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Appendix A
Nomenclature

This appendix provides a list of symbols used in this thesis.

A	a fuzzy set.
α_{goal}	scalar variable in goal attainment method.
α_{SA}	cooling rate in simulated annealing.
α_{ant}	constant in ACO algorithm.
B_{ij}	delay per bit due to the network device feeding the link connecting LANs i and j, equal to $b_{i,j}/\omega$.
b_i	goal associated with and objective in goal attainment method.
b_{ij}	delay per packet.
β	variable in the Ordered Weighted Average operator.
β^e	variable in the OWA operator for link evaluation function in SimE.
β_{SA}	annealing constant.
β_{ant}	constant in ACO algorithm.
C_i	current cost of individual i in SimE.

c_1, c_2	acceleration coefficients in PSO.
d	total number of networking devices in the network, where nodes are connected to networking devices.
D_{nd}	delay due to network devices.
η	heuristic value in ACO.
ε_j	upper bounds in ε-constraint method.
G	syntactic rule which generates the terms in $T(\Omega)$.
g_i	goodness of individual i in SimE.
$g_m(x)$	set of inequality constraints.
γ	overall external traffic in bps.
γ_{ij}	external traffic in bps between nodes i and j.
$h_m(x)$	set of equality constraints.
L	number of links of the proposed tree topology.
λ_i	traffic in bits per second (bps) on link i.
$\lambda_{max,i}$	capacity in bps of link i.
M	markov chain in simulated annealing.
μ	membership function (overall goodness) of a solution in fuzzy logic.
N	semantic rule which associates with linguistic value its meaning.
N_i	neighborhood in l_{best} model of PSO.
n	number of nodes (i.e. LANs).
ν	variable in the Unified And-Or operator.
O_i	optimal cost of individual i in SimE.
Ω	name of linguistic variable in fuzzy logic.
ω	average packet size in bits.

p_i	maximum number of nodes that can be connected to node i.
$p^k_{\iota\psi}$	probability of moving from state ι to state ψ.
$\Re$	set of all real numbers.
R_s	reliability of the network.
R_i	reliability of a link i.
ϱ	evaporation/forgetting constant in ACO.
S	feasible region.
s	number of particles used in PSO.
T	$n \times n$ topology matrix where, $t_{ij} = 1$ if LANs i and j are connected and $t_{ij} = 0$ otherwise.
T_i	target level for objective function in goal programming method.
$T(\Omega)$	term set of Ω in fuzzy logic.
τ_i	pheromone trail on edge i in ACO.
V_{max}	velocity clamping.
$\mathbf{v_i}$	the current velocity of the particle.
W_i	weight associated with an objective function in weighted sum method.
w	inertia weight in PSO.
X	universe of discourse.
$\mathbf{x_i}$	the current position of the particle.
$\mathbf{y_i}$	the personal best position of the particle.
$\mathbf{\hat{y}_i}$	the neighborhood best position of the particle.

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Appendix B
Linear Regression Analysis

In many problems there are two or more variables that are related, and it is important to model and explore this relationship. Regression analysis is frequently used in this type of situation. In regression analysis data is analyzed from both designed and undesigned experiments. In *simple regression analysis*, the relationship between a single regressor variable x and a response variable y needs to be determined. The regressor variable x is usually assumed to be a variable controllable by the experimenter. When the experiment is designed, the experimenter chooses that values of x and observes the corresponding value of y [180]. The expected value of y for each value of x is given by the following mathematical model:

$$\mathrm{E(y|x)} = \vartheta_0 + \vartheta_1 x + \phi$$

where ϑ_0 is the *intercept*, ϑ_1 is called the *regression coefficient* associated with variable x, and ϕ is a random error with mean zero and variance σ^2. In the above equation, ϑ_1 is of special interest. It signifies the rate at which y changes if x is varied. A high value of ϑ_1 will cause y to change at a faster rate when x is varied, while a low ϑ_1 will have a slow effect on y when x is varied.

In the experiments conducted in this thesis, the following model was used:

$$\text{E(Objective)} = \vartheta_0 + \vartheta_1(nodes) + \phi$$

Here, the regressor variable is the number of nodes, while the response variable is the design objective (e.g. cost, delay, hops, reliability etc.) Using the above model, many regression equations were developed to study the effect of change of number of nodes on cost, delay, hops, and reliability for the OWA and UAO operators.

Appendix C
Derived Publications

This appendix provides a list of publications that have been derived from work presented in this thesis. These publications have been published, currently being reviewed, or yet to be submitted.

Journal Publications

1. Salman A. Khan and Andries P. Engelbrecht, "A New Fuzzy Operator and its Application to Topology Design of Distributed Local Area Networks", International Journal of Information Sciences, Elsevier, Vol 177, no. 13, July 2007, pp. 2692 - 2711.

2. Salman A. Khan and Andries P. Engelbrecht, "Multi-objective Hybrid Simulated Annealing Algorithms for Topology Design of Switched Local Area Networks", Soft Computing Journal, Springer, Vol 13, no. 1, January 2009, pp. 45 - 61.

3. Salman A. Khan and Andries P. Engelbrecht, "Design and Analysis of Multi-objective Iterative Heuristics for Distributed Local Area Network Topology

Design", Under review, IEEE Transactions on Fuzzy Systems.

4. Salman A. Khan and Andries P. Engelbrecht, "Fuzzy Multi-objective Swarm Intelligence Algorithms for Distributed Local Area Network Topology Design", To be submitted, Swarm Intelligence Journal.

5. Salman A. Khan and Andries P. Engelbrecht, "Fuzzy Hybrid Stochastic Evolution and Simulated Evolution Algorithms for Topology Design of Switched Local Area Networks", To be submitted.

6. Salman A. Khan and Andries P. Engelbrecht, "Particle Swarm Optimization Approach to Multi-objective Topology Design of Switched Local Area Networks", To be submitted.

7. Salman A. Khan and Andries P. Engelbrecht, "A Comparison of Evolutionary and Swarm Intelligence Techniques for Multi-objective Topology Design of Switched Local Area Networks", To be submitted.

8. Salman A. Khan and Andries P. Engelbrecht, "A Comparison of Ordered Weighted Averaging and Unified And-Or Operators - Application to Evolutionary and Swarm Intelligence Techniques for Multi-objective Topology Design of Local Area Networks", To be submitted.

Conference Publications

1. Salman A. Khan and Andries P. Engelbrecht, "A fuzzy ant colony optimization algorithm for topology design of distributed local area networks ", In Proceedings of the IEEE Swarm Intelligence Symposium, 2008.

2. Salman A. Khan and Andries P. Engelbrecht, "Application of Ordered Weighted Averaging and Unified And-Or Operators to Multi-objective Particle Swarm Optimization Algorithm", Accepted in 6th IEEE International Conference on Fuzzy Systems and Knowledge Discovery, August 14-16, 2009

3. Salman A. Khan and Andries P. Engelbrecht, "Dynamic Assignment of Parameters in Iterative Heuristics - a case study of distributed local area network topology design.