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Dynamic route selection: An artificial intelligence based approach

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***Abstract*—In this paper we have pointed out new trends for efficient routing strategies. Firstly we have introduced the concept of fuzzy rule during path detection. Secondly we have depicted another technique of routing based on application specific operational models. In this context we have shown the delivery schemes of packets in cubic models. Lastly packet delivery based on event discovery model in the light of Bayesian belief network is explained.**

***Keyword*—srouting , fuzzy rule , path detection , Bayesian belief network**

I. PATH DETECTION BASED ON FUZZY RULE

A. Path detection

The proposed strategy is assigning fuzzy values to possible communication paths. As per greedy rule the path selection can be based on values derived from fuzzy operations after estimation of probability of hacking corresponding to data transmission .

Let the parameter based on which the security analysis of each path is determined be x1,x2,x3 and x4. The paths dedicated for transmission be P1,P2,P3 and P4. We assume that fuzzy values are in the following structure:

P1 = {(x1,0.3),(x2,0.7),(x3,0.4),(x4,0.8)}
P2= {(x1,0.6),(x2,0.5),(x3,0.2),(x4,0.1)}
P3= {(x1,0.1),(x2,0.4),(x3,0.5),(x4,0.7)}
P4= {(x1,0.7),(x2,0.6),(x3,0.1),(x4,0.9)}

Out of x1,x2,x3 and x4 , we assume that optimum selection can be made based on minimum values of parameters x1,x3 and maximum values of parameters x2,x4. Hence optimum path selection based on the accumulation of respective membership functional values.

Hence communication directives can be based on P_{opt} = {(x1,0.7),(x2,0.4),(x3,0.5),(x4,0.1)}

B. Nested networking operations

If the statements are as S_1, S_2, S_3…………… S_8, then the codes in terms of fuzzy value are as follows:-

$S_1 = 0.1, S_2 = 0.2, S_3 = 0.3, S_4 = 0.4, S_5 = 0.5, S_6 = 0.6, S_7 = 0.7, S_8 = 0.8$.

We assume that (i)the outcomes of the statements are based on applications A_1, A_2, A_3, and A4., (ii)the application A1 will be dependent on the statements S_1, S_3 , A2 will be on S_2, S_4., A3 on S_5, S_7 and A4 on S_6, S_8 (iii)the desired application is $(A_1.^{\sim}UA_3.^{\sim})$. The elements of the application can be treated as the values. If we consider each application as a set then as per the condition specified, the fuzzy values that we have assigned to each corresponding statement are as follows: -

Statement	**Fuzzy Values**	**Belonging Set**
S_1	0.1	A_1
S_3	0.3	A_1
S_2	0.2	A_2
S_4	0.4	A_2
S_5	0.5	A_3
S_7	0.7	A_3
S_6	0.6	A_4
S_8	0.8	A_4

The above chart involves the statements and its respective fuzzy values and set. Since the applications are based on fuzzy operation, so we can denote each application as a fuzzy set and the results are shown below:

Fuzzy Set	**Member Function**	**Value**
$A_1^{\sim}$	S_1,S_3	$A_1^{\sim} = \{(x_1, 0.1), (x_2, 0.3)\}$
$A_2^{\sim}$	S_2,S_4	$A_2^{\sim} = \{(x_1, 0.2), (x_2, 0.4)\}$
$A_3^{\sim}$	S_5,S_7	$A_3^{\sim} = \{(x_1, 0.5), (x_2, 0.7)\}$
$A_4^{\sim}$	S_6,S_8	$A_4^{\sim} = \{(x_1, 0.6), (x_2, 0.8)\}$

Now , $\mu_{(A1.\sim UA3.\sim)}(x1) = \max(0.1, 0.5) = 0.5$;
$\mu_{(A1.\sim UA3.\sim)}(x2) = \max(0.3, 0.7) = 0.7$.

Hence operation union is dependent on the statements S_5, S_7

Theorem : If optimum path directive based on parameter x1 be done in y1 ways and that based on x2 in y2 ways, then if x1 and x2 can be performed in sequence , in that case total path directive counting will be equal to the product of y1 and y2.

Proof: We apply the analysis based on graphical representation for y1=3 and y2=5

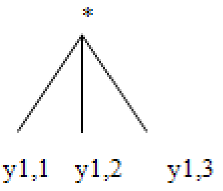

Figure1 Path directive for x1

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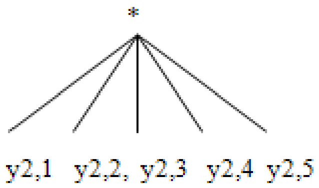

Figure2 Path directive for x2

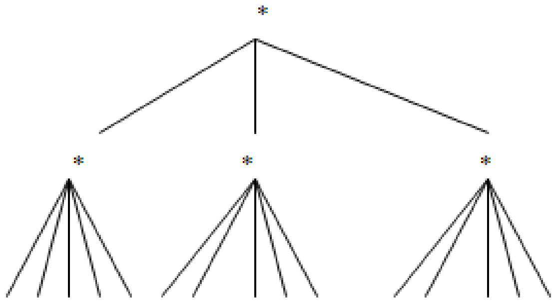

Figure3 Path directives for parameters x1 and x2 working in sequence

II. ROUTING BASED ON NEED OF APPLICATION IN CUBIC MODELS

A. Communication in cube

To find out the number of channels required for communication from a processor to its farthest processors in a distributed system where there are eight processors placed in a cubicle fashion where the nodes are communicating processors.

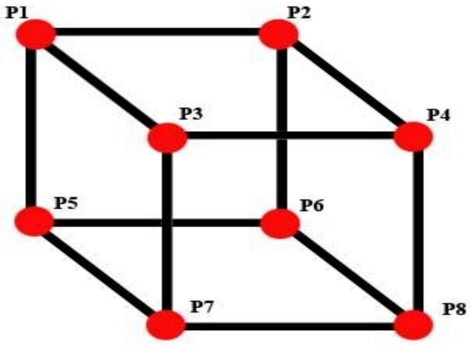

Figure4 Cubic Model

Since the model is of distributive nature the sharing of information between receiver and sender should take place in an optimum way.

As per the model the nodes denote the processors. Let us assume that P1 is the source processor. We require the communication to be between the source processor and its farthest processor in an optimum way i.e. the number of channels or paths are necessary and sufficient. Hence the farthest processor from P1 (the source processor) in this case is P8.

Thus, the number of communication channels = 3.

The possible paths in which optimized communication may take place are:

P1 → P2, P2 → P4, P4 → P8 or,
P1 → P2, P2 → P6, P6 → P8 or,
P1 → P3, P3 → P4, P4 → P8 or,
P1 → P3, P3 → P7, P7 → P8 or,
P1 → P5, P5 → P7, P7 → P8 or,
P1 → P5, P5 → P6, P6 → P8.

Optimum transmission means that the number of channels will be based on a certain criterion such that the cost complexity as the time required are minimized provided there are no transmission errors or interference of any noise (spikes) .Thus, we may mathematically denote the number of channels required for communication between the source and its farthest processor placed in a cubic model as **$\log_2 N$**, where N= total number of processors.

B. Communication in hyper-cubic model

In the case of the processors being arranged in a hyper-cubical fashion the total number of processors are 16. Now the number of channels required for a processor to communicate with its farthest processor will be one more than the number of communication channels if there were only one cube. Thus the number of communication channels = 4.

Thus, the general formula **$\log_2 N$**, where N= total number of processors is applicable to a hyper-cubical model.

C. Optimum communication between a processor and its farthest processor being arranged in matrix model

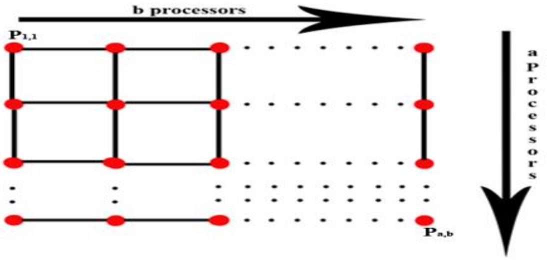

Figure5 Matrix model of the form a X b

In this model we consider $P_{1,1}$ to be the source processor. Thus the farthest processor is $P_{a,b}$. Now, for $P_{1,1}$ to communicate with $P_{a,b}$, (b-1) channels must be covered horizontally and (a-1) channels must be covered vertically. Thus the total number of channels required for communication of the source processor to the farthest processors can be mathematically stated as **(a-1) + (b-1)**. To support the above logical deduction let us consider a mathematical example. Let a=2 and b=3. Thus the arrangement is as follows:

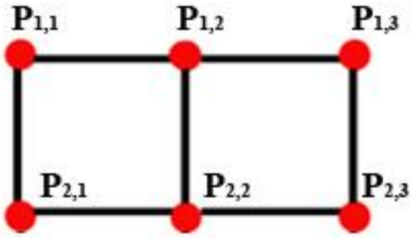

Figure6 A sub model of Matrix model of the form a X b

$P_{1,1}$ communicates with $P_{2,3}$ by taking one of the following paths:

$P_{1,1} \rightarrow P_{1,2}$; $P_{1,2} \rightarrow P_{1,3}$; $P_{1,3} \rightarrow P_{2,3}$ or,
$P_{1,1} \rightarrow P_{1,2}$; $P_{1,2} \rightarrow P_{2,2}$; $P_{2,2} \rightarrow P_{2,3}$ or,
$P_{1,1} \rightarrow P_{2,1}$; $P_{2,1} \rightarrow P_{2,2}$; $P_{2,2} \rightarrow P_{2,3}$.

Thus we see for optimized communication to take place, 3 channels need to be covered which satisfies the above deduced formula **(a-1) + (b-1) [**(2-1) + (3-1) = 3**]**.To find out the general formula for the number of communication channels required for optimal communication between a processor and its farthest processor. The processors being arranged in a **(a X a)** square matrix model.

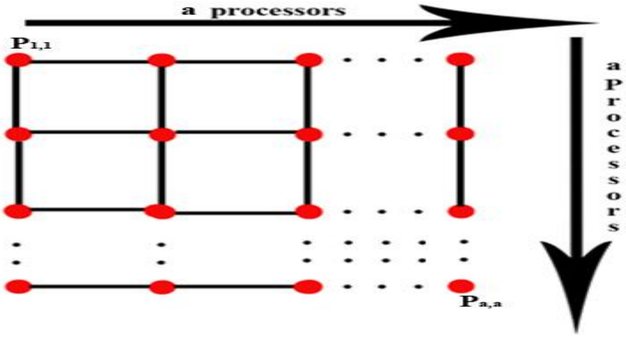

Figure7 Matrix model of the form a X b

In the previous model if we replace **b=a** we get a square matrix of the form **a X a.** We know that for a matrix of **a X b** form, Number of communication channels required for optimized communication = **(a-1) + (b-1),**

Replacing **b = a**, we get, number of communication channels required for optimized communication = **(a-1) + (a-1)** = **2(a-1).** To support the above deduction let us consider a mathematical example. Let a=3. Thus the arrangement is as follows:

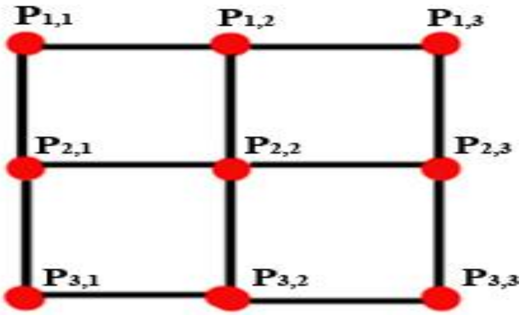

Figure8 A matrix of form 3X3

$P_{1,1}$ communicates with $P_{3,3}$ by taking one of following paths:

$P_{1,1} \rightarrow P_{1,2}$; $P_{1,2} \rightarrow P_{1,3}$; $P_{1,3} \rightarrow P_{2,3}$; $P_{2,3} \rightarrow P_{3,3}$ or,

P1,1 → P1,2 ; P1,2 → P2,2 ; P2,2 → P2,3 ; P2,3 → P3,3 or,

P1,1 → P1,2 ; P1,2 → P2,2 ; P2,2 → P3,2 ; P3,2 → P3,3 or,

$P_{1,1} \rightarrow P_{2,1}$; $P_{2,1} \rightarrow P_{2,2}$; $P_{2,2} \rightarrow P_{2,3}$; $P_{2,3} \rightarrow P_{3,3}$ or,

$P_{1,1} \rightarrow P_{2,1}$; $P_{2,1} \rightarrow P_{2,2}$; $P_{2,2} \rightarrow P_{3,2}$; $P_{3,2} \rightarrow P_{3,3}$ or,

$P_{1,1} \rightarrow P_{2,1}$; $P_{2,1} \rightarrow P_{3,1}$; $P_{3,1} \rightarrow P_{3,2}$; $P_{3,2} \rightarrow P_{3,3}$.

Thus we see for optimized communication to take place, 4 channels need to be covered which satisfies the above deduced formula **2(a-1) [** 2(3-1) = 4 **].**

III. BAYESIAN MODEL BASED PATH ANALYSIS

Here path establishment has been termed as events.

A. Event sensing In the light of Bayesian belief form

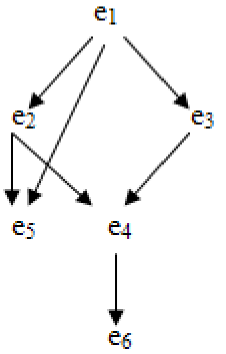

Figure9 Bayesian belief network based event prediction

Network representation for uncertain dependencies are motivated by observations made earlier. We assume that the event space = E = {e1, e2, e3, e4, e5, e6} and e2,e3 are derived from e1; e4 from e2 and e3 both ; e5 from e1 and e2 both ; and e6 from e4.

In Fig. 9 we represent the events as nodes indicating prepositional variables e_i (i=1 to 6), connected by arcs which represents causal influences or dependencies among the event. The strength of the influences are quantified by conditional probabilities of occurrence of each event. Joint probability of the event will be given by $P(k_1,k_2,\ldots k_6) = P(k_6 \mid k_4)\, P(k_5 \mid k_2, k_1)\, P(k_4 \mid k_2,k_3) P(k_3 \mid k_1)\, P(k_2 \mid k_1)\, P(k_1)$

B. Pattern matching

We want to study the trend analysis of future events based on prediction using previously observed data. If the event delivers some numerical based data estimation , then we can predict so in certain forms.

We assume d_p to be predicted datum and d_o as observed datum

If d_p and d_o are linearly related, then $d_p= a + b\, d_o$ ……...(11)

If exponentially related , the equation will be in the form of$d_p=ab^{do}$ …………..…………………………………...(12)

If logarithmic transformation based prediction rule is observed, then equation will be $D_p = A + B\, d_t$ ………..(13)

where $D_p = \log d_p$, A = log a and B = log b.

IV. CONCLUSION

The paper has pointed out the application of fuzzy rule in case of path detection . We have also shown optimum data transfer in case of cubical structure message transmission. Finally the event discovery and matching relative to path establishment has been explained in the light of statistical approach.

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