INTERNATIONAL RESEARCH JOURNAL OF SCIENCE ENGINEERING AND TECHNOLOGY

ISSN 2454-3195

An Internationally Indexed Peer Reviewed & Refereed Journal

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A Study of Dependencies among Processors in Interconnection Network

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Abstract:
Study of dependencies is determined by topological properties, data structure, system architecture, processing mode and algorithm used. Basic concepts of interconnection network and data structure are elaborate in this paper. Increase in nodes, reliability and reduction in complexities (communication time and communication cost) have greatly enhanced the performance of interconnection network. Parallel computing is an efficient form of processing which emphasizes the exploitation of concurrent events in the computing process. For elaborate parallel computing in perfect difference network we are trying to investigate dependencies and then convert model of interconnection network(PDN) into its equivalent data structure which is useful for processing and then find smallest individual unit in perfect difference network. This paper consider incidence matrix as data structure then apply divide and analyze method to find relations and dependencies among processors.

Key Words- Parallel Computing, Interconnection Network, Perfect Difference Network(PDN), Topological Properties, Discrete Structure.

Introduction:

Parallel computing is a mode of operation in which a process is split into parts, which are executed simultaneously on numerous processors attached to the identical computer. It is a type of computation in which many calculations or processes are carried out in chorus. Enormous problems can regularly be divided into smaller ones, which can then be solved at the same time. For instance, the system could receive the next instruction from memory as the current instruction is processed by the processors. Breaking up different parts of a task among multiple nodes will help reduce the amount of time to run a program. The degree of each node in perfect difference network is $2\delta^{[1,2]}$. We have 4 different sub node/path in $\delta=2$ for processing. On the whole, it is a kind of computing architecture where the large problems breaks into independent, smaller, usually similar parts that can be processed in one go. It is done by multiple nodes communicating via shared memory, which combines results upon completion. This enables you to complete the same task multiple times quicker. Practically, when a program is executed in parallel, the hypothesis that the parallel program will run faster is not always satisfied. If the main goal of parallelizing a serial program is to obtain a faster run then the main criterion to be considered is the speedup gained from parallelization. Databases and Data mining. Real-time simulation of systems. Science and Engineering. Advanced graphics, augmented reality, and virtual reality are the example of parallel computing. In perfect difference network parallel processing, may take in multiple different forms of computation at the same time. This is

especially important in vision/ vector . For example, when node accept an objects/data coming towards node, it also accept its properties all at once. Parallel computing is the simultaneous use of multiple compute resources to solve a computational problem. Parallel implementation of algorithms involves many difficult problems. In particular among them are round-off analyses, the way to convert sequential programs and algorithms into the parallel mode, the choice of appropriate or optimal computer architect and so on. To solve these problems, it is necessary to know very well the structure of algorithms. This paper deal with the mathematical properties and dependences that permits us to investigate structures of both sequential and parallel algorithms. This study assist us to recognize and explain the relations between different methods of constructing parallel algorithms, the methods of analysing round-off errors, the methods of optimizing memory traffic, the methods of working out the fastest implementation for a given parallel computer and other methods attending the joint investigation of algorithms and computation.

Perfect Difference Network

PDN consists of a set of nodes($\delta^2 + \delta + 1$) and another set of links to connect the nodes. Our basic assumption in this paper is link is bidirectional. The node of PDN is connect via ring and chordal links. Linear relation is shows through ring link($i \pm 1$)[9,10].

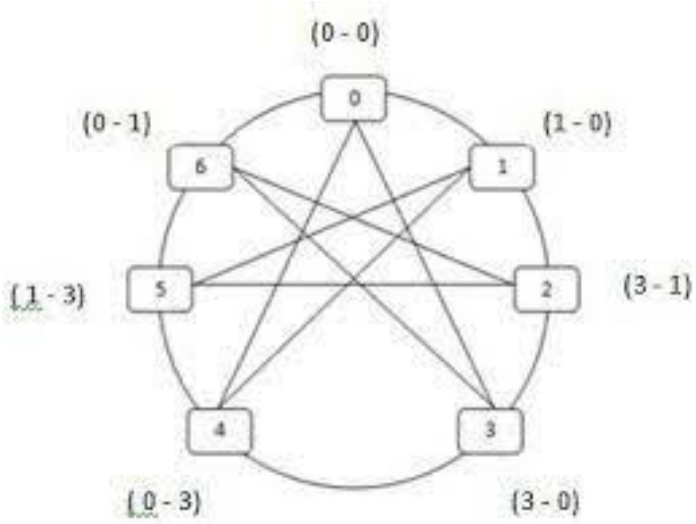


Fig -1: PDN with n = 7, δ = 2 and PDS = {0, 1, 3}

The Perfect Difference Set of each node of the PDN can be evaluated by the remainder theorem[3,9] i.e.

, N = R + D * Q,

Where N = Numerator, R = Remainder, D = Denominator and Q = Quotient

The above equation can be written as

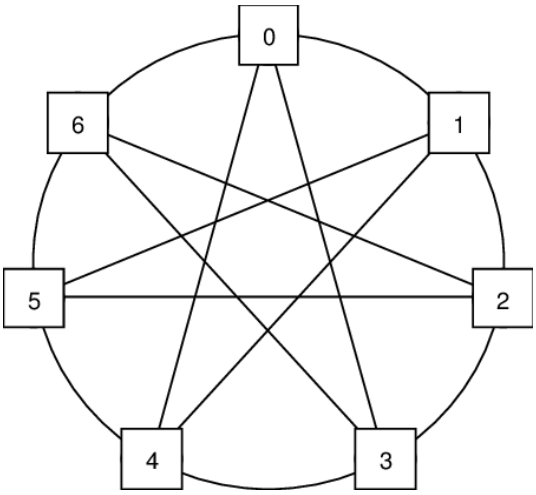
Integer = $(S_i - S_j) + (\delta^2 + \delta + 1) * 1$

Where integer is a member of the set (1, 2, ..., $\delta^2 + \delta$) and $S_i - S_j$ is numerator or the difference set.

So we can write as

$(S_i - S_j)$ = (Integer) mod $(\delta^2 + \delta + 1)$ ...eq(1)

= 1 mod 7represented mode t 8 mod 7 = 1 ,= 2 mod 7 rep. 9 mod 7 =2, = 3 mod 7 represented t 10 mod 7 = 3, = 4 mod 7Hence (0 – 3) is the Perfect Difference Set for node 4[3].Perfect Difference Network is the network architecture, in which the diameter is always 2, i.e., every node ith needs to vitsit only two links to communicate with other nodes i ± 1 & i ± sj (mod n), for $2 \leq j \leq \delta$. In a Perfect Difference Network, the total number of nodes is $\delta^2 + \delta + 1$, i.e., if δ = 2 then the total number of nodes in PDN is 7 and if δ =3, then number of nodes in PDN is 13[4,5]. Also the degree of every node in a PDN is 2δ i.e., if $\delta = 2$ then degree of every node in a PDN is 4 and similarly for other prime or power of prime numbers. The design of Perfect difference network is done in such a way where each node is connected via directed links to every other node. The links in PDN architecture are bidirectional in nature and the connectivity leads to a chordal ring of degree 2δ i.e., δ in-degree and δ out-degree and diameter D = 2[5,6].



For further study we label the links in PDN as follows

Label/Name	Connected nodes
A	**0-1**
B	**1-2**
C	**2-3**
D	**3-4**
E	**4-5**
F	**5-6**
G	**6-0**
H	**0-3**
I	**0-4**
J	**1-4**
K	**1-5**
L	**2-5**
M	**2-6,**
N	**3-6**

The incidence matrix of a PDN is **a | $\delta^2 + \delta + 1$| ×|E| matrix**. The element a_{ij}= the number of times that node n_i is incident with the link e_j. The adjacency matrix of PDN is the | $\delta^2 + \delta + 1$| × | $\delta^2 + \delta + 1$| matrix. a_{ij}= the number of edges joining $n_i$and n_jThe incidence matrix for the PDN with δ=2 is given below.[6,7]

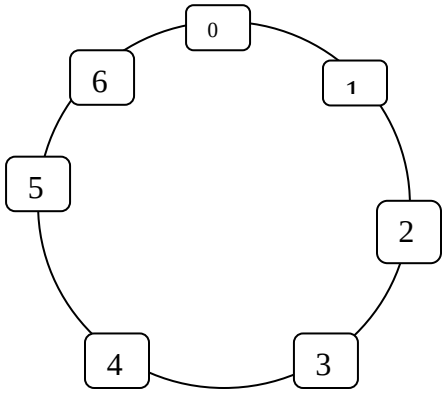
Incidence matrix is that data structure which represents the model such that with the help of that we can derived relations between nodes[7,8,9]. The rows of that data structure represent the number of nodes and the column of the data structure represent the number of links in perfect difference network. If there are 'δ2 + δ + 1' number of rows in a incidence matrix, that means in a PDN there are 'δ2 + δ + 1' number of nodes. Similarly, if there are 'E' number of columns in that given incidence matrix, that means in that graph there are 'E' number of Links. In the PDN with δ=2, there are PDN with δ2+ δ+1 nodes and 15 links. Thus the **incidence matrix** for the PDN with δ=2 will have δ2+ δ+1 rows and 15 columns.

	a	**B**	**c**	**d**	**E**	**F**	**G**	**h**	**i**	**j**	**k**	**l**	**m**	**n**
0	1	0	0	0	0	0	1	1	1	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	1	1	0	0	0
2	0	1	1	0	0	0	0	0	0	0	0	1	1	0
3	0	0	1	1	0	0	0	1	0	0	0	0	0	1
4	0	0	0	1	1	0	0	0	1	1	0	0	0	0
5	0	0	0	0	1	1	0	0	0	0	1	1	0	0
6	0	0	0	0	0	1	1	0	0	0	0	0	1	1

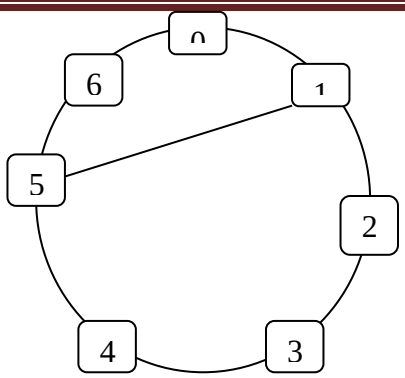
There is a row for every node and a column for every links in the incident matrix. The number of ones in an incidence matrix of the PDN is equal to the sum of the degrees of all the nodes in a perfect difference network[9,10].

Now divide the data structure into minimum smallest individual unit knows as circuit. Following minimum circuits starting from 0,1 are required to design the PDN having δ^{2+} δ+1.

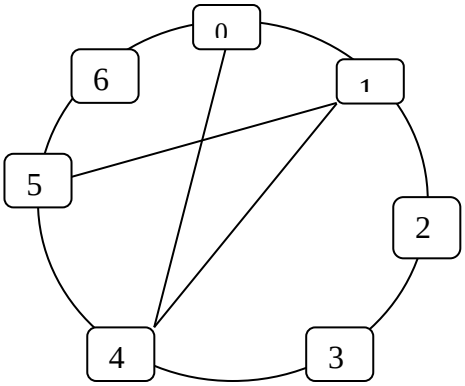
0-1-2-3-4-5-6-0



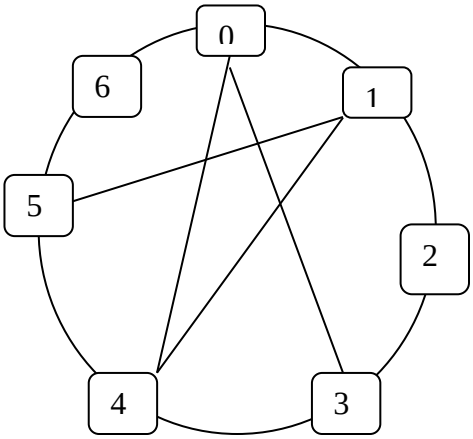
0-1-5-6-0



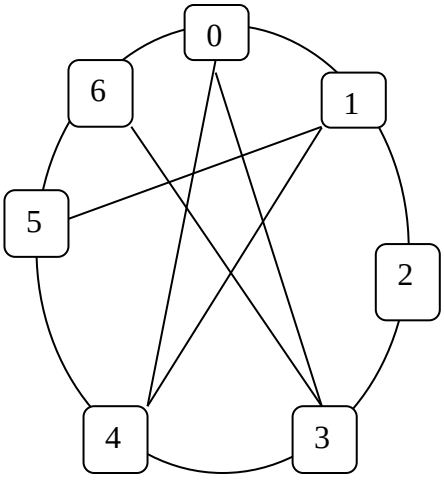
0-1-4-0



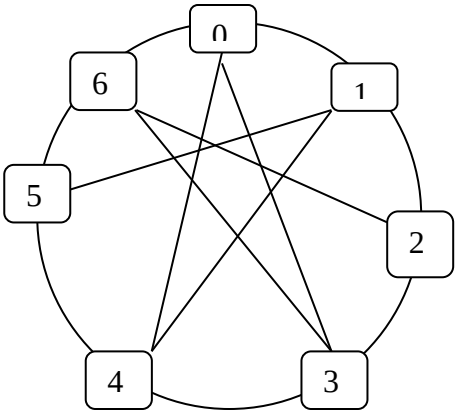
0-1-2-3-0



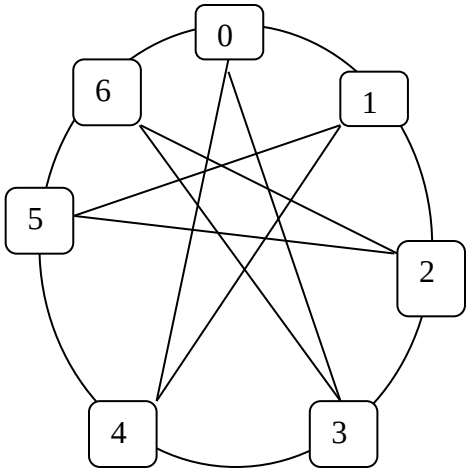
0-3-6-0



1-2-6-0-1



1-2-5-1



Now design circuit matrix of perfect difference network.

	a	B	c	d	E	F	G	h	i	j	k	l	m	N
1	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
3	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**
4	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
5	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**
6	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
7	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**

In this circuit matrix C, there are 7 circuit vectors namining 1 to 7 and 14 links naming a to n. $C_{i,j}$ contains 1 if ith circuit includes jth links. A column of all 0 corresponds to a noncircuit links. vector 1 contains 7 one it shows there are 7 links in the corresponding circuit and so on.

From the above study we find some relation which is represent in the form of lemma

Lemma1: Continuous mapping among processors design at least one circuit having δ^{2+} δ+1.

Proof: Continuous mapping is a direct relation between two node i±1 shows continuous mapping. $(S_i - S_j)$ = (Integer) mod $(\delta^2 + \delta + 1)$ mapping said to be continuous if the reverse and

inverse relation is valid. Let discuss i±1 mod $\delta^2 + \delta + 1$ and map. Let consider node 0 as initial node

0+1 mod $\delta^2 + \delta + 1$

1 mod 7 = 1

2 mod 7 = 2

3 mod 7 = 3

4 mod 7 = 4

5 mod 7 = 5

6 mod 7 = 6

7 mod 7 = 0

Now Consider 0 - 1 mod $\delta 2 + \delta + 1$

0-1 mod 7 =-1 mod 7 = 6

6-1 mod 7 = 5 mod 7 =5

5-1 mod 7 = 4 mod 7 =4

4-1 mod 7 = 3 mod 7 =3

3-1 mod 7 = 2 mod 7 =2

2-1 mod 7 = 1 mod 7 =1

1-1 mod 7 = 0 mod 7 =0

hence we observed there is no discontinuities between nodes of PDN and we can draw a circuit from node 0 to (traverse or include) all other nodes of PDN without lifting the connection from the plane/space.

Conclusion:

Study of dependencies is determined by topological properties, data structure, system architecture, processing mode and algorithm used. Basic concepts of interconnection network and data structure are elaborate in this paper. This paper consider incidence matrix as data structure then apply divide and analyze method to find relations and dependencies among processors. The relation and properties for solving the problem have been apply in PDN . The use of perfect difference network to solve parallel processing is growing rapidly from the past few decades. In this study, we elaborate mathematical and numerical properties of PDN that gives many relation and structure to improve the communication complexities and connectivity. In many real time or real life applications very often we need to perform a lot of numerical computations, which may range from matrix multiplication, polynomial interpolation, solving polynomial equations, solving system of equations and so on. In future, We consider these structure and relation in perfect difference network to solve some numerical and communicational problems, namely Lagrange interpolation and polynomial root finding etc..

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