertices such that their eccentricity equals $r(G)$.

A connected graph G does not contain a cycle is called a **Tree**. Collection of all trees are called **Forest**. The chromatic number of a graph G is the smallest number of colors needed to color the vertices of G so that no two adjacent vertices share the same color and it is denoted by $\chi(G)$ [2]. A graph G which is 2-colorable is called bipartite. For any vertex v in a graph the degree of vertex is equal to the number of edges which contain the vertex. The maximum degree of the graph is denoted as $\Delta(G)$. A path of length $'n'$ is the graph p_n on $n +$ 1 vertices with n edges. A cycle of length n is a graph c_n on n vertices with n edges.

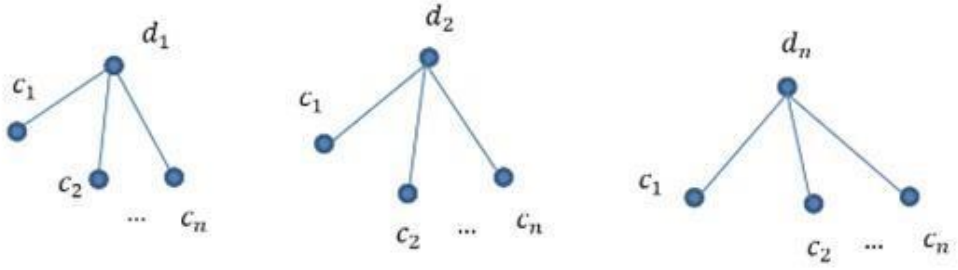
Construction of $D_w(G)$

Stage 1



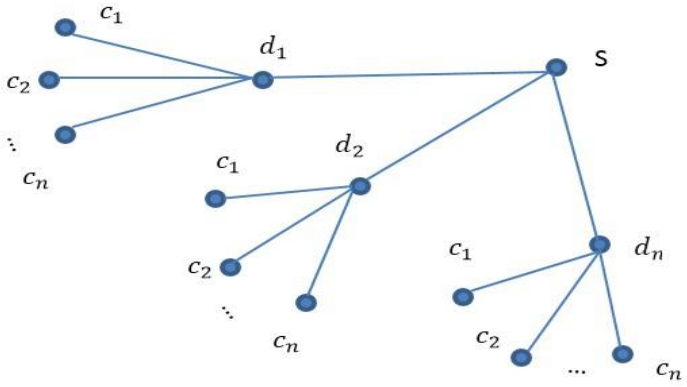
In the above graph the vertex d_1 represent the dabbawala. The other vertices $c_1, c_2, \dots c_n$ denotes the customers. It is easy to understand that the above graph is a star graph $S_{1,n}$

Stage 2



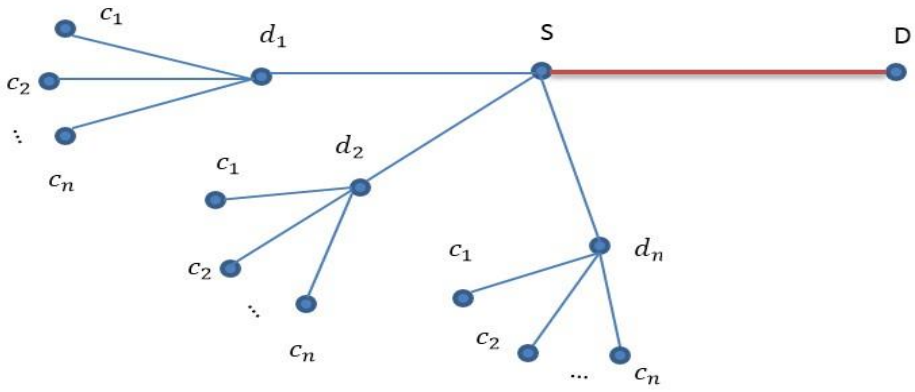
In the above graphs we consider 'n' number of dabbawalas with $c_1, c_2, \dots c_n$ number of customers. This graph is a forest.

Stage 3



The above tree illustrates the process of sorting practiced by dabbawalas after meeting at a place which is represented as Vertex S.

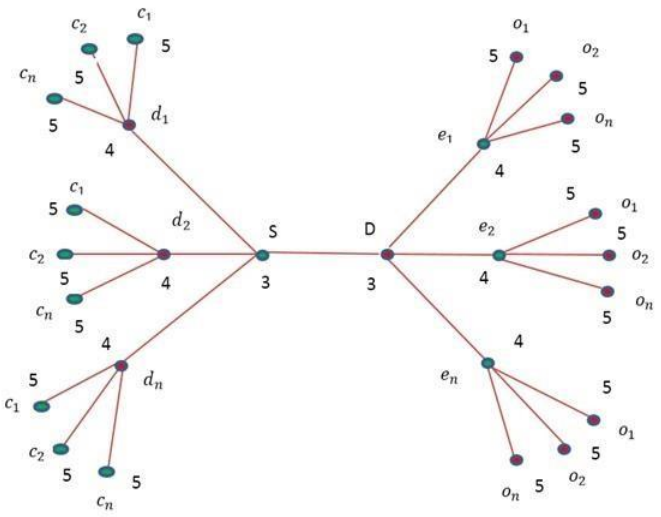
Stage 4



The point of destination D is introduced in the tree that edges S. This edge represented in red denotes the metro network. To quantify the importance of the nodes in the network, centrality properties were used [3]. \

Stage 5

Yet another labor for dabbawalla starts in the forenoon. After the lunch, the dabbas need to be returned at the residence of the customers. The entire process of dabbawalla is represented in the graph below.



where,
$c_{1,2,\ldots,n} \rightarrow$ Point of collection
$d_{1,2,\ldots,n} \rightarrow$ Initial stage *dabbawalas*
$e_{1,2,\ldots,n} \rightarrow$ Intermediate stage *dabbawalas*
$o_{1,2,\ldots,n} \rightarrow$ Point of delivery
$S \rightarrow$Point of sorting junction
$D \rightarrow$ Point of Loading junction
From the above final graph, we conclude:
The eccentricity of the vertices is denoted by 3, 4 & 5.
The Minimum eccentricity (G) = 3
The Maximum eccentricity = $diam(G)$ = 5.
$D(G)$ as a 2-centered graph.
The following theorems are from [4]

Theorem 1
A graph with n vertices is a tree $\Leftrightarrow$ it is connected and has $n-1$ edges.
Theorem 2
Every tree with at least one edge contains two end points.
Theorem 3
Every tree is a bipartite graph.
Theorem 4
A graph which is 2 −colorable is called bipartite.
Theorem 5
The chromatic number of any tree is 2.
Theorem 6
A graph has chromatic number 2 exactly when there are no cycles with an odd number of vertices.
Theorem 7
A graph is bipartite $\Leftrightarrow$ it contains no cycles of odd length.

Our Results:
1. $D(G)$ is tree.
2. The Chromatic number of $D_W(G)$ is 2
3. $D(G)$ is a 2-centered graph.
4. $D_W(G)$ with $'n'$ vertices and $'m'$ edges have radius 3 and diameter 5
5. For $D(G)$, $\Delta(G)$ is infinity, the above results hold good.

Theorem 1
$D(G)$ is a bipartite graph $\Leftrightarrow$ does not contain a cycle.
Proof: By result 1 and 2 we can easily conclude.

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