46) by flipping one bit, value change from v to $\bar{v}$,

to represent between $[-2^{n-1}, 2^{n-1}]$, formula can be $\sum_{i=0}^{n-2} a_i 2^i - a_{n-1} 2^{n-1}$ where last bit has negative sign bit, then flip bit i is equivalent to $|v - \bar{v}_i| = 2^i$ for binary string

then average difference : $\frac{\sum_{i=0}^{31} 2^i}{32} = \frac{2^{32}-1}{32}$ //

maximal : 2^{31} //

minimal : $2^0 = 1$ //

41) How many different offspring can be created from the two parents A and B by using the 2-point-cross-over recombination-operator?
Both genomes (A and B) are L-dimensional vectors that consist of L = 64 independent real values; the individual values are not changed by the 2-point-cross-over operator.

If $L = 2$

Parents $P_1 : X_1\ X_2$ $\quad P_2 : Y_1\ Y_2$

Possible children:

$C_1 : X_1\ X_2$ $\quad C_2 : X_1\ Y_2$ $\quad 4 = 2^2 - 0$

$C_3 : Y_1\ X_2$ $\quad C_4 : Y_1\ Y_2$

If $L = 3$

Parents $P_1 : X_1\ X_2\ X_3$ $\quad P_2 : Y_1\ Y_2\ Y_3$

Offsprings:

$C_1 : X_1\ X_2\ X_3$ $\quad C_2 : X_1\ X_2\ Y_3$ $\quad C_3 : X_1\ Y_2\ Y_3$ $\quad C_4 : X_1\ Y_2\ X_3$

$C_5 : Y_1\ X_2\ X_3$ $\quad C_6 : Y_1\ X_2\ Y_3$ $\quad C_4 : Y_1\ Y_2\ X_3$ $\quad C_8 : Y_1\ Y_2\ Y_3$

$8 = 9 - 1$

$= 3^2 - 1$

~~L=1~~ ~~L=2~~

If $L = 4$

Parents $P_1 : X_1\ X_2\ X_3\ X_4$ $\quad P_2 : Y_1\ Y_2\ Y_3\ Y_4$

Children

$X_1X_2X_3X_4$, $X_1X_2X_3Y_4$, $X_1X_2Y_3X_4$, $X_1X_2Y_3Y_4$

$X_1Y_2X_3X_4$, $X_1Y_2X_3Y_4$, $X_1Y_2Y_3X_4$, $X_1Y_2Y_3Y_4$

$Y_1X_2X_3X_4$ $\quad Y_1X_2X_3Y_4$, $Y_1X_2Y_3X_4$, $Y_1X_2Y_3Y_4$

$Y_1Y_2X_3X_4$ $\quad Y_1Y_2X_3Y_4$, $Y_1Y_2Y_3X_4$, $Y_1Y_2Y_3Y_4$

Number of Children $= L^2 - (L-2)$ $\quad$ for $L > n$

$= 64^2 - (64-2)$

2

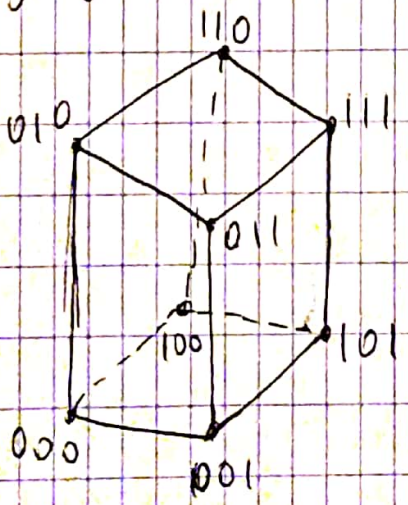
$= 4034.$

43) An evolutionary algorithm is proposed to find a solution for a ~~taten~~ Salesman who has to plan a cycle journey, visiting all cities from a given set of L cities exactly once. For this application the genome has been structured as a sequence of all L cities to visit.
An easy to implement mutation operator would be to swap two cities within this list. Is it possible to generate all possible sequences of cities by this mutation operator?

1 Yes, it is possible. If we choose the list of cities and assign them any value and sort the sequence afterwards according to these values, we can get every possible sequence since we assign the values as we wish. Thus we can generate any possible sequence using only swap operations.

44) Explain how a hypercube and a binary genome of an Evolutionary Algorithm are related to each other. Draw a sketch, visualizing this for a binary genome that has more than two bits.

2



45) Within an Evolutionary Algorithm a parent individual $X(i)$ with a genome of L bits has created N offspring $X(i) = Y(i)_n$ identical to the parent $X(i)$.
$N = 20$, $L = 100$ and $P = 0.01$.

P = probability that a certain bit is flipped.
$1 - P$ = probability that a certain bit is not flipped.
$(1-P)^L$ = Probability that no bit in a certain ~~third~~ child is flipped (child is identical to parent)

$(1-(1-P)^L)$ = Probability that a certain child differs from the parent.

$(1-(1-P)^L)^N$ = Probability that all the children differ from the parent.

$$Q = (1-(1-P)^L)^N$$
$$= (1-(1-0.01)^{100})^{20}$$
$$= (1-0.99^{100})^{20}$$
$$Q = 0.00011.$$