

gul nara j anel iZe

**qsel Si materialuri nakadebis operatiul i marTvis
sistema**

wardgenili ia doqtoris akademiuri xarisxis
mosapovebl ad

saqarTvel os teqnikuri universiteti
Tbilisi, 0175, saqarTvel o
ianvari, 2008w.

saqarTvel os teqnikuri universiteti

informatikisa da marTvis sistemebis fakul teti

Cven, qvemore xel ismomwerni vadasturebT, rom gavecaniT
janel iZe gul naras mier Sesrul ebul sadisertacio naSroms
dasaxel ebiT: "qsel Si material uri nakadebis operatiul i
marTvis sistema" da vaZI evT rekomenadas saqarTvel os
teqnikuri universitetis "informatikisa da marTvis sistemebis
fakul tetis" sadisertacio sabWoSi mis ganxil vas doqtoris
akademiuri xarisxis mosapovebl ad.

? ? ? ? ?

xel mZRvanel i: prof. g. gogi Cai Svi T i

recenzenti:

recenzenti:

recenzenti:

saqarTvel os teqnikuri universiteti

2008w.

avtori:	janelize gul nara
dasaxel eba:	qsel Si material uri nakadebis
	operatiul i marTvis sistema
fakul teti:	informatikisa da marTvis sistemebis
	fakul teti
akademuri xarisxi:	doqtori
sxdoma Catarda:	? ? ? ? ?

individualuri pirovnebebis an institutebis mier zemomoyvani i dasaxel ebis disertaciis gacnobis mizni T moTxovnis SemTxevaSi misi arakomerciul i miznebi T kopirebisa da gavrcel ebis ufl eba miniWebul i aqvs saqarTvel os teqnikur universitets.

avtoris xel mowera

avtori inarcunebs danarcen sagamomceml o ufl ebebs da arc mTI iani naSromis da arc misi cal keul i komponentebis gadabeWda an sxva raime meTodi T reproduqcia dauSvebel ia avtoris weril obiT nebarTvis gareSe.

avtori irwmuneba, rom naSromSi gamoyenebul i saavtoro ufl ebebit dacul masal ebze miRebul ia Sesabamisi nebarTva (garda im mcire zomis citatebisa, roml ebic moi Txoven mxol od specifiur mimarTebas I literaturis citirebaSi, rogorc es miRebul ia samecniero naSromebis Sesrul ebisas) da yvel a maTganze i Rebs pasuxismgebl obas.

reziume

warmodgenil i naSromis saprobl emo sferos warmoadgens rTul i topol ogiuri strukturis, didi ganzomil ebis ganawil ebul i sistemebi, roml ebic xasiaTdebian qsel Si material uri nakadebis arsebobiT. zogadad, aseT sistemebSi ar xerxdeba optimal uri gadawyvetil ebis miReba, rac ZiriTedad funqciorebis normal ur da avariul reJimebSi nakadebis optimal ur ganawil ebaSi mdgomareobs.

naSromis mizans warmoadgens qsel Si material uri nakadebis marTvis model ebisa da al goriTmebis damuSaveba, xel ovnuri intel eqtis meTodebis gamoyenebiT. am Tval sazrisiT, safuzvl ad aRebul ia genetikuri al goriTmi (ga), romel ic sakmaod efeqturia maval eqstremal urobis pirobebSi. optimizaciis kriteriumad miRebul ia saxeobaTa populaciis *fitness* funqcia anu Semguebl oba. aracxadi paral el izmis wyal obiT genetikur al goriTmebs SeuZl ia saZlebo sivrcis didi raodenobis areebis erTdroul i testireba.

SemuSavebul ia genetikuri al goriTmi s modifciarebul i varianti, romel ic arsebul Tan SedarebiT garkveul i upiratesobebiT, kerZod amonaxsnis maRal i sizustiTa da iteraciebis SedarebiT simciriT, xasiaTdeba. sawyis etapze mimdinareobs populaciis randomizebul i inicializacia da Sesabamisi amonaxsnebiS Sefaseba anu gamoiTvl eba populaciis yovel i saxeobis *fitness* funqcia romlis Semdegac Catardeba saxeobaTa kl ebadobiT sortireba. Sesabamisad, xdeba populaciis ranJireba anu TiToeul i saxeobi saTvis gani sazRvreba rangi, igive, adgil i populaciisi.

Semdgom, sel eqciis Sedegad, mocemul i populaciia iyofa sam nawi l ad: maRal i Semguebl obis mqone e.w. `I iderTa j gufis saxeobebi, roml ebic daeqvemdebarebi an krossoveris operators; dabali Semguebl obis mqone, `autsaiderTa j gufi~, roml ebic Semdgom evoluciaSi ukve aRar gani xil ebian da saSual o Semguebl obis mqone saxeobebi, roml ebic daeqvemdebarebi an mxol od mutaciis operators.

I iderTa j gufis saxeobaTa krossoveris Semdeg yovel i wyvil is aTvis sauKeTeso wyvetis wertil is povnis Tval sazrisiT xdeba Sidawyil uri gadarCevi cikl i, romlis drosac miReba krossoveris sauKeTeso varianti anu gani sazRvreba ori sauKeTeso STamomaval i. Tu STamomaval Ta Sefaseba mSobel Ta *fitness* funqciaze uaresi aRmoCnda, maSin mSobel Ta wyvill i SeinarCunebs adgil s populaciisi. saSual o j gufis TiToeul i saxeobi saTvis Sesrul deba mxol od mutaciis operatori. aRniSnul i iteracia meordeba optimumis miRwevamde Tu I ideris funqciuri mni Svnel oba aRar icvl eba, maSin unda Catardes mocemul i

saxeobis mutacia, xol o Tu mutaciis meSveobiT mi znobrivi funqciis mniSvnel oba kvl av ar Seicval a, al goriTmi amTavrebs muSaobas, rac ni Snavs, rom funqciis optimumi napovnia.

modificirebul i genetikuri al goriTmis gamoyenebiT damuSavebul ia nakadebis ganawil ebis probl emis gadawyeta. xis struqtura warmodgenil ia doneebis saxiT, rac ganapiroebes al goriTmis etapobriv muSaobas anu warmodgenil i al goriTmi mraval etapobrivia. simartivisaTvis aRniSnul i xis struqtura ganxil ul ia el ementarul i xeebis sistemis saxiT, e.i. yovel i donis yovel i kvanZi misgan gamodinare rkal ebis CaTvl iT qmnis e.w. el ementarul xes. am proceduras SeiZI eba vuwodoT *defragmentacia*.

al goriTmi muSaobs cikl Si yovel i avtonomiuri xis cal keul i fragmentisaTvis daRmaval i principiT. yovel i el ementarul i xisaTvis nakadebis ganawil ebis optimizaciis amocana mdgomareobs nakadze moTxovnasa da ganawil ebil nakads Soris sxvaobaTa minimizaciaSi, mocemul i SezRudvebis dros. amocana wydeba genetikuri al goriTmebis gamoyenebiT, sadac TiToeul i nakadi am SemTxvevaSi warmodgenil ia namdvil i ricxvebis masivis saxiT. Tavis mxriiv, genetikuri al goriTmi axorciel ebs sel eqciis, krossoverisa da mutaciis operaciebs. yovel i operatoris win xdeba amocanis piroebes Semowmeba. fragmentul i (l okal uri) optimumis povnis Semdeg al goriTmi meordeba cikl Si, vidre mTel i xisaTvis ar Sesrul deba.

genetikuri al goriTmi poul obs nakadebis ganawil ebis ramdenime optimal ur amonaxsns, amis Semdeg miRebul i variantebidan amoircева is erTi amonaxsni, romel ic iZI eva minimal ur ekonomikur maCvenebel s.

avariul situaciaSi, roca irRveva romel imē rkal is mTI ianoba da Sesabamisad mocemul i rkal i ukve veRar ganxil eba Tavis struqturaSi, an SemTxveebSi, rodesac nakadebis gadanawil eba ver aRadgens sistemis muSaobis normal ur rejims, saWi ro xdeba al ternatiul i variantebis gadarCeva saukeTeso struqturis povnis mi zniT. swored topol ogiuri moqnil obis Tval sazrisiT ganapiroebul ia qsel uri struqturis xisebr struqturerebad *dekompozicia* da misi al goriTmis Seqmnis aucil ebl oba. SemuSavebul i al goriTmis original uroba mdgomareobs imaSi, rom qsel is dekompoziciis Sedegad mi i Reba ramdenime avtonomiuri, urTierteSemavsebel i xe, romel Ta fesvebs swored sistemaSi Semomaval i wyaroebi warmoadgenen, xol o arc erTi rkal i ar ikargeba ganxil vis sferodan. qsel is yovel i wibo xasiATdeba Sesabamisi woniT koeficientiT. dekompoziciis Sedegad mi Rebul i xeebis mwerval ebis ganlageba xdeba ierarqiu i doneebis mixedviT.

dekompoziciis al goriTmis meSveobiT moxdeba axal i xeebis regeneracia da misi real izeba TiToeul i rkal is bol oebSi arsebul i sarqvel ebis an CamrTvel ebis mier. marTvis sqema warmoadgens aRniSnul i mowyobil obebis binarul i mdgomareobis masivs, romel ic gaicema dispetcerisaTvis rekomenadaciis saxiT. Semdgom nakadebis ganawil ebis al goriTmis gamoyenebiT gani sazRvreba nakadebis optimaluri mniSvnel obebi axal i struqturebis pirobebi.

sistemis operatiul i marTvisatTvis gamoyenebul ia xel ovnuri neironul i qsel ebis metodi da codnis bazebis warmodgenis freimul i model i. obieqtis marTvisas mimdinareobs sistemis uwyveti monitoringi, roml is drosac xdeba qsel is komponentebis mimdinare mniSvnel obebis permanentul i Secnoba da Sedareba codnis bazaSi arsebul etal onur model Tan Sesazl o ganTanxmebis aRmoCenis Tval sazrisiT. codnis bazaSi Setanil ia warsul i marTvis gamocdil eba qsel Si nakadebis ganawil ebis Taobaze anu sl otebis statistikuri simravl e da Sesabamisi miRebul i gadawyvetil ebabis, marTvis wesebis anu freimebis simravl e. sistemis uwyveti monitoringis Sedegad miRebul i informaciis safuZvel ze xdeba konkretul i situaciis Secnoba. codnis bazidan Sesabamisi freimebis 'arCeva'. Tu arsebul i freimebis bazidan ver moixerxda msgavsi freimis moZieba, xdeba axal i situaciis (freimis) formireba mocemul i pirobebis Sesabami sad.

codnis bazis ganswavl a-ganaxl ebis procesi metad efekturad Seizi eba ganxorciel des genetikuri al goriTmebis gamoyenebiT, roca axal i informaciis Semosvl is dros aRmoCndeba, rom ar arsebobs Sesabamisoba arsebul freimebsa da mocemul real obas Soris. am SemTxvevaSi, genetikuri al goriTmis amonaxsnit moxdeba axal i freimis formireba, romel ic daakmayofil ebs zemoxsenebul moTxovnebs.

warmodgenil i model ebi mkveTrad amari ebs qsel is marTvis operatiul obis xarisxs, gansakuTrebit pikuri datvirTvebisa da avariul i situaciebis warmoSobis dros. garda amisa, igi Zal ian mosaxerxebel ia arasrul i informaciis SemTxvevaSi marTvis Tval sazrisiT, rac qsel is im monakveTis gansazRvrvis safuZvel s qmnis, sadac moxda sistemis muSaobis normaluri reJimiis darRveva, rasac dispetcerizaciis procesSi udidesi mniSvnel obeniWeba.

zemoTganxil ul i model ebis safuZvel ze damuSavebul ia operatiul i marTvis avtomatizebul i sistema, roml is funqcionireba, ZiriTadar Seizi eba ganvixil oT, rogorc gadawyvetil ebis miRebis procesi, sadac mTavar sakiTxs konkretul situaciaSi gadawyvetil ebis povna warmoadgens. obieqtis marTvis procesSi mimdinareobs qsel is uwyveti monitoringi. qsel Si mimdinare procesebis normaluri mdgomareobidan gadaxris

Sem TxvevaSi, Tu moxda situaciis Secnoba, maSin codnis bazidan marTvis freimebis Sesabamisi mza gadawyvetil eba gaicema qsel ze mmarTvel i zemoqmedebisaTvis. Tu mimdinare situaciis Secnoba ar moixerxda, maSin nakadebis ganawil eba unda moxdes modifierebul i genetikuri al gori Tmis da qsel is xisebri strukturis adapturi gadawyobis al gori Tmis gamoyenebi T.

Summary

Problem sphere of the presented work is big dimension distributed systems of complex topological structure characterized with material fluxes in the network. Generally it becomes impossible to make optimum decisions in such systems that mainly consist in optimum distribution of fluxes in normal and emergency situations of functioning.

The aim of the work is to elaborate the models and algorithms of material fluxes control in the network using the methods of artificial intellect. With this view, the genetic algorithm (GA) is taken as a basis which is effective enough in multi extreme conditions. Fitness function or adaptation of species population is taken as optimization criterion. By means of nonexplicit parallelism genetic algorithms may simultaneously test a great number of areas of the research space.

A modified version of genetic algorithm is developed which, compared to the existing one, has definite advantages, particularly, high precision of solution and comparative shortage of iterations. At the initial stage randomized initialization of population and estimation of the respective solutions are done or fitness function of each type of population are calculated after which downward classification of species is done. Respectively, population ranging is done or the rank or place in population is determined for each species.

Afterwards, after selection the given population is divided into three parts: high adaptation, the so called “leaders’ group” species which submit to cross-over operator; low adaptation “outsiders’ group” which are not considered in the further evolution and middle adaptation species that submit only to mutation operator.

After cross-over of leaders’ groups species in order to find the best discontinuity point for each pair the cycle of interpair selection occurs when the best version of cross-over is received or two best descendants are determined. If the estimation of the descendants appear to be worse than fitness function of parents then parent pair will preserve the place in population. For each species of middle group mutation operator will only be performed. The mentioned iteration is repeated until optimum. If functional significance of the leader does not changed any more then mutation of the given species should be done, but if

purpose functional significance is not again changed by mutation, algorithm finishes the operation meaning that function optimum is found.

Using the modified genetic algorithm the solution of flux distribution problem is developed. Tree structure is presented in the form of levels which conditions stage-wise operation of algorithm or the presented algorithm is many staged. For simplicity the mentioned tree structure is considered as the system of elementary trees i.e. each node of each level including the issuing arcs constitutes the so called elementary tree. This procedure may be called defragmentation.

Algorithm operates in the cycle for separate fragment of each autonomous tree in descending principle. For each elementary tree the problem of flux distribution optimization consists of demands for fluxes and minimization of differences between distributed fluxes at given limitations. The problem is solved using genetic algorithms where each flux is presented as the massive of real numbers. On its part genetic algorithm realizes the operations of selection, cross-over and mutation. Before each operator the problem conditions are tested. After finding fragmental (local) optimum the algorithm is repeated in the cycle until is fulfilled for the whole tree.

Genetic algorithm finds several optimum solutions of flux distribution, and then from the received versions the solution is chosen which gives minimum economical factor.

In emergency situations when the integrity of any arc is broken and respectively, the given arc cannot be considered in its structure, or in cases when flow redistribution cannot renovate normal mode of system operation, it becomes necessary to select alternative versions in order to find the best structure. Just in the view of topological flexibility *the decomposition of network structures into tree structures* and the indispensability of creation of its algorithm are conditioned. The singularity the developed algorithm is that as a result of network decomposition there is received several autonomous, intercomplementary trees, the roots of which are the sources entering the system while no arc falls out of consideration. Each edge of the network is characterized with the respective weight coefficient. Tree tops received as a result of decomposition are arranged according hierarchical levels.

With the help of decomposition algorithm the regeneration of new trees and its realization by gates or switches existing at the ends of each arc will be done. Control diagram represents the massif of binary state of the mentioned devices that is given as a recommendation to the dispatcher. Then, using the distribution algorithm of flows the optimum values of flows are determined in conditions of new structures.

The method of artificial neuron networks and frame model of knowledge bases representation are used for operative control. At object control the continuous monitoring of the system is done when permanent identification and

comparison of network components current values happens with standard model existing in knowledge bases with the view point of detection of the possible discrepancy. The experience of past control about flow distribution in network or statistical set of slots and the respective set of made solutions, control rules or frames are introduced into knowledge basis. On the basis of information received as a result of continuous monitoring of the system the identification of concrete situation and “selection” of respective frames from knowledge basis is done. If it is not possible to find the similar frames from the existing frame basis a new situation (frame) is being formed.

The process of study and renewal of knowledge basis can be very effectively realized with the help of genetic algorithms when new at incoming of new information it appears that there is no adequacy between the existing frames and given reality. In this case, with the help of genetic algorithm solution the formation of new frames will happen that will satisfy the above mentioned requirements.

The presented models increase the quality of network control efficacy, especially when peak loads and emergency situations arise. Besides, it is very convenient in the case of incomplete information control which makes the basis of determination of that section of the network where the normal mode of system operation failed which has a great importance in the process of dispatcherization.

On the basis of the above considered models automatic system of operative control is developed the functioning of which can mainly be considered as the process of decision making where the main problem is solution finding in concrete situation. In the process of object control the continuous monitoring of the network is done. In the case of deviation of the processes going on in the network from standard state, if the situation is recognized, the ready solution corresponding to control frames is delivered. If the current situation is not recognized the flow distribution must be done using modified genetic algorithm and adaptive redistribution algorithm of network tree structure.

S i n a a r s i

Sesaval i	13
I Tavi . model irebis evol uciuri metodebis analizi	
\$1.1. qsel Si material uri nakadebis operatiul i marTvis amocana.....	16
\$1.2. evol uciuri model irebisa da misi praqtkul i gamoyenebis mimoxil va.....	20
\$1.3. qsel Si material uri nakadebis operatiul i marTvis sistemis arqiteqtura.....	38
II Tavi . material uri nakadebis operatiul i marTvis metodebis damuSaveba	
\$2.1. sistemis model ebis analizi	41
\$2.2. genetikuri al goriTmis metodi	51
\$2.3. modifcirebul i genetikuri al goriTmi	62
\$2.4. qsel is xisebr struqturebad dekompozicia.....	66
\$2.5. nakadebis operatiul i marTva.....	74
III Tavi . material uri nakadebis marTvis procesis model irebisa da analizis al goriTmebi	
\$3.1. marTvis procesis intel eqtual uri al goriTmebi	81
\$3.2. genetikuri al goriTmis da qsel is dekompoziciis al goriTmis aRwera	86
\$3.3. nakadebis marTvis al goriTmebi	96
\$3.4. informaciul i uzrunvel yofa da marTvis sistemis struqtura.....	100
\$3.5. programul i kompl eqsis struqtura da interfeisi	111
IV Tavi . material uri nakadebis marTvis sistemis eqsperimentul i SemoWmeba	
\$4.1. operatiul i marTvis imitacia.....	114
\$4.2. modifcirebul i genetikuri al goriTmis Sedegebis analizi	116
\$4.3. nakadebis ganawil ebis Sedegebis analizi	119
daskvna.....	121
marTvis sistemis interfeisi	122
I literatura.....	129

cxril ebis nusxa

1. grafis (qsel is) wiboTa incidiisi matrica cxr.2.4.1.....	71
2. wiboTa mosazRvreobis matrica X1 mwerval isatvis cxr.2.4.2.....	72
3. wiboTa mosazRvreobis matrica X3 mwerval isatvis cxr.2.4.3.....	72
4. wiboTa mosazRvreobis matrica X6 mwerval isatvis cxr.2.4.4.....	73
5. cxril i "kvanZi" cxr.3.4.1.....	100
6. cxril i "Semomaval i magistral i" cxr.3.4.2.....	101
7. cxril i "mil sadeni" cxr.3.4.3.....	101
8. cxril i "kvanZi" cxr.3.4.4.....	101
9. cxril i "incidencia" cxr.3.4.5.....	102
10. cxril i "rezervuari" cxr.3.4.6.....	102
11. cxril i "adgil obrivi rezervi" cxr.3.4.7.....	102
12. cxril i "sarqvel i" cxr.3.4.8.....	102
13. cxril i "mil sadenis mdgomareoba" cxr.3.4.9.....	103
14. cxril i "rezervuaris mdgomareoba" cxr.3.4.10.....	103
15. cxril i "WaburRil is mdgomareoba" cxr.3.4.11.....	103
16. cxril i "magistral is mdgomareoba" cxr.3.4.12.....	104
17. cxril i "satumbo sadguri is mdgomareoba" cxr.3.4.13.....	104
18. cxril i "sarqvel ebis mdgomareoba" cxr.3.4.14.....	104
19. cxril i "avariul i situaciebi" cxr.3.4.15.....	105
20. cxril i "avariis saxeobebi" cxr.3.4.16.....	105
21. cxril i "wnevebi mil sadenebSi" cxr.3.4.17.....	105
22. obieqtis Semaval i da gamomaval i parametrebi cxr.4.3.1.....	119

naxazebis nusxa

1. wyal momaragebis sistemis zogadi kartografiul i model i nax.1.1.....	19
2. materialuri nakadebis marTvis sistemis arqitektura nax.1.3.1.....	40
3. xel ovnuri neiuronis ganzogadoebul i sqema nax.2.1.1.....	46
4. mul tineiuronul i perceptronis zogadi sqema nax.2.1.2.....	47
5. qsel is mimdinare mdgomareobis ganswali is procesis sqema nax.2.1.3.....	48
6. qsel is marTvis freimul i model i nax.2.1.4.....	49
7. ga-s procesis sqema nax.2.2.1.....	52
8. ga-s gaCerebis kriteriumi, optimumis are nax.2.2.2.....	58
9. proporciiul i gadarCeva, rul etis meTodi nax.2.2.3.....	59
10. ga-s "kunzul is model i" nax.2.2.4.....	61
11. qsel is warmodgena grafis saxiT nax.2.4.1.....	70
12. qsel is warmodgena xisebri struktturebis saxiT nax.2.4.2.....	73
13. nakadebis ganawil ebis sqema erTi avtonomiuri xisaTvis nax.2.5.1.....	76
14. nakadebis ganawil ebis sqema nax.2.5.2.....	78
15. xeebis warmodgena sawyis etapze nax.2.5.3.....	79
16. xeebis warmodgena regeneraciis Semdeg nax.2.5.4.....	80
17. sistemis marTvis algoritmisi sqema nax.3.1.1.....	82
18. modifirebul i genetikuri algoritmisi sqema nax.3.2.1.....	86
19. genotipebis Seguebadobis gamoTvl is bl ok-sqema nax.3.2.2.....	87
20. sawyisi striqonebis formirebis bl ok-sqema nax.3.2.3.....	88
21. striqonebis dekodirebis bl ok-sqema 3.2.4.....	88
22. striqonebis SeguebadobiT sortirebis bl ok-sqema nax.3.2.5.....	89
23. striqonebis ranjirebis bl ok-sqema nax.3.2.6.....	90
24. populaciis jumuri Seguebadobis gamoTvl is bl ok-sqema nax.3.2.7.....	91
25. populaciis rangiT dalagebis bl ok-sqema nax.3.2.8.....	92
26. populaciis analizis bl ok-sqema nax.3.2.9.....	93
27. krossoveris, mutaciis bl ok-sqema nax.3.2.10.....	94
28. qsel is xisebr strukturedad dekompoziciis algoritmisi sqema nax.3.2.11.....	95
29. nakadebis operatiul i marTvis ganzogadoebul i sqema nax.3.3.1.....	97
30. normal ur reJiMSi nakadebis marTvis algoritmisi sqema nax.3.3.2.....	98
31. avariul reJiMSi nakadebis marTvis algoritmisi sqema nax.3.3.3.....	99
32. marTvis sistemis monacemTa bazis struktura nax.3.4.1.....	100
33. mdgomareobaTa da marTvis freimebis struktura nax.3.4.2.....	108
34. qsel is marTvis sistemis struktura nax.3.4.3.....	110
35. sistemis marTvis programul i kompl eqsis struktura nax.3.5.1.....	111
36. marTvis sistemis interfeisis struktura nax.3.5.2.....	113
37. marTvis obieqtis sqema nax.4.1.1.....	114
38. genetikuri algoritmisi Sedegebi sur.4.2.1.....	117
39. modifirebul i genetikuri algoritmisi Sedegebi sur.4.2.2.....	118
40. moTxovnaTa da ganawil ebis Sedegebis diagramebi sur.4.3.1.....	120
41. marTvis sistemis interfeisi: formebris maketebi.....	122
42. marTvis sistemis interfeisi: moTxovnebris maketebi.....	124
43. marTvis sistemis interfeisi: angariSebis maketebi.....	128

Sesaval i

Tanamedrove informaciul i teqnol ogiebis ganvi Tarebam mni Svnel ovnad gaafarTova svedasxva sferoSi teqnol ogiuri kvl evis horizonti. ukve didi xania kompiuteri aRar isazRvreba mxol od eqsperimentul i monacemebis damuSavebisa da anal izis funqciiT. ZviradRirebul i da Znel adreal izebadi fundamenturi Teoriul i Tu eqsperimentul i gamokvl evebis nacvl ad sul ufro farTod iki debs fexs manqanuri model irebis paradigm[31].

naSromis interesebis sferos warroadgens rTul i, kerZod, ganawil ebul i sistemebi, roml ebic xasiaTdebian didi ganzomil ebit, rac ganpirobekul ia sistemis mraval parametrul obiT, strukturul i da teqnol ogiuri sirTul iT; dinamiurobiT; marTvis mraval miznobriobiT; optimumis Zebnis sirTul iT.

aRni Snul i kl asis obieqtebs mieuTvnebian rTul i topol ogiuri strukturis mqone sakomunikacio, wyal momaragebis, gazmomaragebis Tu el eqtromomaragebis sistemebi, agreTve svedasxva satransporto qsel ebi (sxa qsel ebi sagan gansxvavebiT, satransporto qsel ebi xasiaTdebian ormxrivi nakadebiT, amdenad igi ar warroadgens mocemul i naSromis interesebis sferos). aRni Snul obieqtebs aerTi anebT sistemaSi nakadebis arseboba, romel ic SeiZI eba iyo material uri, energetikul i an informaciul i. CamoTvl il ganawil ebul sistemebi saerTo aqvT marTvis principebi, rac nakadebis ganawil ebaSi mdgomareobs, Tumca Ti Toeul i maTgani xasiaTdeba nakadebis marTvis specifikiT. aseTi obieqtebis marTvis mizani, Ziri Tadad, nakadebis optimal ur ganawil ebaSi mdgomareobs. didi ganzomil ebisa da teqnol ogiuri sirTul is gamo aseTi donis marTvis sistemebi ar xerxdeba anal itikuri gadawyeta da

dispētcerizaciis probl emebi mxol od mom saxure personal is gamocdil ebis xarj ze wydeba.

aqedan gamomdinare naSromis mi zania, qsel Si nakadebis operatiul i marTvis al goriTmebis da maT safuZvel ze material uri nakadebis marTvis avtomatizebul i sistemis damuSaveba. am mi znis misaRwevad ZiriTadi yuradReba eTmoba Semdegi amocanebis gadawyvetas:

- modifificirebul i genetikuri al goriTmis damuSavebas nakadebis optimal uri ganawi l ebisaTvis;
- avariul reJimsi marTvis aTvis da agreTve deficitis probl emis gadawyvetisaTvis qsel is regeneraciis mi zni T qsel is dekompoziciis al goriTmis damuSavebas;
- warmodgeni l i al goriTmebis bazaze nakadebis operatiul i marTvis sistemis damuSavebas;
- sistemis operatiul i marTvis aTvis xel ovnuri neironul i qsel ebis model isa da codni s bazis warmodgenis freimul i model is damuSavebas;
- material uri nakadebis marTvis sistemis informaciul i da programul i uzrunvel yofis damuSavebas monacemTa bazebis marTvis sistemis - MS SQL Server da obieqt-orientirebul i daprogramebis sistemis bazaze.

Catarebul i kvi evis Sedegad damuSavda:

modifificirebul i genetikuri al goriTmi; qsel is dekompoziciis al goriTmi; nakadebis marTvis al goriTmi; operatiul i marTvis sistemis model i; damuSavda sistemis marTvis al goriTmul i, informaciul i da programul i uzrunvel yofa.

pirvel TavSi warmodgenil ia qsel Si materialuri nakadebis operatiul i marTvis probl ema da SemoTavazebul ia am probl emis gadawyeta genetikuri al goriTmis meTodiT.

Catarebul ia evol uciuri, kerZod genetikuri model irebis meTodebis safužvel ze Seqmnii i maval i samecniero proeqtisa da disertaciis mimoxil va, romel ic cxadyofs evol uciuri midgomis mizanSewonil obas. damuSavebul ia nakadebis marTvis avtomatizebul i sistemis arqiteqtura.

meore TavSi damuSavebul ia modifiциrebul i genetikuri al goriTmi, romel ic metad efekturia maval eqstremaluri optimizaciis amocanebis gadasawyvetad; avariul rejimSi qsel is regeneraciis probl emis gadawyvetisaTvis damuSavebul ia qsel is dekompoziciis model i; damuSavebul ia xel ovnuri intel eqtis meTodebit sistemis marTvis model i, sadac sistemis operatiul i marTvisatvis gamoyenbul ia xel ovnuri neironul i qsel ebris meTodi da codnis bazebis warmodgenis freimul i model i.

mesame TavSi warmodgenil ia: damuSavebul i model ebris al goriTmebi; monacemTa baza MS SQL Server da MS Access sistemebis bazaze; nakadebis marTvis sistemis programul i uzrunvel yofa obieqt-orientirebul i sistemis – Delphi bazaze.

meoTxe TavSi damuSavebul ia obieqtis imitaciuri model i; warmodgenil ia naSrromSi miRebul i Teoriul gamokvl evaTa Sedegebis analizi.

I Tavi. model i rebis evol uciuri meTodebis analizi

\$1.1. qsel Si material uri nakadebis operatiul i marTvis amocana

qsel ur ganawi l ebul obieqtebs, roml ebic warmoadgenen mocemul i naSromis interesebis sferos da romel Tac mieuTnebian rTul i topol ogiuri strukturis mqone, wyal momaragebis, gazmomaragebis sistemebi, aerTianebeT sistemaSi material uri nakadebis arseboba. qsel ebi gansxavdebi an rogorc strukturul ad, ise Semadgeni obiTa da maTematikuri model ebiT. maT saerTo aqvT mxol od marTvis anu nakadebis ganawi l ebis principebi.

Tavis mxriv, TiToeul i tipis qsel i xasiaTdeba nakadebis marTvis specifikiT, rac ki dev ufro mraval ferovans xdis aseTi kl asis sistemebis model i rebis, procesebis organizaciisa da marTvis al goriTmebis, agreTve programul saSual ebaTa funqciioni rebis Iogikis Tval sazrisiT. Tumca wyal momaragebi sa da gazmomaragebis sistemebi garkveul i principul i anal ogiurobiT xasiaTdebi an. amdenad, material uri nakadebis marTvis magal iTis saxiT sakmarisia ganvixi l oT Tundac erTerTi maTgani.

marTvis Tval sazrisiT, qal aqis wyal momaragebis sistema iTvi eba rTul samarTav ekol ogiur obieqtad mTel i rigi faqto-rebis gamo. sistemis ziriTadi komponenti _ wyal gamanawi l ebel i qsel i mudmivi eqspl oataciisa da ganaxl ebis procesSia. urbanistul i procesebis dinamika, momsaxurebis permanentul oba da sirTul e, wyl is stoqasturi danakargebi, wyl is xarisxobrivi Tu raodenobrivi maCvenebl ebis kontrol isa da marTvis probl emebi qmnian perturbaciebs qal aqis wyal momaragebis sistemis funqciioni rebaSi [31].

wyal momaragebis sistema, qsel is topol ogiis didi ganzomilebiTa da teqnologiuri sirtul iT, agreTve sakmaod didi inerciul obiT xasiaTdeba. sakiTx s kidev ufro arTul ebs avariul situaciTa sixSire da maTi likvidaciis mizniT marTvis operatiul obis maRal i xarisxi. rac mTavaria, obieqtis mieuTvneba sasicocxl o mniSvn obisa da maRal i riskis ekol ogiur klasis obieqtebs, rac kidev ufro amari ebs gamokvl evebi sadmi motxovnebs.

wyal momaragebis marTvis avtomatizebul i sistemis funqciонirebis xarisxis kvl eva SeuZI ebel ia sistemaSi gaerTianebul el ementTa Tvis sebebis, maT Soris arsebul urTierTkavSi rebis xasiatisa da urTierTqmecdebis meqanizmebis Seswavi is gareSe.

wyal momaragebis sistemebis aTvis damaxasi aTebel ia marTvis strukturis cval ebadoba damyarebul i wyl iT uzrunvel yofis procesis Sesabamisad, marTvis parametrebisa da rejimis efekturobis maCvenebl ebis `aramkafioba~ da ganusazRvrel oba, adamianTa aucil ebel i monawil eoba operatiul i marTvis processi (rac Tavis mxriv damoki debul ia individualuri gadawyvetil ebaTa miRebis `araerTgvar ovnebas da `aramkafiobaze~) da sxva. aRniSnul is gamo arc Tu i SviaTia realuri sistemebis marTvis procesebSi probl emata arseboba [18].

miuxedavad imisa, rom msofl ios mraval qal aqSi warmatebiT funqciонireben wyal momaragebis marTvis avtomatizebul i sistemebi, warmmarTvel i rol i mainc adamians ekisreba, radgan aseTi donis marTvis sistemebSi rTul ad real izebadia analitikuri gadawyeta. dispetcerizaciis probl emebi ZiriTadad eyrdnoba momsaxure personal is gamocdil ebas, ris gamoc xSirad miuRwevel ia optimaluri amonaxsnis povna.

qal aqis wyal momaragebis sistemaSi wydeba amocanaTa kompl eqsi daproeqtebis, dagegmvis, prognozirebis, kontrol i sa da marTvis

Tval sazrisiT. mocemul i naSromi ar isaxavs miznad mTel i kompl eqsis gadawyvetas, aramed ifargl eba mxol od wyl iT uzrunvel yofis procesis operatiul i marTviT, roml is mizani ZiriTadar qsel is maval ricxovan ganStoebebSi wyl is nakadebis optimal ur ganawil ebaSi mdgomareobs, muSaobis rogorc normal ur, ise avariul reJimebSi.

unda aRiniSnos, rom wyl iT uzrunvel yofis procesis operatiul i marTva warmoadgens didi ganzomil ebis, maval parametrul amocanas, romel ic efuzneba masSi mmdinare sxvadasxva procesis model irebas. zogadad, sistemis marTvis xarisxi ganiSazRvreba obieqtis model uri uzrunvel yofis adeqvaturopiT.

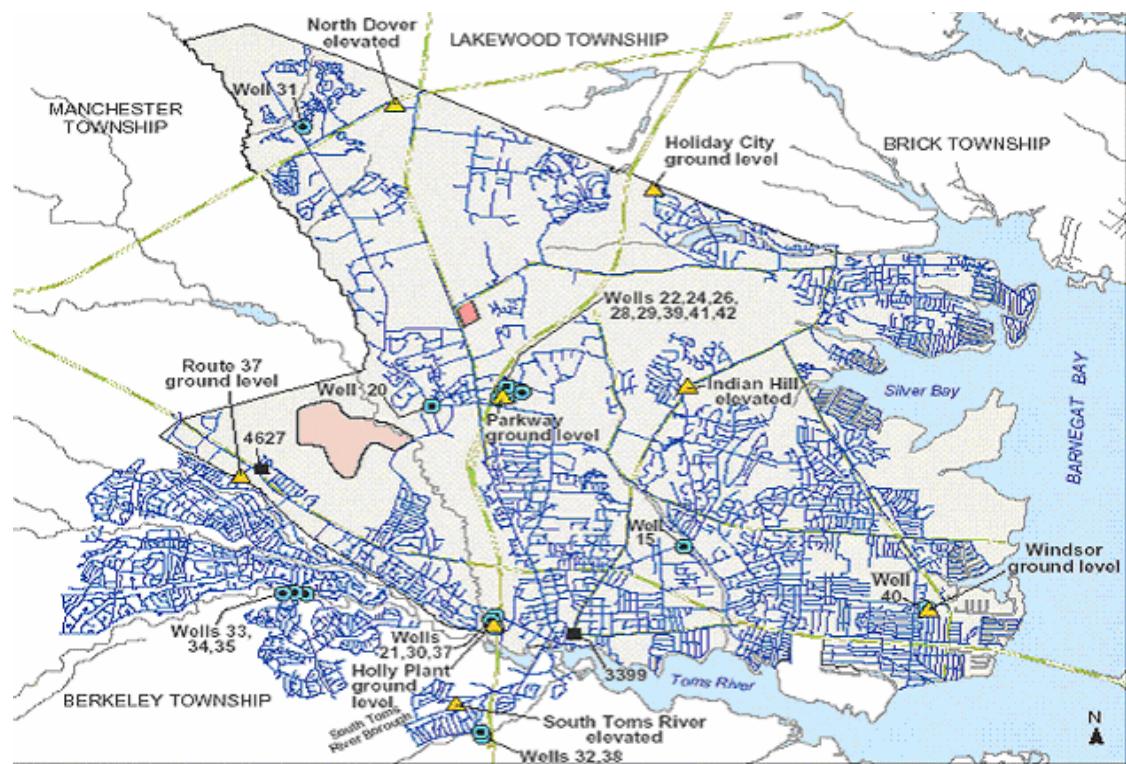
amdenad, didi mniSvnel oba eniWeba qal aqis wyal momaragebis sistemis komponentebis funqcionirebis xarisxisa da dispetCerizaciis strategiebis model ebis agebas.

qsel is marTva mmdinareobs ZiriTadar or reJimsi: normal ur da avariul reJimebSi. sakiTxs kidev arTul ebs avariul situaciTa sixSire da maTi l ikvidaciis mizniT marTvis operatiul obis maRal i xarisxi. Lokaluri anu cal keul i magistraluri mil sadenis doneze datvirTvebisa Tu sxvadasxva parametrebis cval ebadoba (sadReRamiso grafikebi, pikuri datvirTvebi da sxva), wyaroebidan Semomaval i nakadebis cvl il ebis SemTxveviTi xasiati, agreTve avariul i situaciebis warmoSobis maRal i al baToba qmnan qsel is struqturaSi nakadebis optimal uri gadanawil ebis aucil ebl obis pirobebs, rac mniSvnel ovnad arTul ebs marTvis problemebs.

zemoT aRniSnul i argumentebidan gamodinare, qal aqis wyal momaragebis operatiul i marTvis gadawyvetil ebis miRebis procesSi sul ufro mkafiod ikveTeba xel ovnuri intel eqtis, rogorc maRal i donis marTvis metodis gamoyenebis aucil ebl oba. obieqtis sirTul isa da didi ganzomil ebis gamo,

agreTve arasrul i informaciis pirobebSi marTvis dros gansakuTrebul mni Svnel obas iZens marTvis procesSi xel ovnuri intel eqtis meTodebis gamoyeneba [35]. amrigad, naSromis Ziri Tadi amocana SeiZI eba Semdegi saxiT Camovayal iboT: nakadebis operatiul i marTvis model ebis damuSaveba qsel is funqcionirebis normal uri da avariul i reJimebisatvis. am model ebis bazaze operatiul i marTvis avtomatizebul i sistemi real izeba.

zogadad, qal aqis wyal momaragebis sistemis kartografiul i model i warmodgenili ia nax.1.1.1-ze.



nax. 1.1.1.

\$1.2. evol uciuri model irebisa da misi praqtkul i gamoyenebis mimoxil va

praqtkul i amocanebis optimizaciis saki Txebis gadawyeta seriozul probl emebTanaa dakavSirebul i. es ganpi robebul ia, jer erTi amocanebis sakmaod didi ganzomil ebiT, meore real uri procesebisaTvis damaxasiaTebel i arawrfivobiT da mesame - rTul i saxis SezRudvaTa sistemis arsebobiT [8].

didganzomil ebiani, maval eqstremal uri amocanebis amoxsnis as xSirad gamoyeneba evristikul i al goriTmebi anu zogadad evristika, maSin rodesac ar aris aucil ebel i optimal uri amonaxsni, aramed sakmarisia kargi amonaxsnis povna. samagierod evristikul i al goriTmebi sakmaod swrafia da martivi, vidre nebi smieri cnobil i zusti al goriTmi. `kargi amonaxsnis~ cneba TviT amocanazea damoki debul i. cnobil i zusti al goriTmiT amocanis amoxsnas SeiZI eba dasWirdes sakmaod didi dro, maSin roca optimal urTan miaxl oebul i amonaxsni SeiZI eba napovni iqnas gacil ebiT mcire droSi [17].

evristikul i al goriTmebis aRweris universal uri struqturebi ar arsebobs. evristikul i al goriTmebis agebis erT-erTi midgoma SemdegSi mdgomareobs: unda CamoiTval os zusti amonaxsnis mi RebisatTvis saWiro moTxovnebi, es moTxovnebi SeiZI eba daiyos ki asebad: moTxovnebi, romel Ta dakmayofil eba SedarebiT martivia, da moTxovnebi, romel Ta dakmayofil eba ar aris martivi. SeiZI eba gvqondes agreTve sxva SemTxvevac: moTxovnebi, roml ebic aucil ebl ad unda dakmayofil dnen da moTxovnebi, romel Ta mimart SeiZI eba kompromisze wasvl a. Tumca es ar niSnavs, rom meore moTxovnis dasakmayofil ebl ad araviTari cda ar keTdeba, aramed niSnavs, rom meore pirobis dasakmayofil ebl ad ar iqneba mocemul i araviTari garantia [10].

zemoTTqm̄ul idan gamomdinare, roca Seiqmneba al goriTmi, romel ic I ogiki dan gamomdinare unda muSaobdes yvel a msgavs amocanaze, magram sistemis specifiki dan gamomdinare SeuzI ebel ia al goriTmis sisworis damtkiceba, am SemTxvevaSi al goriTmi gani xi l eba rogorc evristikul i [11].

evristikul -evol uciurma Teoriam Tavisi gamoCenis momenti danve Secval a adamianTa msofI mxedvel oba. Tanamedrove etapze mecnierul i codnis mralval i sfero xasiaTdeba azris TavisufI ebiT, romel ic dayrdnobill ia evol uciisa da ganvi Tarebis Teoriaze. ganvi Tarebis safuZvel s warmoadgens bunebrivi gadarCeva. ganvi Tarebis mTavar i meqanizmi mdgomareobs SemdegSi: gadarCeva cvl il ebebTan SerwymiT. es meqanizmi xsnis bunebaSi arsebul sakmaod farTo speqtris movl enebs. amitomac kompiuterul i kvl evebiT dakavebul ma mecnierrebma mimarTes evol uciuri kanonebis anal ogias kompiuterul i imitaciis Tval sazrisiT. evristikul -evol uciuri midgomis sxvadasxvaobis miuxedavad, TiToeul ma maTganma Tavisi wwl il i Seitan optimizaciis axal i meTodebis Seqmnasa da kompiuterul real izaciaSi [25,30].

bunebrivi gadarCeviS principebze dafuZnebul amocanebSi am sistemebiT sargebl obis mTavar sirTul es warmoadgens, rom bunebrivi sistemebi sakmaod qaosuria, xol o yvel a Cveni moqmedeba, faqturad atarebs zust mimarTul ebas. kompiuters viyenebT Cvens mier formul irebul i gansazRvrul i amocanebis amoxsnis instrumentad, vamaxvil ebT yuradRebas, rom minimaluri danaxarj ebiT miviroT Sesrul ebis maqsimaluri siswrafe. bunebriv sistemebs ara aqvT aseTi miznebi da SezRudvebi, yovel SemTxvevaSi CvenTvis es ar aris cnobil i. bunebaSi "gadarCena" ar aris TviTmizani anu mimarTul i raime fiqsirebul i mizni saken, amis nacyl ad evol ucia dgams nabij s win nebismieri SesaZI o mimarTul ebiT [12]

Zal i sxmeva, romel ic mimarTul ia bunebrivi sistemebis anal ogebTan evol uciis model irebaze, SeuZl eba daiyos or kategoriad:

a) sistemebi, roml ebic model irebul ia biol ogiur principebze. isini warmatebi T gamoyenебian funkcionaluri optimizaciis tipis amocanebisatvis da martivad aRiwerebian arabiol ogiur enaze;

b) sistemebi, roml ebic arian biol ogiurad ufro realuri, magram roml ebic ar aRmoCndnen gansakuTrebi T sasargebl o gamoyenebi Ti Tval sazrisiT. isini xasiaTdebi an rTul i da saintereso qcevi T, da swrafad Rebul oben praqtikul gamoyenebas.

praqtikaSi ase mkacrad ver gamovyoft am sakiTxebs. es kategoriebi ubral od ori pol usia, romel Ta Soris devs sxvadasxva gamoTv iTi sistemebi. pirvel pol usTan axl osaa - evol uciuri al goriTmebi, iseTi rogoricaa evol uciuri programireba (*Evolutionary Programming*), genetikuri al goriTmebi (*Genetic Algorithms*) da evol uciuri strategiebi (*Evolution Strategies*), meore pol usTan axl osaa sistemebi, roml ebic kl asificirdebi an, rogorc xel ovnuri sicocxl e[12,30].

evol uciuri model irebis praqtikul i gamoyenebis mimoxil va.

unda aRiniSnos, rom amJamad evol uciuri model irebis metodebi didi popul arobi T sargebl obs samecniero-sainJinro wreebSi, ramac farTo asaxva hpova sxvadasxva samecniero proeqtebsa da disertaciebSi. bunebrivia, SeuZl ebel ia mTI ianad moicva samecniero publ ikaciis srul i speqtri aRniSnul i mimarTul ebi T, magram Tundac qvemod moyvanil i mcire mimoxil vac ki cxadyofs evol uciuri model irebisadmi interess.

d.e. gol dbergma (*ilinois universiteti*) gaza denis sistemisaTvis daamuSava marTvis maswavl i al goriTmebi [26]. gaza deni kompl eqsi Sedgeba maval i ganStoebisagan, roml ebSiC svedasxva raodenobis gazi gaedineba. marTvis erTaderTi saSual ebaa kompresorebi, roml ebic zrdian gaza denis totebSi wnevas da sarqvel ebi, roml ebic sacavidan aregul ireben gazis nakads. gazis wneva mil ebSi, sakmaod cval ebadia datvirTvis cval ebadobis gamo, rac moiTxovs kompresorebisa da sarqvel ebis operatiul funqcionirebas. gaza denis marTvis amo canas ar gaaCnia anal itikuri amonaxsni da dispetCeri gadawyetil ebas iRebs gamocdil ebis safuzvel ze. gol dbergis sistema ara marto amcirebs gazis eqspl oataciis danaxarj ebs, aramed gamoimuSavebs e.w. wesebis ierarqias, romel sac unari aqvs arasrul i informaciis SemTxvevaSiC adeqvaturi reagireba gaakeTos gaza denSi mouI odnel ad warmoqmnili i probl emebis dros. Kl asifikatori, romel ic Seicavs minimum 8000 wess, gamoimuSavebs gadawyetil ebas operatiul i marTvis aTvis.

I . deivis “*Tica Associates*” kompani idan (*kembrij i, masacusetis Stati*) sargebl obda anal ogiuri meTodebiT sakomunikacio qsel ebis konstruirebisaTvis; misi komputerul i programis mizani mdgomareobs imaSi, rom minimaluri gadamcemi xazebisa da maTi damakavSi rebel i komutatorebis SemTxvevaSi gadai ces maqsimaluri informacia.

mkvl evarTa j gufma “*General Electric*” kompani idan da agreTve renzel erovskis politeqnikuri institutid dan, warmatebiT gamoiyena genetikuri al goriTmi reaqtiul i Zravas turbinebis konstruirebisaTvis. es turbinebi gamoiyeneba Tanamedrove avial ainerebSi da metad ZviradRirebul ia. turbinebis konstruqciaSi monawil eobs minimum 100 cvl adi, romel Tagan TiToeul i maTgani Seizi eba icvl ebodes svedasxva diapazonSi. Sesabami sad saZiebo sivrce Sesdgeba 10^{387} wertil isagan.

turbini s efekturoba damoki debul i maze, Tu ramdenad kargad akmayofil ebs igi 50 SezRudvis simravl es, iseTs, rogoricaa misi Sida da gare konturebis sigl uve, agreTve wneva da a.S. Cixuri situaci idan gamosaval i napovni iqna genetikuri al goriTmebis gamoyenebi T. mi Rebul iqna 3-j er ufro ukeTesi konstruqcia, vidre xel iT damuSavebis dros da Tanac gacil ebi T mokl e droSi.

genetikuri al goriTmebi amoixsneba mraval i real uri amocana. magal iTad, igi gamoi yeneba xidis konstruqciis proeqtirebaSi, simtkicisa da wonis maqsimal uri Tanafardobis ZiebisaTvis an kidev qsovili s formebad daWris optimal uri variantis ZiebisaTvis. igi gamoi yeneba agreTve procesis interaqtiul i marTvis, magal iTad qimiur qarxanaSi, an mraval procesori an kompiuterSi datvirTvis bal ansirebisaTvis.

israel is kompaniam `Sema~ daamuSava programul i produqtii ~Channeling~ qsel uri kavSiris muSaobis optimizaciisaTvis. programa irCevs optimal ur sixSires, romel zec Seuferxebl ad mimdinareobs saubari.

genetikuri al goriTmebi mraval parametriani funqciebis optimizaciis saSual ebas izI eva. mraval i real uri amocana SeiZI eba formul irdes, rogorc optimal uri mniSnel obis Zieba, sadac mniSnel oba aris rTul i funqcia, damoki debul i zogiert Semaval parametrebze. zogjer saWiroa im parametrebis mniSnel obis povna, roml is drosac miiRweva funqciis yvel aze zusti mniSnel oba. zog SemTxvevaSi zusti optimumi ar moi Txoveba, amonaxsnad SeiZI eba CaiTval os nebi smieri mniSnel oba, romel ic ukeTlesia romel imo mocemul si di deze [24].

genetikuri al goriTmis efekturoba mdgomareobs imaSi, rom mas aqvs mraval i parametris erTdroul ad manipul irebis unari. am TvisebaTa gamo genetikuri al goriTmebi sxvadasxva formiT gamoi yeneba mraval i teqnikuri da samecniero probl emebis

gadasawyvetad. i sini gamoi yeneba sxvadasxva gamoTvl iTi strukturis Sesaqmnel ad, rogoricaa, magal iTad, avtomatebi an sortirebis qsel ebi. manqanur swavl ebaSi i sini gamoi yenebi an xel ovnuri neironul i qsel ebi proeqtirebisatvis an robotebis marTvisatvis. aseve gamoi yenebi an sxvadasxva sagnobriv sferosi ganvi Tarebis model irebisatvis, biologuri (ekol ogia, imunologia da populaciuri genetika), socialuri (ekonomika da politikuri sistemebi), kognitivni sistemebi.

mni Svnel ovani Sedegebi mi i Ro j. hintonma xel ovnur neironul qsel ebze Catarebul i neirofsiqikuri gamokvl evebiT [29].

ganswavl adi manqanebis Seqmnia da gamoyenebis sferos erTerT Tval saCino mimarTul ebad Camoyal ibda e.w. genetikuri al goriTmebz dafuznebul i rTul i adapturi sistemebi [24], roml ebic kompiuterul i eqsperimentebis mixedviT gamosakvl evi obieqtis Sesaxeb codnis dagrovebis saSual ebas iZI eva. bunebrivi SerCevis principze Seqmni i genetikuri al goriTmebi sakmaod efektur saSual ebas warmoadgens mraval ganzomil ebiani arawrfivi, mraval eqstremumi ani sistemebis SemTxvevaSi. grafikul i kompiuterul i programebis meSveobiT mraval variantiani gadarCevis Semdeg fizikosma r.smol im SesZl o wakveTil i ikosaedris strukturis mqone naxSirbadis makromol ekul uri kl asteris C60 model is ageba [14].

genetikuri al goriTmebis gamoyenebis sferoebi.

saxeta Secnoba. Tanamedrove tel ekomunikaciuri industria xasiatdeba Zal ze maRal i dinami urobiT, rac umeteswil ad ganpi robebul ia xel momwerTa xSiri gadarTviT erTi provайдеридан мөрөзэе маTi миграциис Sedegad. amis gamo satransporto danaxarj ebi mitanaze mkveTrad matul obs. yvel a kuriers gaachnia kl ientebis Sesaxeb sakmaod didi mocol obis monacemTa baza, magram mudmivadmoZravi kl ientebis identificireba real ur droSi metad rTul amocanas

warmoadgens. am Tval sazrisiT, genetikuri al goriTmebis gamoyenebiT SesazI ebel i xdeba probl emis gadawyveta "If-Then" tipis wesebis krebul is generacia sistemis ganswavi sa da klientTa sxvadasxva j gufebis moZraobis al baTobis gansazRvr is mizniT [36]. xel ovnuri intel eqtis sxva meTodebTan, kerZod xel ovnuri neironul i qsel ebis, gadawyvetil ebaTa xeze dafuznebul al goriTmebTan SedarebiT genetikuri al goriTmebi bevrad ufro zust amonaxsns iZI evi an.

maTematika da al goriTmebi. genetikuri al goriTmebi gamoyeneba agreTve maRal i rigis arawrfivi kerzo diferencial uri gantol ebebis amosaxsnel ad da izl eva TiTqmis zust amonaxsns. garda amisa, kompiuterul mecnierebaSi, gamanawi ebel qsel SimonacemTa sortirebis amocana warmatebiT wydeba genetikuri programirebis meSveobiT.

masal ebis inJineringi. erTerT Tval saCino magal iTad SeiZI eba Cai Tval os naxSirbadovani pol imerebis e.w. pol ianil inis sasurvel i Tvisebabis mqone (el eqtrul ad gamtari) axal i mol ekul ebis daproeqteba, romel ic metad rTul probl emas warmoadgens. maRal i reaqtiul obis gamo naxSirbadis atomebs SeuZI iaT uamravi struqturebis formireba, saidanac axal i mol ekul ebis miznobrivi daproeqteba TiTqmis SeuZI ebel ia imitaciuri model irebis gareSe. am Tval sazrisiT, genetikuri al goriTmebi Seucvl el ia sawysi populaciis SemTxveviTi generaciis Semdeg genetikuri operatorebis meSveobiT xdeba sasurvel i Tvisebabis mqone axal i mol ekul ebis daproeqteba.

geofizika. seismologiuri monacemebis bazaze miwiSvr is epicentris adgil is gansazRvra zedmiwenviT rTul i amocanaa. genetikuri al goriTmebis gamoyenebiT SesazI ebel i xdeba swrafad iqnas gansazRvrul i optimal urTan miaxl oebul i amonaxsni .

ekonomika. bazris qaosurobi dan gamodinare, prognostul i amocanebis gadawyvetis dros maRaL i riskis gamo, metad rTul deba gadawyvetil ebis miReba. am mxriv, sakmaod efeqturia maragisa da miwodebis marTvsi kl asifikasiis Tval sazrisiT `If-Then" tipis wesebis generacia genetikuri al goriTmebis gamoyenebi T.

qimia I azerul energias SeuZl ia rTul i mol ekul ebi daSal os martiv mol ekul ebad. am process farTo gamoyeneba aqvs organul qimiasa da mikro-el eqtronikaSi. aRniSnul i reaqciis sabol oo produqtis miRebis procesis marTva I azeris impul sis fazis cvl il ebiT. didi mol ekul ebis SemTxvevaSi sasurvel i impul sis model is miReba anal itikuri xerxit Zal ian rTul ia, xol o gamoTvi ebi metad Sromatevadia. amdenad, evol uciuri al goriTmebis gareSe am probl emis gadawyeta praqtkul ad SeuZl ebel ia. farmacevtul industriaSi genetikuri al goriTmebis gamoyenebam dasabami daudo agreTve e.w. kombinatorul i qimii Camoyal i bebas, rogorc axal da perspektiul mimarTul ebas.

robototeqnika. robotebis rTul i qcevis marTvsa da ganswavl is sistema warmoudgenel ia xel ovnuri intel eqtis, kerZod genetikuri programirebis gamoyenebis gareSe. unda iTqvas, rom am mimarTul ebiT Zal ian bevri proeqti aris Seqmnili da amdenad Znel i xdeba ert romel imeze yuradRebis SeCereba.

samxedro saqme. sabrZol o qmedebebis taqtikuri gegmebis Sedgena warmoadgens maRaL i ganzomil ebis amocanas, xSirad urTiertsawinaRmdego cvl adebsa da kriteriumebis arsebabis gamo. ase magal iTad, sakuTari msxverpl is minimizacia, mowinaaRmdegis msxverpl is maqsimizacia, teritoriis sasurvel i kontrol i, resursebis Senarcuneba da sxva. am Tval sazrisiT, metad aqtual uria trenajori sistemis Seqmna genetikuri

al goriTmebis gamoyenebi T, rogorc gadawyvetil ebis mi Rebis damxmare saSual eba.

mol ekul uri biol ogia. cocxal organizmebis transmembranul i cil ebi asrul eben metad mni Svnel ovan funciebs, rogoricaa uj redis gareT garkveul i substanciebis Secnoba da maTi uj redSi transportireba. transmembranul i cil ebis qcevis gageba Sesazi ebel ia mxol od cil ebis im nawi l is identifikasiT, romelic transmembranul ares warmoadgens. garda amisa, yvel a cil a aigeba ocamde aminomJavis kombinaciis Sedegad. am mxriv aminomJavebis Tanmimdevrobas udi desi mni Svnel oba aqvs transmembranul i ares formirebis Tval sazrisiT. am procesis model irebisatvis swored genetikuri al goriTmebi aris yvel aze xel sayrel i.

astronomia da astrofizika. genetikuri al goriTmebi farTod gamoi yeneba agreTve iseTi amocanebis amosaxsnel ad, rogoricaa magal iTad: gal aqtikis brunvis mrudis dadgena, cvl adi varskvl avis pul saciis periodis gansazRvra, mzis qaris magnitohidrodinamikul i model isaTvis kritikul i parametrebis amoxsna da sxva. metad aqtual uria agreTve axal i ciuri obieqtis identifikasiis problema, rac saxeTa Secnobis genetikuri al goriTmebis meSveobiT wydeba.

akustika. optimal uri akustikuri Tvis sebebis mqone mraval ganzomil ebiani obieqtibis daproeqtebis SemTxvevaSiC genetikuri al goriTmebis gamoyeneba ufro efekturia, vidre optimizaciis sxva metodebi.

saswavl o procesis dagegma. am mxriv, metad saintereso problemas warmoadgens iseTi mraval ganzomil ebiani da mraval kriteriumiani sistemis marTva rogoric umaRI esis saswavl o dawesebul ebaa. saswavl o kontingentis, fakultetebis, kaTedrebis, Sesabamisad special obebis, personal is raodenoba, saswavl o gegmebi sa da programebis siuxve, SezRudul i

auditorul i fondi da droiT i regl amenti, sxva SezRudvebTan erTad saswavl o datvirTvebis a da ganrigis Sedgenis amocanas warmoudgeni ad arTul ebs. aseT SemTxvevaSi, swored evol uciur evristikul i meTodebi iZI eva optimal urTan miaxl o-ebul i amonaxsnis povnis saSual ebas.

disertaciebi evol uciuri model irebis Temaze.

s. gustafsoni (*notingemis universiteti*) sadoqtoro disertaciaSi [37] gani xil avs genetikuri meTodis gamoyenebis perspektivebs avtomaturi daprogamebis Tval sazrisiT, kerZod rogorc metaevristikul i Ziebis meTods, romel ic iyenebs cvl adi sigrZis kompiuterul programebis popul acias. Zebnis strategia efuzneba biologiuri evol uciis princips. cnobil ia, rom daprogamebis avtomatizaciis idea ukve karga xania warmoadgens xel ovnuri intel eqtis mizans. swored genetikuri midgoma ganapirobebs programis avtomaturad TandaTanobiT, evol uciur daxvewas. popul acia dakavSi rebul ia genetikuri algoriTmis maval ganzomil ebian aspeqtTan. am SemTxvevaSi variaciebi gamoiyeneba popul aciis aRweris, anal izisa da Zebnis efekturobisaTvis, xol o evol uciuri procesSi xorciel deba programul i struqturebis amorceva da gadawyoba. disertaciaSi warmodgenil i Sedegebi aucil ebl ad moitanen sargebl obas evol uciasa da cvl adi sigrZis amonaxsnze dafuZnebul i meTodebis ganvi Tarebis saqmeSi.

r.p. vigendis (*jorj meisonis universiteti*) disertacia eZRvneba kooperatiul koevol uciur algoriTmebs. praqtkid dan cnobil ia, rom koevol uciuri algoriTmebis qceva xSirad probl ematuria da garkveul ad winaRmdegobrivic. arsebobs garkveul i Teoria da agreTve empiriul i anal izic, raTa gairkves, Tu ra arsebiTi gansxvaveba da msgavseba aris koevol uciur da Cveul ebriv evol uciur algoriTmebs Soris. am mxriv, disertaciaSi

ganxi l ul ia koevol uci i s al gori Tmebis gamoyenebi s saki Txebi statikuri optimizaci i s amocaneb Tan mimar TebaSi.

farid xol aSxani (*tarmiat mordersis universiteti, Teirani*) disertaciaSi ganixil avs genetikur al gori Tmebs, rogorc Ziebis erTerT metaevristikul meTods warmoebis marTvis probl emebis gadawyvetis dros. aqcenti keTdeba genetikuri al gori Tmis SerCavis proceduraze, romel ic efuzneba warmoebis processi Sesazi o operaciebis bunebriv maxasiaTebl ebs. am Tval sazrisiT, genetikuri al gori Tmis sel eqci i s operatorSi Setanil ia garkveul i siaxl e, kerZod ga s parametrebis gansazRvris adapturi meTodi. warmodgeni l i meTodebis muSaoba gamokvl eul ia ori xerxit: jer I literaturidan SerCeul iqna standartul i sacdel i funqciebi da maTze gakeTda Sedareba da statistikuri analizi warmodgeni l meTodebsa da standartul genetikuri al gori Tmebs Soris.

masaud j amei (*Sefil dis universiteti*) disertaciaSi aRwers axal genetikur meTodol ogias simbiotikuri evol uci i s gamoyenebi T optimal uri aracxadi wesebis gamovl eni s mi zni T. am evol uciuri midgomi T SemTxevi T SerCeul i wesebis j gufze gamoTvI ebi s safuzvel ze xdeba aracxadi daskvnebis sistemis awyoba, rodesac yovel wess ekisreba proporciul i kontribuciaj arima. Sedegad, gamoi TvI eba popul aciaSi yovel i wesis srul i vargisianoba da maTi sicocxl i sunarianobis safuzvel ze SeirCevian Semdeg TaobaSi aRwarmoebisa da gadarceni saTvis. gansxvavebi T Cveul ebrivi al gori Tmisagan, romel ic efuzneba generaci i s aracxad al gori Tmebs, warmodgeni l midgomaSi erTi Taobi dan meoreSi gadasvl is wesi evol uci urad yal ibdeba da ara sabazo wesi T. mocemul i al gori Tmi xorciel deba ori versii T: Tvi Torgani zebadi simbol uri evol uci i s (SOSE) da Tvi TSguebad i simbol uri evol uci i s (SASE) versii T. SOSE meTodSi dadgeni l ia wevrobis funqci i s parametrebi, da meTodi qmnis mxol od aracxad wesebs, xol o SASE meTodSi al gori Tmi

axdens rogorc daskvnebis sistemis, i se wevrobis funqciis parametrebis optimizacias.

j.d. noul zi (*ridingis universiteti, gaer Tianebul i samefo*) disertaciaSi gani xil avs I okal uri Ziebisa da hibridul evol uciur al goriTmebs pareto optimizaciisaTvis. ukanasknel wl ebSi garkveul ad viTardeba mul timiznobrivi evol uciuri al goriTmebi (MOEAs) pareto optimizaciisaTvis. aRni Snul naSromSi warmodgenil ia I okal uri Ziebis evol uciuri al goriTmebi pareto optimizaciisaTvis (PEAS), romel ic ukve sakmaod popul arul (MOEAs) – Tan SedarebiT ukeTesad asrul ebs funqcias da real uri samyaros tel ekomunikaciur probl emebs. garda amisa, PEAS – s el ementebi aseve farTod SeiZI eba gamoyenebul iqnas sxva al goriTmebis proeqtebSiC. kerZod, I okal uri Ziebisa da evol uciuri meTodebis kombinirebiT pareto optimizaciisaTvis miReba axal i al goriTmi, romel ic zogierti maval kriteriumiani amocanis SemTxevaSi sakmaod karg Sedegebs iZI eva.

j.i. van hemertis (Leidenis universiteti, niderlandebi) disertacia eZRvneba evol uciuri al goriTmebis gamoyenebas samTo saqmeSi. sxvadasxva situaciebisaTvis SemuSavebul ia al goriTmebi, orientirebul i saZiebo amocanebze, garkveul i SezRudvebis dakmayofil ebis pirobebSi. naSromSi xdeba amonaxsnTa Sefaseba da Sedareba arsebul evol uciur meTodebTan.

franc rotl aufi (beiruTi universiteti, germania) disertaciaSi akeTebs genetikuri da evol uciuri al goriTmebis (GEAs) anal izs da akeTebs daskvnas, rom GEAs sfero marTI ac gadatvirTul ia genetikuri operatorebisa da testirebis TeoriebiT da empiriul i kvl evebiT, magram TviT probl emis warmodgena xSirad rCeboda i sev Zvel doneze. disertaciaSi ganxil ul ia fundamenturi cnebebi, rogoricaa siWarbe,

gansazRvravs mis adgil mdebareobas da gavl enas GEAs-s muSaobaze. Teoriul i koncepciebi praqtkul ad iqna aprobi rebul i mTel ricxva optimizaciis da agreTve qsel ebis efekturi daproeqtebis probl emebis gadawyvetisaTvis.

akira ojama (*tohokus universiteti, sendai, iaponia*) Tavis disertaciaSi ganixil avs Tvi Tmfrinavis frTis daproeqtebis saki Txebis evol uciuri al goriTmebis gamoyenебi T. sawarmos organizaciul i marTvis sistemis arqiteqturis daproeqtebis garda evol uciuri al goriTmebi sul ufro popul arul i gaxda aerodinamiul i obieqtebis daproeqtebis saqmeSi. rogorc cnobil ia, aerodinamiul i obieqtebi mi ekuTvnebi an mraval parametrul obieqtTa kl ass. magal iTad, frTis forma bgerasTan miaxl ovebul i siCqaris Tvi TmfrinavebisaTvis Cveul ebriv Seicavs asze met saproeqto parametrs. amgvarad, probl ema mdgomareobs mraval ganzomil ebian optimizaciis amocanis gadawyetaSi, rac dakavSirebul ia Zal ian didi raodenobis gamoTvl ebTan, rac mni Svnel ovnad aRemateba daproeqtebis standartul i sistemebis SesaZl ebl obebs.

tomoxaru hakaSi ma (*osakis prefekturis universiteti, iaponia*) Tavis disertaciaSi exeba genetikur principze dafuznebul manqanuri swavl ebis saki Txebis "saxeTa" SecnobisaTvis, kerzod SemuSavebul ia manqanuri swavl ebis ramdenime al goriTmi, roml ebic gankuTvnil ni arian maRal i ganzomil ebis sistemaTa kl asifikasiisaTvis.

Son I iukis (*meril endis Statis universiteti, aSS*) disertacia eZRvneba genetikuri programirebis kidev erT saitreso gamoyenebas, kerzod, im kompiuterul i programebis Zebnis saki Txebis, roml ebic izI evian saukeTeso amonaxsns. disertaciaSi warmodgenil ia axal i, swrafqmedi genetikuri al goriTmebi, roml ebic standartul i programebis xis regeneraciis saSual ebas izI eva.

ekart zitzl eri (*ciurixis teqnoi ogiuri instituti, Sveicaria*) Tavis disertaciaSi ganxi l avs maval miznobrivi optimizaciisaTvis evol uciur al goriTmebis gamoyenebis meTodol ogiis sakiTxebs. samecniero siaxl es warmoadgens e.w. eqsperimentul i meTodol ogia, rogorc axal i midgoma maval miznobrivi optimizaciis meTodebis Sedarebis Tval sazrisiT. agreTve, heterogenul i aparaturul i da programul i uzrunvel yofebis sinTezis mul tikriteriumiani apl ikacia da cifrul i signal ebis procesorebis programul i uzrunvel yofis maval ganzomil ebiani gamokvl evebi.

tina ius (*I ondonis sauniversiteto kol ej i, didi britaneTi*) disertacia eZRvneba genetikuri programirebis problemebs daprogramebis avtomatizaciis Tval sazrisiT. masSi ganxi l ul ia sxvadasxva funqciional uri daprogamebis meTodebi, roml ebi c garkveul ad aCqarebs programis ganviTarebis process. maval funqciional ur meTods Soris Serceul iqna sami meTodi: polimorfizmi, aracxadi rekursia da maRal i rigis funqciebi. aRniSnul is damtkicebis Tval sazrisiT, genetikuri programirebis sistema gaZI ierebul iqna aRniSnul i meTodebis CarTviT. eqsperimentebis Sedegebma cxadyo Semdegi: polimorfizmis meSveobiT genetikuri programirebis meTodi geografiul -sainformacio sistemebis (GIS) amocanebs ufro efekturad wyets, xol o maRal i rigis funqciebi da aracxadi rekursia mnisVnel ovnad zrdis genetikuri programirebis SesazI ebl obebs maRal i xarisxis zogadi paritetul i amocanebis amoxsnis SemTxevaSi sxva cnobi l meTodebTan SedarebiT.

david a. van vel dhuizenis (*sahaero Zal ebis instituti, dei toni, aSS*) disertacia Seexeba mul timiznobrivi evol uciur al goriTmebs (MOEAs). LiteraturaSi ganxi l ul i ramdenime aseul i apl ikacia funqciuri testirebis sistemis meSveobiT kl asificirebul i da katal ogizebul i iqna da Semdgom gamoyenebul i mul timiznobrivi evol uciuri al goriTmebis

raodenobrivi da xarisxobrivi detaluri analizisatvis. disertaciaSi warmodgenili ia eqsperimentul i Sedegebi, maTi statistikuri kvl evebi da sxva nel evanturi dakvirvebani.

tim teiloris (*edinburgis universiteti, didi britaneTi*) disertacia exeba xel ovnuri evol uciisa da xel ovnuri sicocxl is sferos, kerzod cocxal i organizmebis ganvitarebis sinteturi model is Seqmnis problebs. aRni Snul i SeiZI eba ganxil ul iqnas rogorc biologuri ganvitarebis i ogikuri strukturis axsnis model oba. naSromis eqsperimentul i nawili orientirebul ia xel ovnur evol uciur sistemaze (e.w. kosmosze), romelic uzrunvel yofs paraleluri damusavebis model irebisa da maval aTasi ani TviTaRwarmoebad komputerul i programebis populaciis ganvitarebas. evol uciuri dinamikis gamokvl evis mizniT Catarebul ma maval ferovanma eqsperimentebma cxadyves, rom xel ovnuri evol uciis sistemebis ganxit j er ki dev ar arsebobs sakmarisi Teoriul i da metodologiuri safuzvl ebi. ganxil ul ia aracocxal i da bioturi garemos urTierTqmedebaTa model ebi, agreTve saxeobaTa reproduqcirebis fenotipuri Sesazi ebl obani.

a.k. srivastavas (*banarasis universiteti, banarazi, indoETi*) disertacia eZRvneba genetikuri algoritmebi xel ovnuri neironul i qsel ebis Cartvis, kerzod adamiani synosvis sistemis model irebis problebs. genetikuri algoritmebi da xel ovnuri neironul i qsel ebis kombinacia qmnis efektur intel eqtual ur sistemas sunis identifikasiis Tval sazrisiT, rac metad aktualuria gazis problebris gadawyetis saqmisi. aq genetikuri algoritmeli gamoyenebul ia rogorc arawrfivi optimizaciis metodi xel ovnuri neironul i qsel ebis ganswali miszniT.

j.k. fiueira pujoli (*birmingemis universiteti, gaerTianebul i samefo*) Tavis disertaciaSi ganxil avs xel ovnuri neironul i

qsel ebis evol uciis sakiTxebs organzomil ebiani warmodgenis gamoyenebiT. am bol o periodSi SemuSavebul ia evol uciur gamoTvl ebze dafuznebul i xel ovnuri neironul i qsel ebis sinTezis axal i meTodebi. Tumca amave dros gasaTval iswi nebel ia is faqtic, rom xel ovnuri neironul i qsel ebi warmoadgenen organzomil ebian struqturebs, rac iTxovs special izebul evol uciur operatorebs. naSromSi SemoTavazebul ia axal i midgoma, special izebul i formis evol uciuri operatorebis gamoyenebiT, romel ic xel ovnuri neironul i qsel ebis arqiteqturis ganviTarebasTan erTad cvl is cal keul i kavSiris wonebs.

p.j. kenedi (*sidneis teqnol ogiuri universiteti, avstral ia*) Tavis disertaciaSi exeba erTuj rediani organizmebis evol uciis model irebis sakiTxebs. naSromSi aRweril ia biol ogiuri uj redis model i, romel ic upirvel es yovl isa Sedgeba genomisa da metabol izmisagan. genomebi da sawyisi qimiuri pirobebi erTdroul ad da erTad ganicdian evol ucias, iseTi uj redebis warmoebis aTvis, roml ebic SeZI eben gadarcenas garemoSi. genoms evol uciis model irebis aTvis gamoyeneba genetikuri al goriTmebi inversiis operatorebis bazaze.

j. gotl ibis (*kl austal is universiteti, germania*) disertacia eZRvneba mraval ganzomil ebiani optimizaciis amocanebs evol uciuri al goriTmebis gamoyenebiT. naSromi atarebs ufro Teoriul -anal itikur xasiaTs da ar aris orientirebul i real ur obieqtze. miuxedavad amisa, miRebul i Sedegebi ekuTvnis kompl eqtaciis kombinatorul i amocanebis gadawyvetis evristikul i meTodebis kl ass, rac Tavis mxriv mraval sferosi gamoyenebis karg perspektivebze metyvel ebs.

patris kal egari (*lozanas teqnol ogiuri instituti, Sveicaria*) Tavis disertaciaSi ganixil avs paral el ur popul aciaze dafuznebul evol uciur al goriTmebs kombinatorul i

optimizaciis amocanebisatvis. paral el ur- populaciuri evoluciuri algoritmebi mnisvnel ovnad amartivebs rTul i kombinatorul i optimizaciis probl emata amoxsnas dasaSveb droSi paral el uri gamotvl ebis meSveobiT. evoluciuri algoritmebis fundamentur ingredients warmodgens klasifikasiis instrumenti e.w. TEA (*Table of Evolutionary Algorithms*), romelic uzrunvel yofs monacemTa maval jeradi nakadis, ganawil ebul i mexsierebis paral el uri funqcionirebis marTvas. aRniSnul i probl emebi arsebobs mobiluri kavSingabmul obis sistemebSi, sadac paral el izmis maral i xarisxia.

devid britenis (*bristol is universiteti, gaerTianebul i samefo*) disertacia eZrvneba tel ekomunikaciuri qsel is optimizacias. kientze orientirebul i tel ekomunikaciuri mimarTvis optimizacia mi Rweva qsel is komponentebis moqnil i gadawyobis meSveobiT, ristvisac gamoyeneba genetikuri algoritmebi. komponentebis moqnil i gadawyoba xdeba rogorc statikuri ise dinamikuri, agreTve ganusazRvrel i mimarTvis Tval sazrisiT.

uve aikelini (*uol es svensis universiteti, gaerTianebul i samefo*) Tavis disertaciaSi gani xil avs genetikuri algoritmebis gamoyenebis sakiTxebs al ternatiul i optimizaciis amocanebisatvis, kerZod didi ganzomil ebis mul tivariaciul i situaciebis SemTxevaSi, rodesac tradiciul i metodebis gamoyeneba verizi eva sasurvel Sedegebs.

patrik siureis (*edinburgis universiteti, didi britaneTi*) disertacia eZrvneba probl emur-orientirebul i evoluciuri algoritmebis agebis formalizaciis sakiTxebs. rogorc cnobil ia, tradiciul evoluciur algoritmebis gaaCniaT binarul i striqonebis saxiT warmodgenis tendencia, rac rigi amocanebis SemTxevaSi qmnis garkveul sirTul eebs standartul i operatorebis gamoyenebis pirobebSi. naSromSi SemoTavazebul ia warmodgenis formalizaciis admi axal i midgoma, sadac

mni Svnel oba eniWeba konkretul genetikur operators fitness – funqciis Sesabami sad.

uil iam mspirs i (jorj meisonis universiteti, aSS) Tavis disertaciaSi exeba evol uciur al goriTmebiSi mutaciisa da rekombinaciis rol s. wl ebis ganmavl obaSi bundovnad rCeboda saki Txi mutaciis an rekombinaciis drouli gamoyenebis mizan Sewoni l obis Sesaxeb. naSromSi Catarebula ia aRni Snul i probremis Teoriul -empiriul i gamokvl evebi am operatorebis ukeT daxasi aTebis Tval sazrisiT.

darko grundl eris (zagrebis universiteti, xovatia) disertaciaSi ganxil ul ia sawarmoo procesis mraval doniani aramkafio marTva genetikuri al goriTmis gamoyenebiT. optimizaciis amocana, energiis minimizaciis kriteriumi T Sesabami si sawarmoo SezRudvebis pirobebSi marTvis parametris aramkafio gawyoba, xorciel deba genetikuri al goriTmis meSveobi T.

peter bentli i (hadersfil dis universiteti, gaerTianebuli samefo) Tavis disertaciaSi ganxil avs myari obieqtebis evol uciur konstruirebas genetikuri al goriTmebiSi gamoyenebiT. evol uciuri konstruireba niSnavs sxvadasxva proeqtebis krebulis Seqmnas evol uciuri principi T. aRweril ia myari obieqtebis genetikuri populacia, Sefasebis mraval miznobrivi metodi da cvl adi sigrzis qromosomebi. eqsperimentul nawil Si warmodgenil ia proeqtebi iseTi obieqtebi satvis, rogoricaa magal iTad, magidebi, gamaTbobl ebi, navis korpusi, aerodinamiuri manqanebi da sxva.

rogorc zemoT ganxil ul idan Cans, evol uciuri model ireba Zal ian aqturad gamoyeneba mraval eqstremaluri optimizaciis amocanebis gadasawyvetad.

\$1.3. qsel Si materialuri nakadebis operatiuli i marTvis sistemis arqiteqtura

nakadebis operatiuli i marTvis sistemis funqcionireba Ziri Tadad SeiZI eba ganvixil oT rogorc gadawyetil ebis miRebis procesi, sadac mTavar saki TxS konkretul situaciSi gadawyetil ebis povna warmoadgens. Cvens mier real izebul marTvis sistemaSi, gadawyetil ebis miRebis procesSi sul ufro mkafidod ikveTeba xel ovnuri intel eqtis, rogorc maRaL i donis marTvis meTodebis gamoyenebis aucil ebl oba materialuri nakadebis marTvis sistemis zogadi arqiteqtura warmodgenili ia nax. 1.3.1 –ze.

obieqtis marTvis procesSi mimdinareobs qsel is uwyeti monitoringi, roml is drosac mTel i sistemis mdgomareoba da komponentTa mimdinare mniSvnel obebi Sedis monacemTa bazaSi. qsel Si mimdinare procesebis normaluri mdgomareobi dan gadaxris SemTxvevaSi, Tu moxda situaciis Secnoba, maSin codnis bazi dan marTvis freimis Sesabamisi mza gadawyetil eba, gaicema qsel ze mmarTvel i zemoqmedebisaTvis. Tu mimdinare situaciis Secnoba ar moixerxda, maSin unda moxdes nakadebis operatiuli i ganawil eba modifidirebul i genetikuri al goriTmis da qsel is xisebri struqturebis adapturi gadawyobis al goriTmis gamoyenebi T.

genetikur al goriTmebs gaaCnia maval i parametris erTdroul ad manipul irebis unari, am Tvisebis gamo genetikuri al goriTmebi sakmaod efekturad gamoyeneba ganawil ebul i sistemebis marTvis aTvis. amdenad, genetikuri al goriTmi metad misaRebi meTodia nakadebis ganawil ebis optimaluri variantis Zi ebi saTvis.

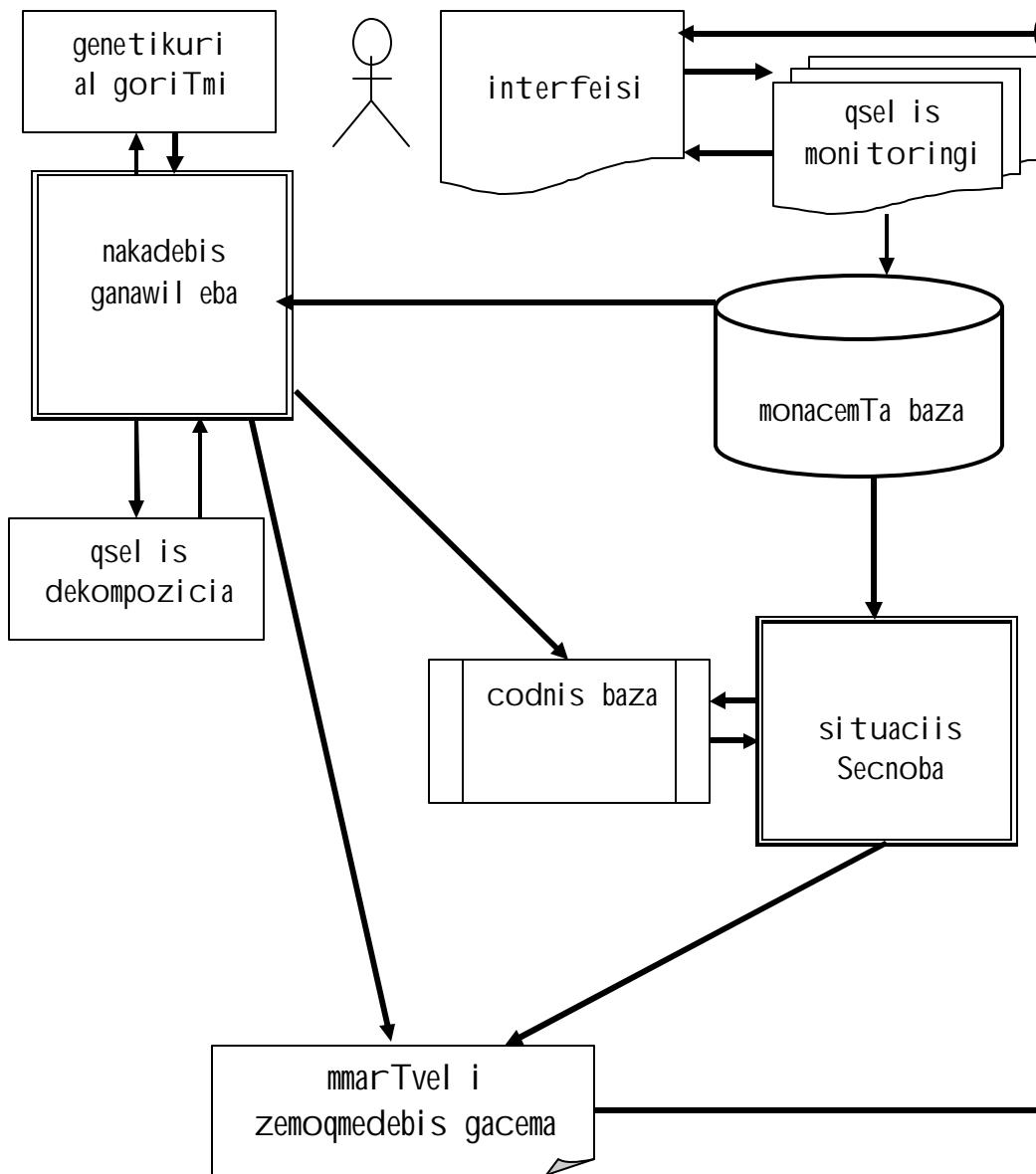
qsel is cal keul i magistral ebi, wyaroebis mixedviT SeiZI eba warmovadginoT xisebri struqturebis saxiT. avariul i reJimiS SemTxvevaSi saWiroa dazianebul i ubnis izoliReba radgan

nakadebis gamanawil ebel i qsel is funqcionireba damoki debul ia cal keul i ubnebis funqcionirebaze, amitom cal keul i monakveTis aRdgena an ganaxl eba unda ganvixil oT mTel i qsel is muSaobis konteqstSi. qsel is xis struqturebad warmodgena amartivebs qsel is regeneraciis probl emas avariul i reJinis dros an ZI ieri deficitis SemTxvevaSi, rodesac mocemul i wyaro veranairad ver akmayofil ebs minimal ur moTxovnebsac ki da saWiroa deficitis Sevseba al ternatiul i variantiT. qsel is dinamiur xeebad dekompozicia iZI eva saimedoobis garantias da amartivebs saeqspl oatacio procedurebs.

aRni Snul i al goriTmebis gamoyenebiT xorciel deba ukve axal i mmartvel i gadawyvetil ebebis gamomuSaveba. mocemul i situacia da miRebul i Sedegebi freimis saxiT Seitaneba codnis bazaSi. garda amisa, dabal sicocxl isunariani freimebi, roml ebic TiTqmis aRar meordebian, codnis bazi dan amovardnas eqvemdebarebian anu xdeba codnis bazis ganaxl eba.

nakadebis operatiul i marTvis sistemis real izebis aTvis Ziri Tadi yuradReba eTmoba Semdegi amocanebis gadawyetas:

- modifcirebul i genetikuri al goriTmis damuSavebas nakadebis optimal uri ganawil ebisaTvis;
- avariul reJiniSi marTvis aTvis, qsel is regeneraciis mizniT dekompoziciis al goriTmis damuSavebas;
- damuSavebul i model ebis bazaze nakadebis operatiul i marTvis sistemis real izebas;
- obieqtis operatiul i marTvis aTvis xel ovnuri intel eqtis metodebis damuSavebas;
- sistemis marTvis informaciul i da programul i uzrunvel yofis damuSavebas.



nax.1.3.1.

II Tavi. materialuri nakadebis operatiuli marTvis metodebis damuSaveba

\$2.1 sistemis model ebis analizi

nakadebis marTvis sistema SeiZI eba warmovidginoT qsel uri grafis saxiT, sadac wi boebi asaxaven qal aqis cal keul rai onebs (an ubnebs), roml ebic warmoadgenen sistemis momxmarebl ebs.

qsel ur ganawil ebul obieqtebs, romel Tac miekutvnebian rTul i topol ogiuri strukturis mqone wyal momaragebis, gazmomaragebis Tu el eqtroenergomomaragebis sistemebi, aerTianebT sistemaSi materialuri nakadebis arseboba. aRniSnul i tipis qsel ebi gansxvavdebi an rogorc strukturul ad, ise Semadgenl obiT da maTematikuri model ebiT, Tumca maT saerTo aqvT marTvis anu nakadebis ganawil ebis principebi.

Tavis mxriv, TiToeul i tipis qsel i xasiatdeba nakadebis marTvis specifikiT, rac ki dev ufro mraval ferovans xdis aseTi kl asis sistemebis model irebis, procesebis organizaciisa da marTvis al goriTmebis, agreTve programul saSual ebaTa funqcionirebis I ogikis Tval sazrisiT.

ganixil oT qal aqis wyal momaragebis qsel i, roml is strukturasi CarTul ia rezervuarebi, satumbo sadgurebi, qal aqSi Semomaval i hidromagistral ebi, adgil obrivi hidroresursebi (arteziul i WaburRil ebi), sarqvel ebi da sxva komponentebi, romel Ta urTierteSeTanxmebul muSaobaze aris damyarebul i momxmarebel Ta wyl iT uzrunvel yofa.

qsel Si wyal momaragebis marTvis strategia Seicavs satumbo sadgurebis, sarqvel Ta sistemis, rezervuarebis, agreTve adgil obrivi hidroresusebis marTvis operaciebs. sawiis etapze, SedarebiTi analizisa da marTvis strategiis SerCeviS Tval - sazrisiT, mizanSewoniL ia obieqtis determinirebul i model ebis mimoxiL va [18,33].

Tu qal aqis wyal momaragebis sistemas gaačnia adgil obrivi hidroresursebis N wyaro (WaburRil ebis saxiT), $n = 1, 2, \dots, N$. yovel wyaros gaačnia sadReRami so anu 24-saaTi ani mowodebis mocul oba. avRni SnoT isini rogorc $x_i(t)$ ($i = 1, 2, \dots, N$, $t = 1, 2, \dots, 24$), sadac i – wyaros nomeria, xol o t –dro (saaTi). sadReRami so j amuri miwodeba iqneba:

$$\sum_{t=1}^{24} x_i(t) = b_i \quad i = 1, 2, \dots, N \quad (1)$$

imis mixedvi T, Tu rogor funqionirebs iuri wyaro, mowodebis mocul oba iRebs Semdeg mni Svnel obebs:

$$x_i(t) = 0 \quad \text{an } x_{i \min} \leq x_i(t) \leq x_{i \max} \quad (2)$$

Sesabami sad, miwodebis mocul oba SeiZI eba Caiweros Semdegi veqtoris saxiT:

$$x = [x_1(1), x_1(2), \dots, x_1(24), \dots, x_i(1), x_i(2), \dots, x_i(24), \dots, x_N(1), \dots, x_N(24)] \quad (3)$$

wyal momaragebis sistemis marTvis strategia mdgomareobs imasi, rom ganisazRvros wyaroebis mier wyl iT uzrunvel yofa, romel ic daakmayofil ebs TiToeul kvanZSi wnevebis moTxovni l ebasa da wyl is donis SezRudvebs TiToeul rezervuarSi. ganvixi l oT marTvis mizani, romel mac M raodenobis kvanZis SemTxvevaSi unda daakmayofil os wnevis minimaluri da maqsimaluri SezRudvebi:

$$p_{\min} \leq p_i(t) \leq p_{\max} \quad i = 1, 2, \dots, M, \quad t = 1, 2, \dots, 24 \quad (4)$$

sadac: $P_i(t)$ - wyl is wneva i-ur kvanZSi t saaTze.

meore aseTi mizani mdgomareobs imasi, rom wyl is done T rezervuarSi unda akmayofil ebdes Semdeg moTxovnebs:

$$L_{j \min} \leq L_j(t) \leq L_{j \max} \quad j = 1, 2, \dots, T; \quad t = 1, 2, \dots, 24 \quad (5)$$

sadac: $L_j(t)$ - wyl is done j -ur rezervuarSi t saaTze.

zemoxsenebul or mi zanTan er Tad, sawyisi $(t=0)$ done rezervuarSi SezRudul ia doniT dRis bol osaTvis $(t=24)$:

$$L_j(24) = L_j(0) \quad j = 1, 2, \dots, T \quad (6)$$

$P_i(t)$ da $L_j(t)$ aris $x_i(t)$ amonaxsnis cvl adebis funqciebi, roml ebic mii Rebian wyl is ganawil ebis sistemis hidravl ikuri model irebiT, magram qsel is sirTul is gamo $P_i(t)$ da $L_j(t)$ funqciebis saxiT warmodgena SeuZl ebel ia.

Tu t droSi i kvanZis wneva $P_i(t)$ akmayofil ebs $p_{\min} \leq p_i(t) \leq p_{\max}$ pi robas, maSin `j arima- $C_i(t)$ iqneba 0-is tol i anu:

$$c_i(t) = \begin{cases} 0 & p_{\min} \leq p_i(t) \leq p_{\max} \\ [p_{\min} - p_i(t)] & p_i(t) \prec p_{\min} \\ [p_i(t) - p_{\max}] & p_i(t) \succ p_{\max} \end{cases} \quad (7)$$

amdenad, `j arima" i kvanZisaTvis mTel i dRe-Ramis ganmavl obaSi iqneba:

$$c_i = \sum_{t=1}^{24} c_i(t) \quad i = 1, 2, \dots, M \quad (8)$$

kvanZebis msgav sad, Tu t droSi j rezervuarSi $L_j(t)$ wyl is done moTavsebul ia minimumisa da maqsimumis interval Si, maSin `j arima" $C_i(t)$ iqneba 0-is tol i anu:

$$c_j(t) = \begin{cases} 0 & L_{j\min} \leq L_j(t) \leq L_{j\max} \\ a_T [L_{j\min} - L_j(t)] & L_j(t) \prec L_{j\min} \\ a_T [L_j(t) - L_{j\max}] & L_j(t) \succ L_{j\max} \end{cases} \quad (9)$$

sadac: a_T aris rezervuarisaTvis `j arimis~ faqtori wyl is donis moTxovnis darRvevi saTvis. amdenad, `j arima" j -uri rezervuarisaTvis mTel i dRe-Ramis ganmavl obaSi iqneba:

$$c_j = \sum_{t=1}^{24} c_j(t) \quad j = 1, 2, \dots, T \quad (10)$$

Tu j -ri rezervuaris wylis done $t=24$ droisaTvis tol i iqneba $t=0$ droisaTvis wylis donisa, masin gantol eba dakmayofil ebulia. winaaRmdeg SemTxvevaSi, jarimis funcia gani sazRvreba rogorc:

$$c_j = a_{Tj} [L_j(24) - L_j(0)] \quad j = 1, 2, \dots, T \quad (11)$$

sadac: a_{Tj} aris jarimis faktori (12) gantol ebis dar Rvevi saTvis.

optimizaciis problemis obieqturi funcia gani sazRvreba `jarimis-sruli funciiis saxiT:

$$C = \sum_{i=1}^M C_i + \sum_{j=1}^T C_j \quad (12)$$

sistemis optimaluri marTvis strategia $C=f(X)$ funciiis saxiT SeiZI eba Camoyal ibdes Semdegnairad:

$$\begin{aligned} f(X) &\Rightarrow \text{Min} \\ \sum_{t=1}^{24} x_i(t) &= b_i \quad i = 1, 2, \dots, N \\ x_i(t) &= 0 \quad \text{or} \quad x_{i\min} \leq x_i(t) \leq x_{i\max} \quad i = 1, 2, \dots, N; \quad t = 1, 2, \dots, 24 \end{aligned} \quad (13)$$

rogorc yovel i marTvis procesi, wyal momaragebis sistemis marTvis strategiac gani sazRvreba ekonomikuri kriteriumiT, rac danaxarjebis minimizaciaSi mdgomareobs. qselis operatiul i marTva, romlis mizani ZiriTadar qselis ganStoebebSi wylis nakadebis ganawili ebiT mi i Rweva, ZiriTadar satumbo sadgurebi da sarqvel Ta sistemis meSveobiT xorciel deba.

sarqvel ebis sistema moqnili ad gansazRvrav i okaluri qselis konfiguraciasa da agreTve nakadebis parametrebs qselis ganStoebebSi. Tavis mxriv, satumbo sadgurebi avi Tareben garkveul wnevebs qsel Si nakadebis saWiro mni Svnel obebis

uzrunvel yofisa da rezervuarebis Sevsebi satvis, rac el eqtroenergiisa da Sesabamisad material ur danaxarj ebTan aris dakavSirebul i.

amdenad, ekonomikuri kriteriumi Ziri Tadar satumbo sadgurebis ekonomiuri muSaobiT aris ganpirobekbul i:

$$\sum_{n=1}^N \left[\sum_{t=0}^T E_n(t) C_n(t) + \sum_{bp=1}^{NBPn} E \max_{n} C_p(bp) \right] \Rightarrow \min \quad (14)$$

aRni Snul i kriteriumisatvis mocemul ia SezRudvebis Semdegi sistema:

$$P_{\min j} \leq P_j(t) \leq P_{\max j} \quad \forall_j, \forall_t \quad (15)$$

$$V_k(t) \leq V_{\max k} \quad \forall_k, \forall_t$$

$$TV_{\min k} \leq TV_k(t) \leq TV_{\max k}$$

$$|TV_k^{final} - TV_k^0| \leq \Delta TV_k$$

$$SW_k \leq SW_{\max k}$$

$$\forall_k, \forall_t, \forall S_k(t) \in S^0 = \{1,0\}$$

sadac: N – kompresorebis raodenoba;

T – marTvis drois monakveTi:

$C_n(t)$ – n-uri kompresorisaTvis energiis erTeul is

Rirebul eba t droSi:

$E_n(t)$ – energiis moxmareba $t, t+1$ drois monakveTSi;

$E \max_n^{bp}$ – n-uri kompresorisaTvis bp saangariSo periodi;

NBPN – n-uri kompresorisaTvis bp-is mni Svnel oba;

P – wneva;

V — nakadis mni Svnel oba;

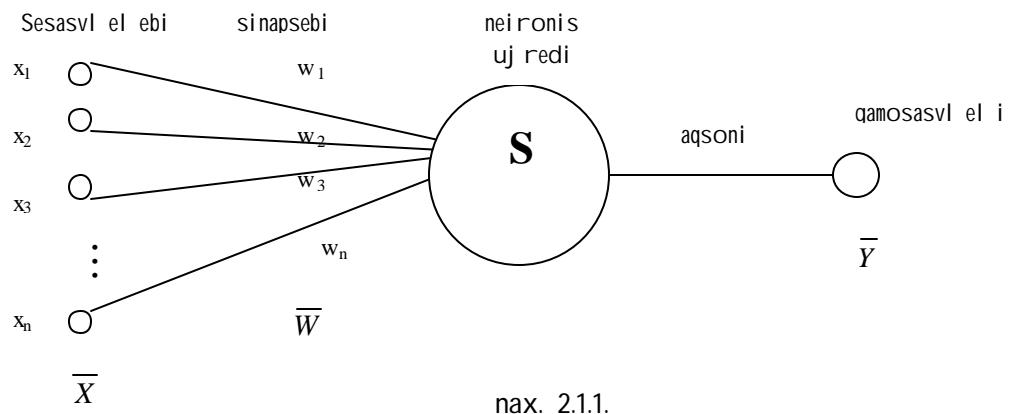
TL — rezervuarSi wyl is done;

TV — rezervuarSi wyl is raodenoba;

SW_k — satumbo sadgurSi CarTul i kompresorebis raodenoba.

amgvarad, marTvis operatiul obis Tval sazrisiT, sistemis didi ganzomil ebis SemTxvevaSi, sirTul is gamo xSirad araefturi xdeba obieqtis determinirebul i model ebis gamoyeneba, rac Tavis mxriv, ufro metad amtkicebs xel ovnuri intel eqtis meTodebis upiratesobasa da mizanSewoni l obas.

xel ovnuri neironul i qsel ebis model i. marTvis obieqtis funqci onirebis uwyeti monitoringis procesis intel eqtual izaci is, kerzod konkretul i situaci is operatiul i identifikasi is mizniT mizanSewoni l ia xel ovnuri neironul i qsel ebis meTodis gamoyeneba[37]. xel ovnur neironul qsel s gaaCnia ganswavl is, codnis Senaxvisa da agreTve reprezentaci is unari. codnis SenaxvisaTvis gamoiyeneba sinapsuri kavSiris maxasiaTebel i e.w. `sinapsis wonebi”, romel ic fizikuri arsiT el eqtrul i gamtarebl obis eqvivalenturia. xel ovnuri neironis zogadi saxe moyvani l ia nax. 2.1.1.-ze



nax. 2.1.1.

neironis mīndinare mdgomareoba gani sazRvreba rogorc Semaval i sinapsebis woni Ti koeficientebis jami:

$$S = \sum_{i=1}^n x_i \cdot w_i \quad (16)$$

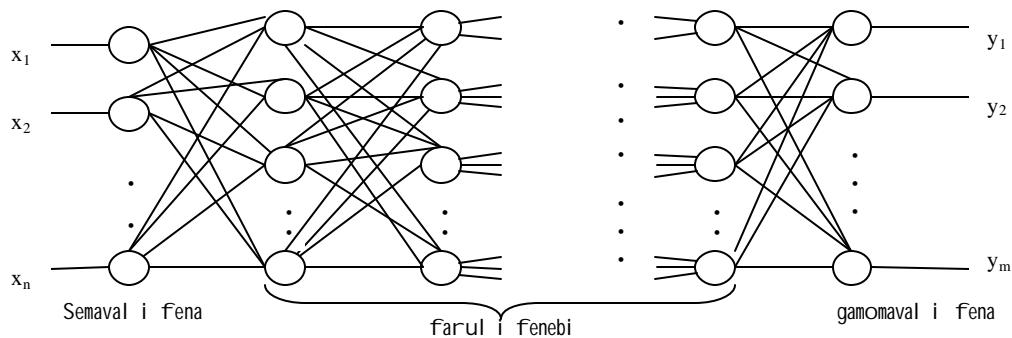
neironis gamosasvl el i aris misi mdgomareobis funcia $y=f(s)$.

magal iTisaTvis SeiZI eba ganvixil oT martivi mul tineironul i perceptroni Sual eduri "farul i" fenebiT, sadac x_i qsel is Semaval i parametrebia, xol o y_j gamomaval i parametrebi. kerZod, Semaval i parametrebia: **T1-Tn** - #1-#n rezervuaris done; **M1-Mn** - #1-#n magistral is debeti; **P1-Pn** - #1-#n satumbo sadguris simZl avre; **V1-Vn** - #1-#n sarqvel is mdgomareoba; **VP1- VPn** - #1-#n sarqvel is wneva. gamomaval i parametrebia: **P1'-Pn'** - #1-#n satumbo sadguris simZl avre; **V1'-Vn'** - #1-#n sarqvel is mdgomareoba.

Semaval da gamomaval parametrebs Soris damokiidebul eba gani sazRvreba:

$$y_j = f\left(\sum_{i=1}^n x_i \cdot w_{ij}\right) \quad j = 1, \dots, m \quad (17)$$

mul tineironul i perceptronis zogadi sqema warmodgeni l ia nax.2.1.2-ze:



nax. 2.1.2.

qsel Si mimdinare procesi SeiZI eba matricul i formi Tac
Caiweros:

$$Y=F(XW) \quad (18)$$

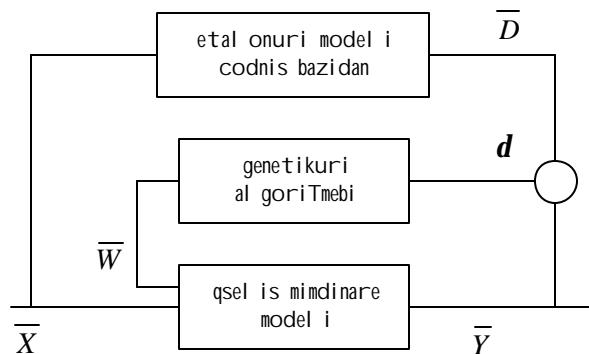
sadac: X da Y Sesabami sad Semaval i da gamomaval i vektorebia;

W - sinapsebis woniTi koeficientebis matrica.

qsel is mi mдинare mdgomareobis ganswavl a war moodgens $D = (d_1, d_2, \dots, dm)$ sasurvel (etal onur) gamomaval vektorTan Y vektoris maqsimal ur adaptacias anu maxl oebas. amisaTvis gamoi Tvl eba Secdoma:

$$d = |Y - D| \quad (19)$$

neironul i qsel is ganswavl is Tval sazrisiT xdeba `farul i` el ementebis woniTi koeficientebis gamoTvl a-awyoba. am mizniT efekturad migvachnia genetikuri al goritmebis gamoyeneba, sadac W wonebis vektorebi qromosomTa registrebs qmnian. qsel is mimdinare mdgomareobis ganswavl is procesis sqema mocemul ia nax.2.1.3.-ze:



nax. 2.1.3.

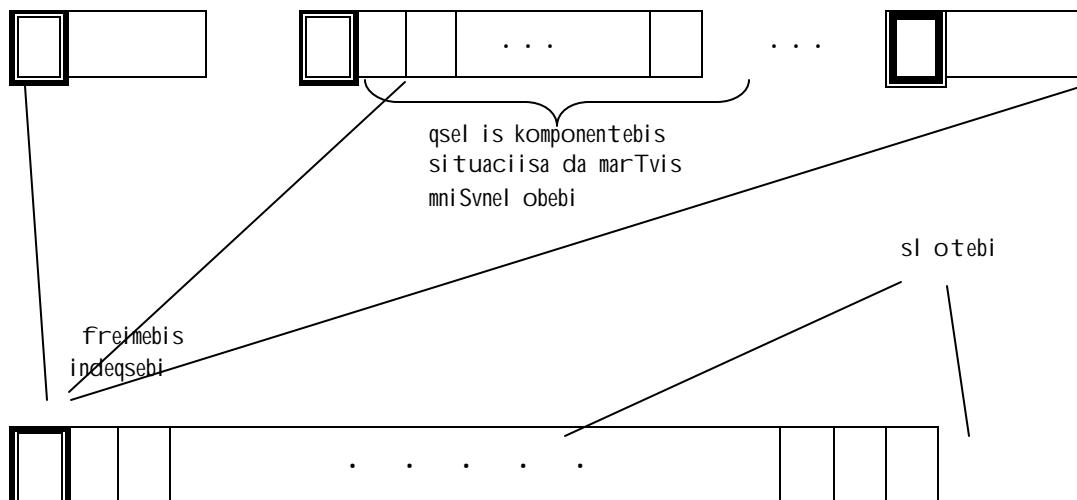
uwyeti monitoringis dros aucil ebel ia qsel is komponentebis mimdinare mnisnel obebis permanentul i Secnoba da Sedareba

codnis bazaSi arsebul etal onur model Tan Sesazi o ganTanzmebis aRmoCenis Tval sazrisiT, rac qsel is im monakveTis gansazRvris safuZvel s qmnis, sadac moxda sistemis muSaobis normal uri rejimis darRveva.

codnis warmodgenis freimul i model i. obieqtis operatiul marTvaSi xel ovnuri intel eqtis gamoyeneba efuZneba codnis bazis warmodgenis freimul model s[32]. freimebis formal izaciis erT-erTi koncepcia misi ierarqiul i struqturis qsel is saxiT warmodgenas gul isxmobs. freimebis `zeda doneebi" fiqsirebul ia da Seicavs faqtebs, roml ebic yovel Tvis WeSmaritia savaraudo situaciaSi. `qveda doneebi" Seicaven maval terminals e.w. sl otebs, roml ebic unda Seivsos konkretul i faqtebiTa Tu monacemebiT.

aRsani Snavia, rom erTi da i give terminal ebis gamoyeneba xdeba ssvadasxva freimebis mier, rac gansxvavebul i wyaroebid an Segrovebul i informaciis koordinirebis saSual ebas iZI eva. meores mxriv, urtTierTdakavSi rebul i freimTa j gufebi erTi andebian freimTa sistemebad, roml ebSiC ai saxebian moqmedebebi, mi zez-Sedegobrivi kavSirebi da a.S.

qsel Si nakadebis marTvis dros freimul i model is struqtura mocemul ia nax.2.1.4-ze:



nax.2.1.4

davuSvaT, rom ukve gagvačni a garkveui i codna, warsul i marTvis gamocdi l eba qsel Si nakadebis ganawi l ebi s Taobaze anu sl otebis statistikuri simravl e da Sesabamisi miRebul i gadawyvetil ebebis, marTvis wesebis anu freimebis simravl ec. yovel saangari So $t=1, T$ periodis aTvis qsel i dan miRebul i informaciis safuzvel ze terminal ebi axdenen situaciis tipis identificirebas an iZI evian konkretul i situaciis parametrebs. maTi erTobl i oba qmni s gansazRvrul situaciebisagan nebi smieri konkretul i situaciis `gageba-Secnobis" safuzvel s. gansakuTreb ul ad `gagebis" procesi ni Snavs mexsierebaSi arsebul i Sesabamisi wesebis aqtivizacias da mis SeTanxmebul obas mimdinare situaciis terminal ebTan.

warumatebl obis SemTxvevaSi, mexsierebidan `airCeva" ukve sxva freimi, roml is terminal ebi aRmoCndnen erTmaneTs Soris ufro Sesabamis damoki debul ebaSi gansaxi l vel i situaciisaTvis sxva SemTxvevaSi anu, Tu arsebul i freimebi dan ver moixer xda msgavsi freimis mozieba, xdeba axal i wesis (freimis) formireba mocemul i pirobebis Sesabamis ad, rac codnis bazis ganswavl a ganaxl ebi s process warroadgens. erTi freimis meoreTi Canacvl eba naTI ad vi indeba bunebrivi intel eqtis SemTxvevaSi c [27].

codnis bazis ganswavl a ganaxl ebi s procesi metad efekturad SeiZI eba ganxorciel des genetikuri al goriTmebis gamoyenebi T, roca terminal ebze axal i informaciis Semosvl is dros aRmoCndeba, rom ar arsebobs Sesabamisoba arsebul freimebs anu wesebis krebul sa da mocemul real obas Soris. am SemTxvevaSi, genetikuri al goriTmis amonaxsni anu gadawyvetil eba warroadgens axal freims. axal i freimis struktura miReba arsebul freimebze genetikuri al goriTmis operatorebis gamoyenebi T.

axal i freimis formirebis Semdeg codnis bazaSi freimebis ganmeorebis sixSiris mTvl el is indikatoris mixedviT xdeba freimebis kl ebadobiT sortireba, rac dabal sicocxl i sunariani freimebis, roml ebic Ti Tqmisi aRar meordebian, codnis bazidan amovardnis safuZvel i xdeba.

\$2.2. genetikuri al goriTmebis meTodi

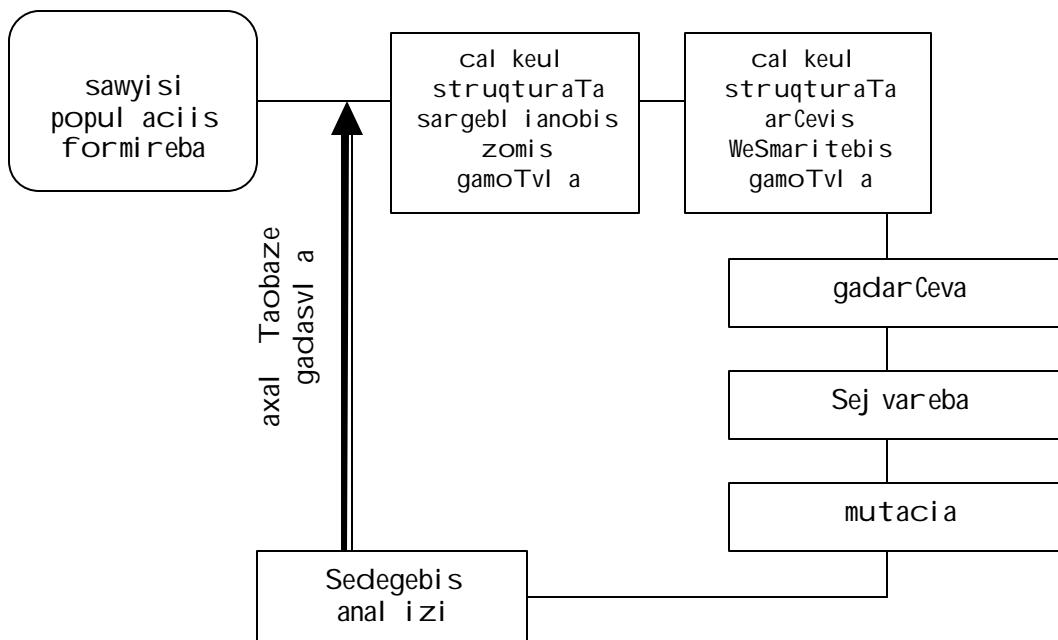
genetikuri al goriTmebi dafuZnebul ia memkvidreobi Tobasa da evol uciis standartul model ebze. igi warmoadgens adapturi meqani zmebis model s, romel ic gaaCni aT cocxal sistemebs. am meqani zmebSi mTavaria:

- agebul i struqturebis moqmedebaze yuradRebis koncentracia;
- _ Ziebis operatorebis erTobl i oba, roml ebic ikvl even struqturul i komponentebis simravl es anu struqturul konfiguraciebs, axal i struqturebis warmoqmnisaTvis da maTi Semdgomi kvl evisaTvis. am procesis wyal obiT, miRebul i al goriTmebi gamoiyeneba probl emebis farTo speqtrisaTvis, roml ebic gvxvdeba adapturi sistemebis konstruirebisas.
- genetikur al goriTmebSi populaciuri genetikis dinamika xorciel deba struqturaTa populaciebis organizaciis gziT, romel ic droTa ganmavl obaSi ganicdis evol ucias samuSao garemoSi misi struqturis qcevis Sesabamisad. Ti Toeul i struqtura al goriTmebSi warmodgeba, rogorc misi Semadgenel i nawil ebis (genotipis) mimdevroba, romel sac amuSavebs Ziebis operatorebi.

struqturis konkretul i interpretacia al ternatiul i amonaxsnebis sivrcesi izI eva erTaderT wertil s gansaxil vel i

probl emisaTvis (fenotipi), romel ic Semdgom SeiZI eba CairTos evol uciur procesSi da romel ic SeiZI eba mi viRoT sargebl ianobis zomad. Zieba xorciel deba mividinare saZiebo aredan struqturebis mudmivi amorCeviT, sargebl ianobis xarisxis safuzvel ze.

arCeul struqturebze xorciel deba genetikuri operaciebi, roml ebic evol uciaSi qmnian axal struqturebs, STamomavl obas. genetikuri al goriTmebi zogedad SeiZI eba aRiweros Semdegi sqemis saxiT(nax.2.2.1.):



nax. 2.2.1.

arCeviS WeSmaritebis gamoTvl a uzrunvel yofs sel eqciur SerCevas struqturebis sasargebl od, mocemul i simravl idan aiReba SedarebiT ukeTesi struqturebi. aseTi arCeviTobis principiT kargi struqturebi TandaTan ikaveben met adgil s populaciiaSi.

Ziebis adapturi strategiis arsi mdgomareobs ara cal keul i struqturebis aprobaciaSi, aramed aprobaciis Sedegad miRebul i

informaciis gamoyenebaSi. kargi struqturebi inaxeba. igi Tavis mxriv qmnis ufrro didi raodenobis msgavsi konfiguraciebis Seqmnis winapirobas. es struqturul i konfiguraciebi SeiZI eba ganvixil oT rogorc sivrcesi regul arul i. erTxel Tu Segvxdva, isini asrul eben e.w. `saSeni bl okebis~ rol s axal i struqturabis SeqmnaSi [28].

axal i struqturabis Seqmnis procesi orientirdeba saZiebo sivrcis metad perspektiul areze. garda amisa sivrcis aseTi gamokvl eva aracxadad mmdinareobs paral el uri saxiT.

krossoveri gaxl eCs mocemul struqturul konfiguracias, Tu arCeul i gaxl eCvis wertil ebi moxvdeba am konfiguraciis komponentebis or mniSvnel obas Soris. gaxl eCvebis dros popul aciebis Seqmnis garkveul i tempis miRweva damoki debul ia im komponentis mniSvnel obaTa konkretul konfiguraciaze, roml ebic gansazRvraven gaxl eCvas. aqedan Sesazi ebel ia damSI el i efeqtebis anal izi, roml ebic iwveven axal i popul aciebis warmoqmnas. krossoveris operators gaaCnia gadarCevis garkveul i tempis Senarcunebis unari, rac ganpirobekbul ia gaxl eCvis dros mcire gansazRvrul i fragmentebis Senarcunebi T.

arsebobs, agreTve gaxl eCvis dros di di gamsazRvrel i fragmentebis rrRevis tendencia, magram ramdenadac struqturebi, roml ebic ekuTvian specifikur gaxl eCvas, uzrunvel yofen funqcionerebis maRaI xarisxs, mcire gamsazRvrel i fragmantebi T TandaTan iwyeben damkvidrebas popul aciaSi, xdeba sxva gaxl eCvebis gamsazRvrel i fragmentebis ricxvis efeqturi Semcireba, rac asustebs krossoveris operatoris damSI el moqmedebas. mutaciis operatori amorcevis faktorze ar axdens mniSvnel ovan zegavl enas, ramdenadac mas ZiebaSi eniWeba mxol od fonuri rol i.

aseT ZiebaSi Sei ZI eba aRi Zvras siZnel eebi, Tu arsebiTi gaxl eCva moicavs grZel ganmsazRvrel fragmentebs. es probl ema warmosaxvasTan aris dakavSirebul i da warmoiSveba strukturul i komponentebis mimdevrobis warumatebel i amorCevisas. am SemTxvevaSi Ziebis produqtul oba inversiis gamoyenebis gziT maRI deba. strukturaSi komponentebis mimdevrobis Secvl is wyal obiT, misi gamoyeneba qmnis didi sigrZis ganmsazRvrel fragmentebSi sigrZis Semcirebis tendencias, amis wyal obiT krossoveris gamoyenebis farTo SesaZI ebl obebi vI indeba.

ase rom, genetikuri al goriTmis SesaZI ebl obebi dakavSirebul ia mis unarTan cxadi gamoTvI ebisa da damaxsovrebis gareSe paral el urad Sei swavl os strukturul i komponentebis Tanmimdevrobis kombinaciTa didi raodenoba. amis daxmarebiT mimidinareobs saZiebo ares koncentrirebul i Seswavl a, yuradReba maxvIl deba im areebze, roml ebic Seicaven saSual oze maRal i sargebl ianobis struqturebs. metnakl ebad popul acia xdeba farTod gansazRvrul i sivrcesi, romel ic Ziebas ar aZI evs romel imel okal ur minimumze gaCerebis saSual ebas.

marTal ia genetikuri al goriTmebi gaTval i swinebul ia simbol oebis striqonebTan muSaobisaTvis, magram is gamoyeneba agreTve freimebze orientirebul warmodgenebSi. genetikuri al goriTmi muSaobs did popul aciebTan, roml ebSic cal keul i wevrebis simravl e mkveTrad ar gansxvavdeba erTmaneTi sagan.

genetikuri al goriTmi intensiurad ikvl evs perspektiul an miznobriv areebs saZiebo sivrcesi, ramdenadac mraval j eradi gamravl ebisa da Sej varebis Sedegad am areSi grovdeba j aWvebis kidev da kidev ufro didi raodenoba. mSobl is rangSi al goriTmi irCevs saukeTeso mimdevrobas da am j aWvis mixedvi T Semdgom TaobaSi warmoiSveba ufro meti STamomaval i.

Zebnis adapturi strategiebis efeqturoba damoki debul ia specialuri tipis struqturebis, (*Shema*), anu msgavsobaTa Sabl onebis arsebobaze, roml ebic aracxadi saxiT figurireben ga-Si. yovel i Sabl oni gansazRvrav s l sigrZis binarul striqonTa simravl es imisda mixedviT Tu romel i biti imyofeba TviT am Sabl onis Sesabamis poziciaSi. Sabl onebi maRaI i Seguebl obiT, dabali rigiT da mcire gansazRvrul i sigrziT qmnian e.w. `saSen bl okebs- axal i struqturebis Seqmnis Tval sazrisiT. faqturad striqoni aris mocemul i Sabl onis warmomadgenel i magal iTad, 1*0*0 Sabl ons aqvs 4 warmodgena : **1000**; **10010**; **11000**; **11010**. mocemul i Sabl onis warmomadgenel Ta raodenoba Sual edur TaobaSi SeiZI eba Caiweros Semdegi formul iT:

$$M(H, t + \text{intermedi ate}) = M(H, t) \frac{f(H, t)}{\langle f(t) \rangle} \quad (1)$$

sadac: $M(H, t)$ H Sabl onis warmomadgenel Ta raodenobaa t TaobaSi; $f(H, t)$, H Sabl onis Seguebadobaa t TaobaSi; xol o $\langle f(t) \rangle$, t Taobis saSual o Seguebadobaa.

ase rom, genetikuri al goriTmi, romelic manipuli rebs rnomdenime aTasobiT jaWvisagan Semdgari populaciiT, sinamdvil eSi akeTebiS bevrad ufrro didi ares testirebas. aseTi aracxadi paralel izmi genetikur al goriTms aniWebs did upiratesobas amocanis amoxsnis sxva meTodebTan Sedarebi T[26].

genetikuri al goriTmebis gamoyeneba mizanSewoni l ia roca saWiroa rTul i zedapiris gamokvl eva, raTa napovni iqnas maqsimal ur SesaZI ebl obaTa areebi.

genetikuri al goriTmebiT amocanis amoxsnis pirvel rigSi gamosakvl evi obieqtebis kl asi zustad unda iqnas warmodgenil i. aRniSnul simravl es SeiZI eba vuwodOT obieqtebis sivrci. sivrcidan unda airces obieqtebis zogierti s warmodgenebi.

srul i saziebo sivrcə gani sazRvreba, vTqvaT, S simravl iT, rac, i give, warmodgenebis sivrcəa. aqedan gamodinare Sei ZI eba davweroT:

$$s \hat{I} S \quad (2)$$

warmodgenebis simravl e yovel Tvis sasrul oa. s warmodgenebis gamoyeneba, obieqtebis sivrcis Tvi sebebi sa da xasiaTis Sesaxeb minimal uri informaciis SemTxvevaSic ki Ziebis ganxorciel ebis saSual ebas iZI eva.

CvenTvis sainteresoa amocana, romel Sic moi Txoveba amonaxsnis saukeTeso variantis povna, ramdenadac es SesaZI ebel ia. es ni Snavs, rom obieqtebis simravl iSaTvis unda gani sazRvros mi znobri vi f funqcia, romel ic amonaxsns aZI evs optimal ur mni Svnel obas. optimal urobaze Sei ZI eba visaubroT, roca ganxi l ul i iqneba warmodgenaTa mTel i S simravl e.

S simravl is mi mdevroba Sei ZI eba gani sazRvros iseTi saxiT, rom saukeTeso obieqtebis warmodgenl ebs Seesabamebodes di di **m** mni Svnel oba, sadac **m** aris warmodgenaTa Sefasebis funqcia. ganxi l ul i saSual ebas iZI eva saukeTeso obieqtis Zieba S simravl idan formul iñdes Semdegi saxiT:

$$s_{opt} = \max \quad (3)$$

$$\text{sadac } s_{opt} \hat{I} S \quad (4)$$

aqedan gamodinare, optimizaciis amocana Sei ZI eba Camoyal ibdes Semdegi saxiT: unda mi viRoT $\max f(x)$, sadac X ekuTvnis saziebo ares $f(x)$ mi znobri vi funqciaa, romel sac Sei ZI eba hqondes ramodenime gl obal uri eqstremumi. amonaxsn i qneba veqtori $X = (x_1, x_2, \dots, x_n)$. amocanis optimal uri amonaxsn i qneba X_{opt} veqtori, roml is drosac $f(x)$ mi znobri vi funqcia i Rebs maqsimal ur

mni Svnel obas. $f(x)$ -is maval eqstremal urobis Sesazl ebl obidan gamomdinare, optimaluri mni Svnel oba Seizl eba iyos ara erTi.

x parametri kodirdeba s binarul i striqoniT. miznobrivi $f(x)$ funqciis gamoyenebiT Seizl eba aigos $\mathbf{m}(s)$ funqcia, genetikuri al goriTmebSi igi iwodeba rogorc Seguebadobis funqcia. ase rom TiToeul i s dasaSvebi amonaxsni, romel sac aqvs Sesabamisi $\mathbf{m}(s)$ Seguebadoba, warmodadgens x amonaxsns. Cveul ebriv, parametrTa sivrcidan binarul i striqonis sivrceze gadasvl a xorciel deba x_1, x_2, \dots, x_n cvl adebis kodirebit saWiro sigrzis orobiT striqonad. striqonis sigrzis SerCeva ganpirobekul ia sasurvel i sizustis uzrunvel sayofad. amisaTvis parametreibis sivrce unda iqnas diskretizebul i iseTi saxiT, rom diskretizaciis kvanzebs Soris daSoreba Seesabamebodes moTxovnil sizustes.

saZiebo sivrcis diskretizebisa da TiToeul i amonaxsnis s striqonad kodirebi saTvis TiToeul i $[a_i, b_i]$ interval i davyoT Tanabari sigrzis $(b-a)/n$ nawil ad, sadac n -is mni Svnel obis gazrda iwevs striqonebis raodenobis zrdas. amis Sedegad mocemul i interval i daifareba qsel iT. qsel is TiToeul kvanzs SevusabamoT orobiTi sistemis anbani $\{0,1\}$, anu, badis TiToeul kvanzs Seizl eba mieniWos unikaluri binarul i kodi l sigriziT. kodis sigrzis gazrda amonaxsnis sizustis pindapi rproporcijul ia.

TiToeul i s kvanzi Seizl eba warmodgeni l iqnas Semdegi Canawerebis wrfivi mi mdevrobis saxiT (qromosoma):

$$s = (\mathbf{b}_1, \mathbf{b}_2, \dots, \mathbf{b}_l) \quad (5)$$

genetikuri al goriTmis TiToeul i amonaxsnis warmodadgens fiqsirebul i l sigrizis s binarul striqons, romel sac Seizl eba

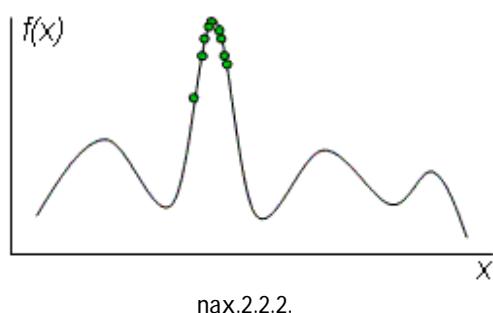
vwuodoT genotipi, romel ic Sedgeba binarul i mni Svnel obebisagan, romel sac Sei ZI eba vwuodoT fenotipi.

amonaxsni Sefasdeba \mathbf{m} sidi di T, romel ic Seesabameba miznobrivi funqciis mni Svnel obas x wertil Si. es sidi de Sei ZI eba ganvixi l oT rogorc genotipis Seguebadoba:

$$\mathbf{m} = f(x) \quad (6)$$

aseTi struktura genetikuri al gori Tmis TeoriaSi war moodgens saxeobas, xol o saxeobebis erTobl ioba qmnis popul acias [28].

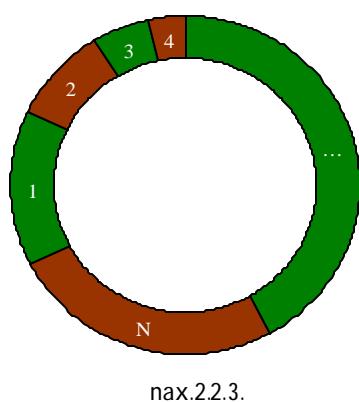
populaciis cxovrebis cikl i aris ramodenime SemTxvevi Ti Sej vareba da mutacia, roml is Sedegadac populaciis emateba axal i individumebis garkveul i raodenoba. gadarcvis dros xdeba Zvel idan axal i populaciis formireba, roml is Sedegadac Zvel i populacia i Rupeba. amis Semdeg axal populaciazec vrcel deba krossoveris, mutaciis da gadarcvis operaciebi. momdevno populacia formirdeba miznobrivi funqciis Sesabamisad. rac ufro Seguebadia individumi, misi krossoveri monawi leobisa da gamravl ebis ufro meti WeSmari teba arsebobs. ga-s gaCerebis kriteriumad Cai Tvl eba populaciis krebada (convergence), es is mdgomareobaa, rodesac yvel a striqoni Tavs moiyris optimumis areSi da Sesabamisad, maT aqvT erTnairi mni Svnel oba(nax.2.3.1.):



aRni Snul i mdgomareoba mi ani Snebs, rom mi Rweul ia optimal urTan miaxl ovebul i amonaxsni. sabol oo amonaxsnad Sei ZI eba Cai Tval os bol o Taobis yvel aze maRal i Seguebl obis mqone arseba.

sel eqciis operatori (*reproduction, selection*) axorciel ebs qromosomebis SerCivas maTi Seguebis funqciata mni Snel obebis Sesabamisad. ganirCeva sel eqciis Semdegi tipebi:

a) proporcional i gadarCeva, rul etis meTodi (*Roulette-wheel Selection*), nax.2.3.2., rodesac yovel i strukturisaTvis SerCeva xdeba al baTobi T:



nax.2.2.3.

$$P_{sel}(i) = \frac{f(i)}{\sum_{i=1}^n f(i)} \quad (7)$$

sadac $f(i)$ aris i -uri strukturis Seguebadoba.

rul etis borbl is yovel i seqtoris zoma $P_{sel}(i)$ -is proporcional ia. SerCeva

xdeba rul etis n `gaSvebis~ meSveobi T.

b) saturniro SerCeva (*Tournament Selection*) n saxeobis SerCeviS mi zniT axorciel ebs n turnirs. yovel i turniri agebul ia populaciidan k el ementis SerCevaze da maTgan xdeba ukve saukeTeso saxeobis SerCeva.

g) `el ituri- meTodebi, romlis drosac `gadarCeba-populaciis saukeTeso wevri an wevrebi. amJamad yvel aze metad gavrcel ebul ia mxol od erTi saukeTeso saxeobis gadarCenis procedura, maSinac ki roca man ver gaiara SerCeviS, Sej varebisa da mutaciis etapebi.

TaobebSi ukeTesi struqturebis martivi gavrcel eba, Semdgomi ufro srul yofil i struqturebis ZiebaSi araviTar biZgs ar iZI eva. am mi znebs emsaxureba Ziebis genetikuri operatorebi. isini ireben mimdinare saZiebo aredan struqturebis da qmnian axal struqturebis.

mutacia

inversia

100100101001010101



10010010001010101

1001.0010.0101.1101

9

2

5

13

$d = -1$



1001.0001.0101.1101

9

1

5

13

\circ

krossoveri

100100101001|010100

X

001000101010|101001



100100101001|101001

○

001000101010|010100

○

axal i struqturebis agebisas maTi Semdgomi aprobaciisaTvis, krossoveris operacia gamoyenebs informacias, romel ic arsebobs mimidinare struqturebSi. Tu konkretul i informacia ar aris, romel ic SeiZl eba dai kargos wina iteraciis etapze gadarCeviS procesSi, maSin am operators ar SeuZl ia Seqmnas misi Semcvel obis axal i struqtura populaciaSi axal i informaciis Sesatanad gaTval iswinebul ia mutaciis operatori, romel ic Tavisufal i saxiT cvl is arCeul i struqturis erT an ramodenime komponents.

Sej varebis operatori (*Crossover*) axorciel ebs j er qromo-somTa dawyvili ebas da Semdgom P_c al baTobiT maT Sej varebas anu maTi nawil ebiS urTieriTgacvl as. ganirCeva krossoveris sxvadasxva variantebi:

Single point crossover; Two point crossover; Uniform crossover; Arithmetic crossover da sxva.

Klasikur ga-Si gamoyenebul ia erTwertil iani krossoveri (*Single point crossover*). mSobel i striqonebisatvis SemTxveviTi saxiT airCeva gaxl eCvis erTi wertil i. STamomavl ebi mi i Rebian gaxl eCil i nawil ebiS urTieriTgacvl iT:

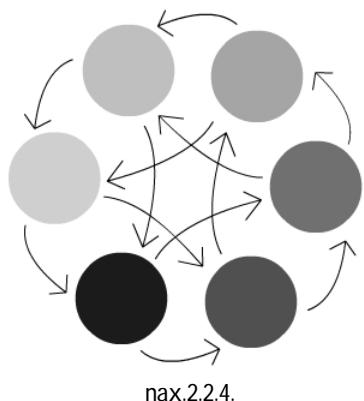
011010.01010001101 => 111100.01010001101

111100.10011101001 => 011010.10011101001

mutaciis gamoyenebis mizanSewoni l oba ukavSi rdeba popul aciis I okal uri eqstremumi dan gamoyvanas, ri Tac faqturad i cavs popul acias naadrevi dasasrul i sagan. mutaciis operatori gamoi yureba Semdegi saxiT:

1110001010110 -> 1110001110110

mutaciis operatori moqmedebs, rogorc fonuri operatori genetikur al goriTmSi, rac ni Snavs, rom misi gamoyenebis WeSmari teba gacil ebi T mcirea.



ga-s model ebidan original uria e.w. "**kunZul is model i**" (*island model*), nax.2.3.4. es aris paral el urad mimdinare genetikuri al goriTmebis model i. popul acia iyofa ramodenime qvepopul aciad, romel Tagan Ti Toeul i vi Tardeba cal -cal ke. SeiZI eba iTqvas, rom arsebebi gansaxl debian izol irebul kunZul ebad. i SviaTad, (magal iTad 5 TaobaSi) mimdinareobs migracia, es aris procesi, roca kunZul ebi awarmoeben ramodenime saukeTeso arsebaTa urTierrgacvl as. marTal ia "kunZul is model i" saukeTeso amonaxsnis miRebis mizniT, gas erTdroul ad ramodenimej er Catarebis da Ti Toeul i kunZul is miRwevebis SeTavsebis saSual ebas iZI eva, magram ramdenadac kunZul ebze arc ise didia "dasaxl eba", ris gamoc SeiZI eba moxdes qvepopul aciebis naadrevi krebada, metad mniSvnel ovania sworad gani sazRvros migraciis sixSi re.

-Genitor- model Si SemTxveviTi mSobl ebis mxol od erTi wyvi i qmnis mxol od erT STamomaval s, romel ic Secvl is ara mSobel s

aramed populaciis yvel aze uares wevrs. marTal ia TiToeul etapze populaciaSi ganaxl deba mxol od erTi arseba, magram kl asikur gasTan SedarebiT krebadoba ufro swrafad mi Rweva.

Hybrid algorithm (Davis) model Si j er gamoyenebul ia genetikuri al goriTmi, Semdeg airCeva saukeTeso arseba, roml istVisac Sesrul deba kl asikuri optimizaciis erT-erTi meTodi. es meTodi aqveiTebis al goriTmis Ziebis unars, magram gl obal uri eqstremumis povnis WeSmaritebas amaRI ebs[21].

genetikuri al goriTmebis model ebis maval ferovneba ganpirobekbul ia kl asikuri genetikuri al goriTmebis maRai i variaciul obis SesaZI ebl obebiT. amdenad, meTodis umni Svnel o modificirebamac ki SeiZI eba gamoiwwios Sedegebis mkveTrad gaumj obeseba.

\$2.3. modificirebul i genetikuri al goriTmi

Cvens mi er SemuSavebul i modificirebul i genetikuri al goriT-mi inarcunebs evoluciur genetikuri Ziebis Teoriis ZiriTad principiobis, magram sakmaod gansxvavdeba tradiciul i sqemi sagan. igi SeiZI eba warmovadgi noT Semdegi etapebis saxiT [2]:

1. sawysi populaciis formireba, anu mocemul i interval idan airCeva sawysi genotipebis SemTxveviTi mni Svnel obebi. amave dros cnobil ia, rom X cvl adebi, anu saxeobebi, $[a, b]$ interval Si Tanabrad arian ganawil ebul ni. bij i tol ia:

$$h = (b - a)/n; \quad X_i = a + h \times i; \quad i = (1, N) \quad (1)$$

2. sawysi amonaxsnebis Sefaseba. SeiZI eba CaiTval os, rom am etapze $t = 1$. yovel i saxeobisaTvis gamoiTvl eba funqciis

mn̄i Svnel oba, m̄i znobrivi funqciis gamosaxul ebi s Sesabami sad. es mn̄i Svnel oba aris saxeobi s Seguebadoba. i gi gansazRvrav saxeobi s sicocxl i sunari anobas momdevno i teraciaSi.

3. saxeobaTa sawyisi daxari sxeba. am etapze Catardeba saxeobaTa sortireba, rac gul isxmobs saxeobebi s dal agebas kl ebi T, Seguebi s maCvenebl i s mixedvi T.

4. saxeobaTa ranJireba. rac i Tval i swinebs sortirebi s Sedegebi s Sesabami sad yovel i saxeobi saTvis rangis mi niWebas. rangi anu adgil i popul aciaSi aRvni SnoT r_j ; ($j = \overline{1, M}$). Semdgom gamoi Tvl eba Ti Toeul i saxeobi s Seguebadobi s al baToba, formul iT:

$$P_{sel}(i) = \frac{f(i)}{\sum_{i=1}^n f(i)} \quad (2)$$

es aris Ti Toeul i saxeobi s Semguebl obi s Sefar deba popul aciaSi Semaval i yvel a saxeobi s jamur Semguebl obas Tan saxeobaTa ranJirebi s xarisxis amaRI ebi s mi zni T gamoi Tvl eba:

$$\mathbf{m}(i) = P'(i)/r_j; \quad (i = \overline{1, N}; j = \overline{1, M}) \quad (3)$$

$$\text{da SerCevi s kriteriumi: } \mathbf{m}_{Sash}^t = \sum_{i=1}^N \mathbf{m}^t(i) / N \quad (4)$$

mocemul i kriteriumi saSual ebas iZI eva mTel i popul acia dai yos sam nawil ad: maRai i Semguebl obi s mqone 'i ider Ta j gufis~ saxeobebi, roml ebic daeqvemdebarebian krossoveris operators; dabal i Semguebl obi s mqone (~autsider Ta j gufi~) saxeobebad, roml ebic Semdgom evol uciaSi ukve aRar ganixi l ebian da saSual o Semguebl obi s mqone saxeobebi, roml ebic daeqvemdebarebian mxol od mutaciis operators.

5. krosoveri. am etapze xdeba l i derTa j gufis saxeobaTa dawyil eba sortirebis Sesabamisad, aq unda gavi Tval i swinot, rom Tu popul aciaSi kenti raodenobis wevrebisa, maSin wyvil i Seivseba saSual o j gufi dan.

yovel i wyvil i saTvis saukeTeso wyvetis wertil is povnis Tval sazrisiT xdeba Si dawyil uri gadarCeviS l-1 cikl i, roml is drosac wyvil Ta nawil ebi j varedinad Seicvl eba anu mi i Reba STamomavl obis SesaZl o variantebi, roml ebic Sefasdeba mi znobrivi funqciis mixedviT. Sida cikl is Sedegad gani sazRvreba saukeTeso Sej vareba da ori STamomaval i. Tumca, Tu STamomaval Ta funqciuri Sefaseba mSobel Ta Sefasebaze uaresi aRmoCnda, maSin maT mi eni WebaT mSobel Ta Sefaseba.

6. mutacia. saSual o j gufis TiToeul i saxeobi saTvis tardeba l-1 Sida cikl i, roml is drosac SerCeul poziciaSi Tanrigis bituri mni Svnel oba Seicvl eba. Sida cikl is meSveobiT gadarCeviS Sedegad gani sazRvreba mutacia TiToeul i saxeobi saTvis.

7. daxarisxeba. Cvens mier Catarebul i SerCeva-Sej vareba mutaciis Semdeg, kvl av xdeba saxeobaTa sortireba kl ebis mixedviT, roml is drosac gamoikveTeba l i deri maqsimal uri Semguebl obis unariT.

8. al goriTmis dasrul eba. mocemul etapze momdeba l i deris funqciuri mni Svnel oba. Tu momdevno i teraciaze l i deris funqciuri mni Svnel oba Tu f_{id}^t Dmni Svnel oba izrdeba, maSin $t=t+1$ da gadavdivarT momdevno etapze. Tu l i deris funqciuri mni Svnel oba aRar ganicdis zrdas an piriqiT iwyebi kl ebas, maSin gadavdivarT mocemul i saxeobiS mutaciaze. Tu mutaciis meSveobiT mi znobrivi funqciis mni Svnel oba ar gai zarda, maSin al goriTmi amTavrebs muSaobas. rac ni Snavs rom optimaluri amonaxsni mi Rebul ia. unda aRini Snos, rom ramodenime i teraciis

Semdeg populaciis wevrebi mni Svnel obaTa erT areSi ganTavsdebian, es aris optimumis are, saidanac moxdeba optimaluri amonaxsnis amorCeva.

algoriTmis Rirsebad SeiZI eba CaiTval os i teraciaTa minimaluri raodenoba da amonaxsnis maRaLi sizuste. warmodgeni i algoriTmi, ra Tqma unda, ar aris Tavisufali nakl ovanebebi sagan, kerZod kl asikur gaSTan SedarebiT mas aqvs SedarebiT dabali gamoTvl iTi siCqare, rac ganpirobebul ia damatebiTi tardeba *I-I* Si dacikluri gamoTvl ebis aucil ebl obiT saukeTeso krosoverisa da mutaciis gamovl inebis mizniT. samagierod, aRniSnul i gadarCeva garkveul ad ganapirobebs saxeobis maRaLi Seguebadunariani Sabl onebiT agebis al baTobas. Cvens mier SemuSavebul i modifiriRebul i genetikuri algoriTmis da kl asikuri genetikuri algoriTmis Sedegebis analizi mocemul ia \$4.2.-Si.

\$2.4. qsel is xi sebr struqtur bad dekompozicia

qsel is marTvisas materialuri nakadebi nawiI deba xe-grafis struqturis mqone obieqtSi (wyal momaragebis, gazmomaragebis Tu el eqtromomaragebis sistemebi). zogadad, obieqtSi waroadgens $G=(X,U)$ grafs anu qsel s, sadac X kvanZia, xol o U -rkal Ta simravl e[9].

yovel i $u \in U$ rkal i xasiatdeba $C_u = 0$ gamtarunarianobi T. gansakuTrebul pirobas qmnis daSveba, rom qsel s gaaCni a: ramdenime wyaro q_i Semaval i nakadi T da mraval i mimRebi, romel ic SeiZI eba iyos yovel i rkal i p_u moxmarebis moTxovni T anu datvirTvi T. obieqtSi Semaval i nakadi gani sazRvreba rogorc wyaroebSi Semaval i nakadebis jami:

$$Q = \sum_{i=1}^k q_i \quad (i = \overline{1, k}) \quad (1)$$

sadac: k – wyaroebis raodenobaa.

bunebrivia Semaval i nakadebi nawiI deba sistemaSi \mathbf{j}_u nakadebad, $\mathbf{j}_u \leq c_u$ pirobis Sesabamisad.

marTvis amocanis simartivis Tval sazrisiT davuSvaT, rom sistema daproeqtebul ia maqsimaluri datvirTvebis gaTval i swinebi T anu C_u unda uzrunvel yofdes $\mathbf{j}_u = \max p_u$ nakadis gatarebas. amdenad, gamtarunarianobis mxriv moxmarebis moTxovnaze SezRudva ar unda arsebobdes. nakadebis marTvis amocana mdgomareobs nakadebis iseT ganawiI ebaSi, roca rkal ebSi ganawiI ebul i nakadebis jami tol ia kvanZSi Semosul i nakadis raodenobisa. xol o mTel sistemaSi ganawiI ebul i nakadebi unda akmayofil ebdes pirobas:

$$\sum_u \mathbf{j}_u \leq Q \quad (2)$$

(2) utol oba ganpirobekl ia sistemaSi Sesazi o danakargebiT. obieqtis specifiki dan gamodinare misi qsel uri struktura unda gamoricxavdes cikl ebisa da maryuJebis arsebolas anu sistema unda warmovi dgi noT k raodenobis xeebis saxiT, sadac fesvi iqneba *i*-uri wyaro, xol o es xeebi ise unda avsebdnen erTmaneTs, rom arc erTi rkal i ar unda daikargos ganxil vis sferodan. es ar niSnavs grafelis TeoriaSi kargad cnobil i e.w. gadamfaravi (karkasul i) xis povnas, aramed qsel uri grafis dekompozicias zemoT aRni Snul xisebr struktura bad, romel TaTvis sac avtonomi urad moxdeba nakadebis optimal ur mni Svnel obaTa gansazRvra.

I okal uri datvirTvebisa Tu wyaroebi dan Semomaval i nakadebis fl uqtua-ciebi, agreTve avariul i situaciebi qmnian xisebri struktura bis dinamiuri regeneraciis da Sesabamisad nakadebis gadanawil ebis pirobebs, rac bevrad arTul ebs marTvis probl emebs.

amdenad, yal ibdeba qsel uri strukturis xisebr struktura bad dekompoziciis probl ema da misi al goritmis Seqmnis aucil ebl oba.

warmodgenil i al goritmi arsiT rekursiul ia da garkveul ad eyrdnoba grafSi gadamfaravi xis mozebnis *BFS* (*breadth-first search*) al goritmis princips, Tumca mni Svnel ovnad gansxavdeba misgan.

upirvel esi Tavisebureba al goritmis mdgomareobs imasi, rom qsel is dekompoziciis Sedegad miReba ramdenime avtonomiuri, magram urTi erTSemavsebel i xe, romel Ta fesvebs swored wyaroebi warmoadgenen. meore, qsel is yovel i wi bo xasiaTdeba woniTi koeficientiT (romi is fizikuri analogi Seizi eba iyos

nakadi, wneva, el eqtrodeni, datvirTva an el eqtrowinaRoba da a.S.). mesame, al goriTmi Sedgeba e.w. bl okebisagan, roml ebi c konkretul funqrias asrul eben da meoTxe, al goriTmis Sedegad mi Rebul i xeebis mwerval ebi ganl ageba xdeba ierarqiul i doneebis mixedvi T.

mocemul i a: qsel is mwerval ebi $\{x_i\} \in X$, $(i = \overline{1, N})$;

wi boebi: $\{u_l\} \in U$, $(l = \overline{1, M})$

wi boTa incidenciis matrica, roml is el ementi $u_{il} = 1$ Tu u_l incidenturia x_i mwerval is, xol o $u_{il} = 0$ Tu u_l araincidenturia x_i mwerval is a

wyaroebi $\{q_i\} \in Q$, $(i = \overline{1, k})$, sadac: k – wyaroebis (igive xeebis) raodenobaa;

wi boTa wonebi $\{d_l\} \in D$, $(l = \overline{1, M})$, sadac: D - qsel is datvirTva.

- srul deba modul i `xis mwerval is SerCeva~. (sawyis i teraciaze aseT mwerval ebad mi i Cneva wyaroebi). mwerval ebi sortirdebi an $\{x_1, x_2, \dots, x_k\}$ masivad wonis zrdadobis mixedvi T. yovel bij ze SeirCeva morigi mwerval i minimal uri woni T. anu xdeba gadasvl a masivis Semdeg el ementze. masivis ganxil vis damTavrebis Semdeg, momdevno bij ze kvl av masivis pirvel el ementze davbrundebi T.

- srul deba modul i `wibos SerCeva~. mocemul i xisaTv is SerCeul mwerval Tan incidenciis Sesabamisad SeirCeva wi bo minimal uri woni T.

- srul deba modul i `totis Semowmeba~. SerCeul i wibos bol o mwerval i mowmdeba pirobaze: $x_j = -1$: Tu piroba mcdaria, maSin wi bo ixsneba ganxil vi dan da gadavdivarT Semdeg wi boze mocemul

mwerval Tan incidenciis Sesabamisad darCenil wi boTa Soris minimal uri wonis kriteriumiT. Tu piroba WeSmaritia, maSin vbrundebiT ~xis mwerval is SerCevis~ modul s, sadac gadavdivarT morig mwerval ze.

- srul deba modul i `xis totis formireba~ mocemul i $u_e \in U$ wi bo izens rkal is saxes:

$$\begin{aligned} u_l^+ &= (x_i x_j) \\ u_l^- &= (x_j x_i) \end{aligned} \quad (3)$$

Semdeg xdeba mocemul i rkal is wonis gamoTvl a:

$$q_j = q_i + d_l \quad (4)$$

amasTan, rkal is aTvis $x_j = -1$, xol o Tvi Ton rkal i u_l gani cdis markirebas.

- srul deba modul i `xis donis testireba~ am dros mowmdeba yovel i xisaTvis mocemul i donis yvel a totis formirebis dasrul ebis piroba. Tu piroba mcdaria maSin vbrundebiT `xis mwerval is SerCevis~ modul ze da grZel deba xeebis formireba mocemul doneze. Tu piroba WeSmaritia, maSin xdeba gadasvl a Semdeg doneze da dabruneba `xis mwerval is SerCevis~ modul ze.

- al goriTmi wyvets muSaobas, roca yvel a wi bo gadaiqca rkal ad anu u_l rkal i markirebul ia, rac niSnabs, rom qsel is xisebr struqturabad dekompoziciis procesi dasrul da.

ganixil oT qsel is xisebr struqturabad dekompoziciis magal iTi:

qsel i warmovadginoT grafis saxiT, nax. 2.4.1. romel ic Sedgeba mwerval ebi sagan:

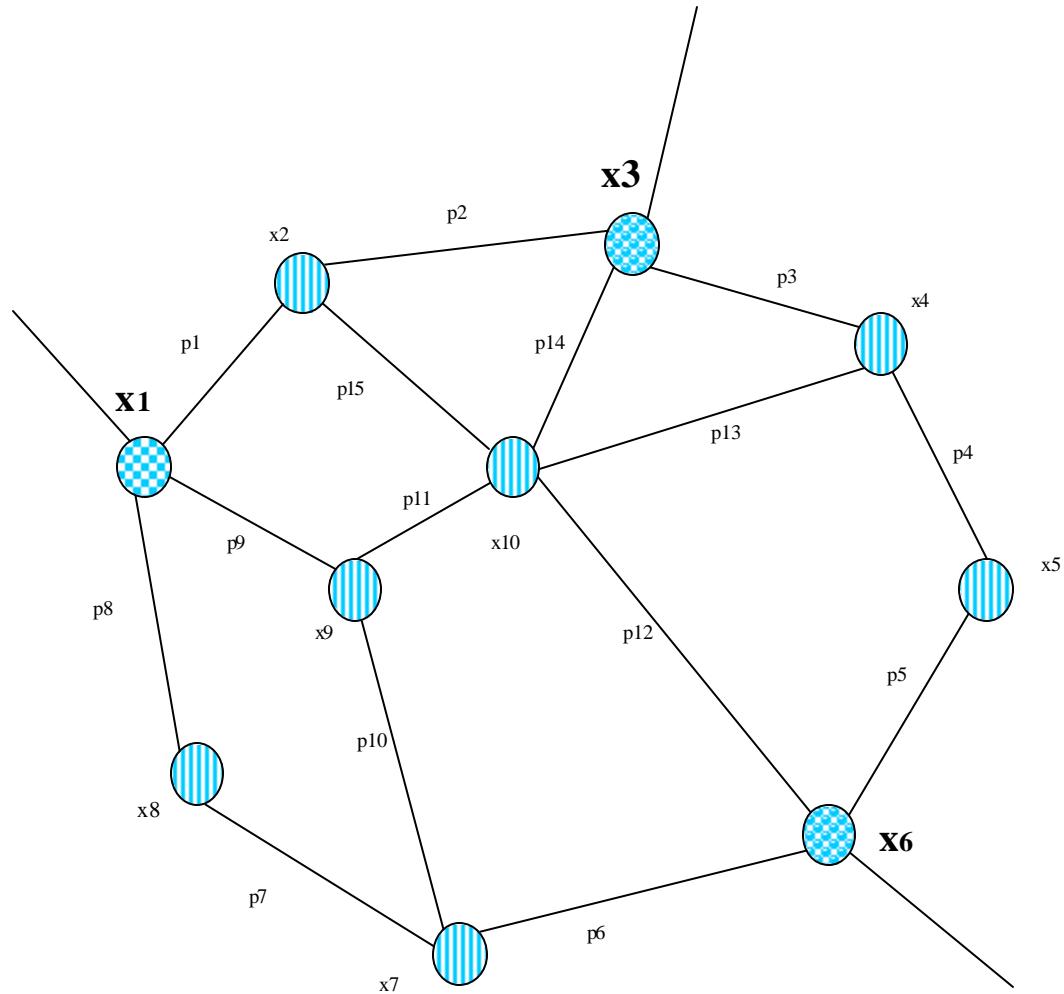
$$\{x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}\}$$

da wi boebi sagan:

$$\{p_1, p_2, p_3, p_4, p_5, p_6, p_7, p_8, p_9, p_{10}, p_{11}, p_{12}, p_{13}, p_{14}, p_{15}\}$$

mocemul ia wi boTa wonebi, Sesabami sad:

$$\{9, 12, 7, 10, 14, 9, 8, 11, 10, 15, 12, 6, 9, 12, 10\}$$



nax. 2.4.1.

CavTval oT, rom X_1, X_3 da X_6 aris wyaroebi, amitom SeiZl eba davuSvaT, rom X_1 -dan gamomaval i wi boebia: P_1, P_8, P_9 .

X_3 -dan gamomaval i wi boebia: P_2, P_3, P_{14} ,

xol o X_6 -dan gamomaval i wi boebia: P_5, P_6, P_{12} .

qsel is xi sebr struqturabad dekompoziciis al goritmis
mixedvi T Sevadgi noT wi boTa incidiens matrica(cxr.2.4.1):

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
X1	+1	0	0	0	0	0	0	+1	+1	0	0	0	0	0	0
X2	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	+1
X3	0	+1	+1	0	0	0	0	0	0	0	0	0	0	+1	0
X4	0	0	-1	-1	0	0	0	0	0	0	0	0	+1	0	0
X5	0	0	0	+1	-1	0	0	0	0	0	0	0	0	0	0
X6	0	0	0	0	+1	+1	0	0	0	0	0	+1	0	0	0
X7	0	0	0	0	0	-1	+1	0	0	-1	0	0	0	0	0
X8	0	0	0	0	0	0	-1	-1	0	0	0	0	0	0	0
X9	0	0	0	0	0	0	0	0	-1	+1	-1	0	0	0	0
X10	0	0	0	0	0	0	0	0	0	0	+1	-1	-1	-1	-1

cxr. 2.4.1.

ganxil ul i al goritmis Tanaxmad grafi unda daiSal os urTierteSemavsebel xeebad, roml Ta fesvebs X_1, X_3 da X_6 wyaroebi warmoadgenen. Sevadgi noT mocemul i mwerval ebisaTvis wi boTa mosazRvreobis matrica faqturad zemoT warmodgenil i wi boTa incidiens matrica daiSI eba wi boTa mosazRvreobis, sam matricad, Sesabamisad X_1, X_3 da X_6 mwerval ebisaTvis (cxr. 2.4.2. cxr. 2.4.3. cxr. 2.4.4):

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
X1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
X2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
X3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X9	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
X10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

cxr. 2.4.2.

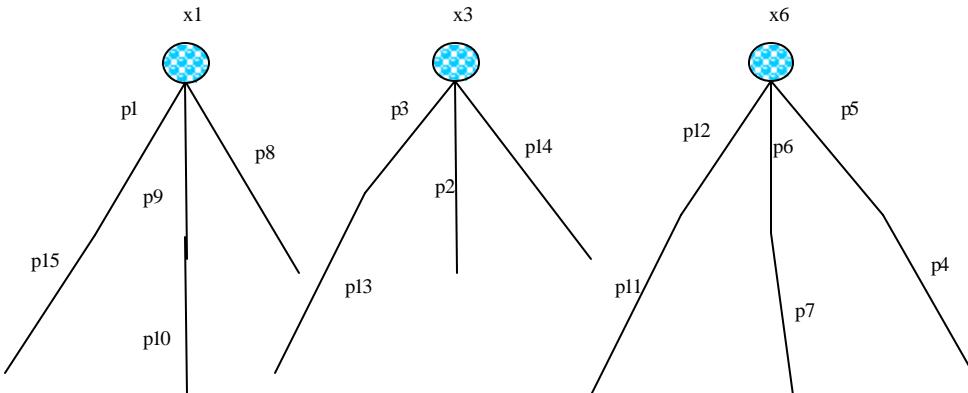
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
X1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X3	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0
X4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
X5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

cxr. 2.4.3.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
X1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
X6	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0
X7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
X8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X10	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

cxr. 2.4.4.

Sesabami sad grafi dai SI eba sam xi sebr struqturad, nax.2.4.2.



nax. 2.4.2.

al gor i Tmi SevamowmoT wi boTa wonebi s gaTval i swinebi T:

X_1 xi saTvis, X_1 mwerval idan gamomaval ia P_1, P_9 da P_8 wi boebi,

P_1 wi bodan gamodis P_{15} , xol o P_9 -dan P_{10} wi bo. gamovi Tval oT X_1

xi saTvis wi boTa wonaTa j ami: $q_1 = S(P_1, P_9, P_8, P_{15}, P_{10}) = 55$;

X_3 xi saTvis, X_3 mwerval idan gamomaval ia P_2, P_3 da P_{14} wi boebi,

P_3 wi bodan gamodis P_{13} . gamovi Tval oT X_3 xi saTvis wi boTa

wonaTa j ami:

$$q_3 = S(P_2, P_3, P_{14}, P_{13}) = 40;$$

X_6 xisaTvis, X_6 mwerval i dan gamomaval ia P_{12}, P_6 da P_5 wi boebi, P_{12} -dan gamomaval ia P_{11} wi bo, P_6 -dan - P_7 , xol o P_5 -dan P_4 wi bo. gamovi Tval oT X_6 xisaTvis wi boTa wonaTa j ami:

$$q_6 = S(P_{12}, P_6, P_5, P_{11}, P_7, P_4) = 59;$$

gamovi Tval oT mocemul i grafis wi boebis wonaTa j ami:

$$Q = \sum_{i=1}^{15} P_i = 154.$$

j ami sa.

rogorc vxedavT, $Q = \sum_{i=1}^3 q_i$ tol oba sworia, rac ni Snavs, rom qsel is xisebr struqturab dekompoziciam warmatebiT Caiara.

\$2.5. nakadebis operatiul i marTva

qsel uri struqturis obieqtebis marTvis mizani ZiriTadad qsel is mral ricxovan ganStoebebSi material uri nakadebis optimal ur ganawil ebaSi mdgomareobs. qsel is marTva ZiriTadad mndinareobs or reJiSi: normal ur da avariul reJimebSi. rogorc wesi, topol ogiis didi ganzomil ebisa da teqnol ogiuri sirtul is, agreTve sistemis inerciul obis gamo aseTi donis marTvis sistemebSi metad garTul ebul ia gadawyvetil ebis miRebis procesi. sakiTx s bevrad arTul ebs avariul situaciaTa sixSire, rac ganapirobebs maTi l i kvidaciis mizniT marTvis operatiul obis xarisxis amari ebas.

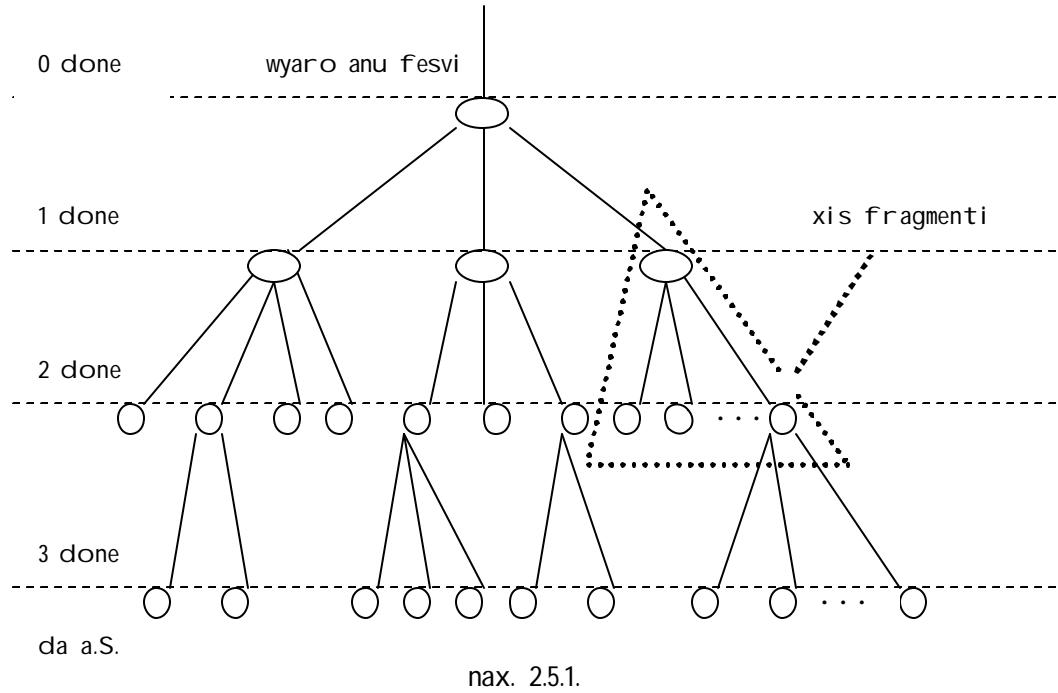
rogorc ukve aRvni SneT qsel uri obieqti SeiZI eba warmovadginoT grafis saxiT, sadac X mwerval ebis (kvanZebis) simravl ea, xol o U - rkal ebis simravl e. yovel i rkal i xasiaTdeba $Cu = 0$ gamtarunarianobiTa da agreTve p_u datvirTviT.

apriorul ad davuSvaT, rom qsel i Sedgeba garkveul i raodenobis avtonomiuri, Tanac urTierTSemavsebel i xisebri struqturebis simravl isagan, romel Ta fesvebs gare wyaroebi warmoadgenen. amdenad, nakadebis marTva qsel Si xorciel deba cal keul i xis SemTxvevaSi damouki debi ad, magram mTI i anobaSi urTierTSemavsebel ad, rac qsel is erTiani marTvis sistemis funqcionirebis aucil ebel i pirobaa[9].

I okal uri anu cal keul i rkal is doneze datvirTvebisa Tu sxdadasxva parametrebis cval ebadoba (sadReRamiso grafikebi, pikuri datvirTvebi da sxva), wyaroebi dan Semomaval i nakadebis cvl il ebis SemTxveviTi xasiati, qmnan xis struqturaSi nakadebis optimal uri gadanawil ebis pirobebs. rac mni Svnel ovnad arTul ebs marTvis probl emebs.

normal ur reJiSi marTvisatvis gamoiyeneba nakadebis gadanawil ebis al goriTmi rogorc xis struqturis cvl il ebis gareSe, ise xisebr struqturaTa sinqronul i cvl il ebeti, rac damoki debul ia deficitis xasiatze.

ganvi xil oT nakadebis gadanawil ebis al goriTmi erTi avtonomiuri xis magal iTze, roml is ganzogadoebul i struqtura naCvenebia nax.2.5.1-ze:



xis struqtura warmovadgi noT doneebis saxiT, rac ganapi robebs al goriTmis etapobriv muSaobs anu warmodgenil i al goriTmi maval etapobrivia. simartivisaTvis aRniSnul i xis struqtura ganixil oT el ementarul i xeebis sistemis saxiT, e.i. yovel i donis yovel i kvanzi misgan gamodinare rkal ebis CaTvl iT qmnis e.w. el ementarul xes. am proceduras SeiZl eba vuwodo defragmentaci a[3,5].

al goriTmi muSaobs cikl Si yovel i avtonomiuri xis cal keul i fragmentisaTvis daRmaval i principiT anu nul ovani donidan qveiT. yovel i el ementarul i xisaTvis nakadebis ganawi l ebis optimizaci is amocana mdgomareobs Semdegi mi znobrivi funqci is Sesrul ebaSi:

$$\sum_u (p_u - \mathbf{j}_u) \rightarrow \min \quad (1)$$

$$\text{SezRudvebi T: } \sum_{u \in W^+(i)} \mathbf{j}_u = \sum_{u \in W^-(i)} \mathbf{j}_u \quad (2)$$

$$p_u^{\min} \leq \mathbf{j}_u \leq c_u \quad (3)$$

SezRudva (2) Tanaxmad G grafis yvel a $i \in X$ mwerval Si Semaval i da gamomaval i nakadebi tol i unda ijos.

al goriTmis mizania yovel i fragmentis rkal ebisaTvis \mathbf{j}_u nakadebis iseTi mniSnel obebis povna, roml is drosac (1) piroba srul deba (2) da (3) SezRudvebis gaTval i swinebi T.

amocana wydeba genetikuri al goriTmebis (\$2.3.) gamoyenebi T, sadac TiToeul i \mathbf{j}_u nakadi am SemTxvevaSi warmodgenil ia namdvil i ricxvebis masivis saxiT. Tavis mxriv, genetikuri al goriTmi axorciel ebs sel eqciis, krossoverisa da mutaciis operaciebs. yovel i operatoris win xdeba (2), (3) pirobebis Semowmeba. fragmentul i (l okal uri) optimumis povnis Semdeg al goriTmi meordeba cikl Si, vidre mTI ianad xisaTvis ar Sesrul deba. Semdgom yovel i ve Tavi dan iwyeba da meordeba Semdegi xisaTvis da a.S. vidre mTel i qsel isaTvis ar dasrul deba nakadebis mniSnel obaTa gamoTvl a. bol os xdeba pirobis Semowmeba:

$$\sum_u \mathbf{j}_u \leq Q = \sum_j q_j \quad (4)$$

sadac q_j -cal keul i wyaros Semomaval i nakadis mniSnel obaa.

al goriTmi poul obs nakadebis ganawi l ebi s ramodeni me optimal ur amonaxsns, amis Semdeg miRebul i variantebidan amoirCeva is erTi amonaxsnsi,

romel ic izI eva minimal ur ekonomikur maCvenebel s.

$$S_u(t) = \sum_{t=1}^n \mathbf{j}_u(t) \cdot E_u(t) \Rightarrow \min \quad (5)$$

$$\text{sadac } E_u(t) = l_u \cdot b_1 + \Delta h_u \cdot b_2 \quad (6)$$

$S_u(t)$ aris kvanZi dan rkal ebSi gamaval i nakadebis j amuri danaxarj i.

$E_u(t) =$ erT rkal Si nakadis gatarebi s danaxarj ia;

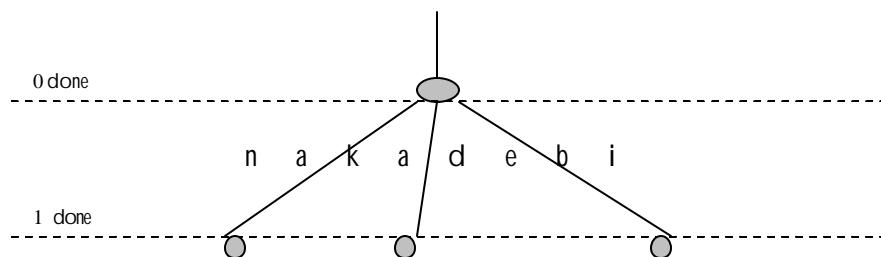
Δh_u — mocemul i rkal i saTvis doneTa sxvaobaa;

l — rkal i sigrZe;

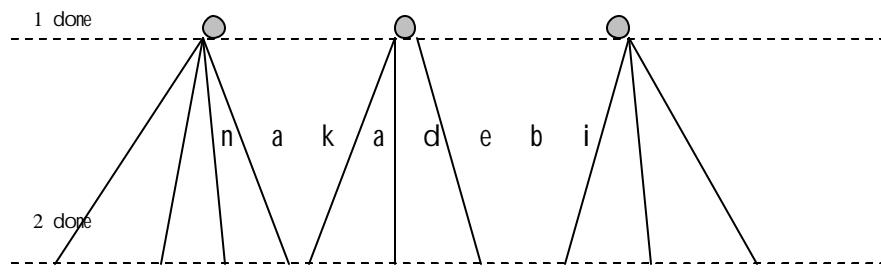
b_1 - erTeul i nakadis gadatanaa erTeul sigrZeze;

b_2 - erTeul i nakadis gadatanaa erTeul simaRI eze;

rogorc aRvni SneT, nakadebis ganawi l eba xdeba etapobrivid. j er dakmayofil deba pirvel i done, rac nax. 2.5.1-ze mocemul i xi saTvis gamoi yureba Semdegi saxiT(nax. 2.5.2):



amis Semdeg dakmayofil deba meore done:



nax. 2.5.2.

da a.S. nakadebis ganawi l eba gagrZel deba xis doneebis mixedvi T.

Tu nakadebis gadanawi l ebam ver aRadgina sistemis mdgradoba, masin xorciel deba qsel i s xisebr strukturata dinami kuri regeneracia dekompozici i s al goriTmis gamoyenebi T.

avariul rejimSi sawiroa konkretul i rkal i s izolacia da avtomaturad unda Seicval os mocemul i xis konfiguracia amisaTvis aucil ebel ia qsel i s strukturul i gadawyoba, radgan konkretul i xis strukturis Secvl a TavisTavad gamoi wvevs rogorc minimum momij nave xeebis strukturul cvl il ebas.

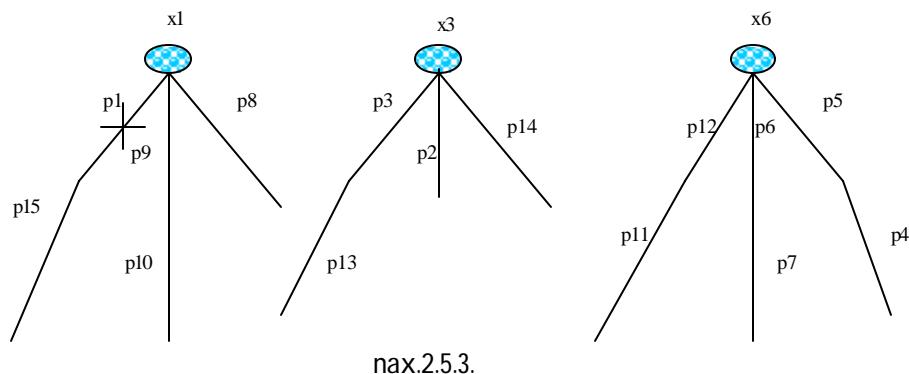
avarul situaciაSi, roca irRveva romel i me rkal is mTl i anoba da Sesabamisad mocemul i rkal i ukve veRar ganixil eba Tavis struqturaSi, saWiro xdeba al ternatiul i variantebis gadarceva saukeTeso struqturis povnis mizniT.

zemoTganxiI ul i dekompoziciis al goriTmis meSveobiT moxdeba axal i xeebis regeneracia da misi real izeba rkal is bol oebSi arsebul i sarqvel ebis (an CamrTvel ebis) mier. marTvis sqema warmoadgens aRniSnul i mowyobil obebis binarul i mdgomareobis masivs, romel ic gai cema dispetcerisaTvis rekomenadaciis saxiT. Semdgom ki nakadebis ganawil ebis al goriTmis gamoyenebiT gani sazRvreba nakadebis optimal uri mniSvnel obebi axal i struqturebis pirobebSi.

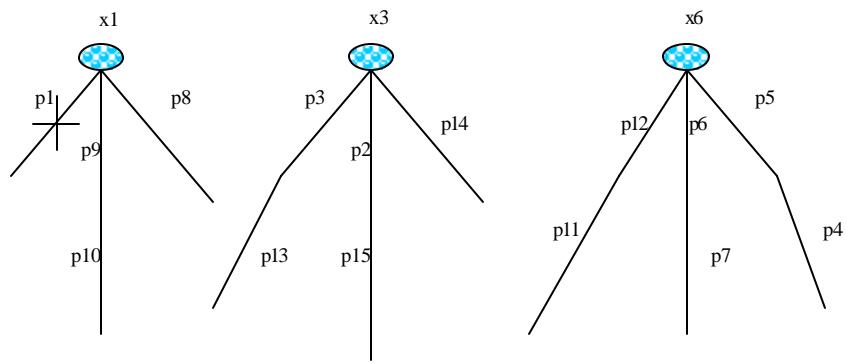
Cvens mier ganxiI ul qsel Si (na.2.4.1), davuSvAT p_1 rkal ze Seiqmna avariul i situacia. e.i. unda moxdes aRniSnul i rkal is izolacia, ris gamoc nakadis gadanawil eba p_{15} rkal Si, agreTve, bl okirdeba. qsel i struqturul ad unda gadaewyos ise, rom p_{15} rkal Si nakadis miwodeba ar Seferxdes. xis struqturul i gadawyobis gaTval i swinebul i unda iqnas (2) da (3) SezRudvebi:

sadac: p_u rkal is datvirTva; C_u - gamtarunarianoba; \mathbf{j}_u - rkal Si ganawil ebul i nakadi.

xeebi, romel Ta struqtura Tavdapi rvel ad warmodgeniI ia Semdegi saxiT, nax. 2.5.3.



regeneraciis Semdeg mi i Reben aseT saxes, nax. 2.5.4.



nax.2.5.4.

xeebis regeneraciis Semdeg nakadebi ganawi l deba zemoaRni Snul i
al gor iTmi T.

III Tavi. materialuri nakadebis marTvis procesis model irebisa da analizis al goriTmebi

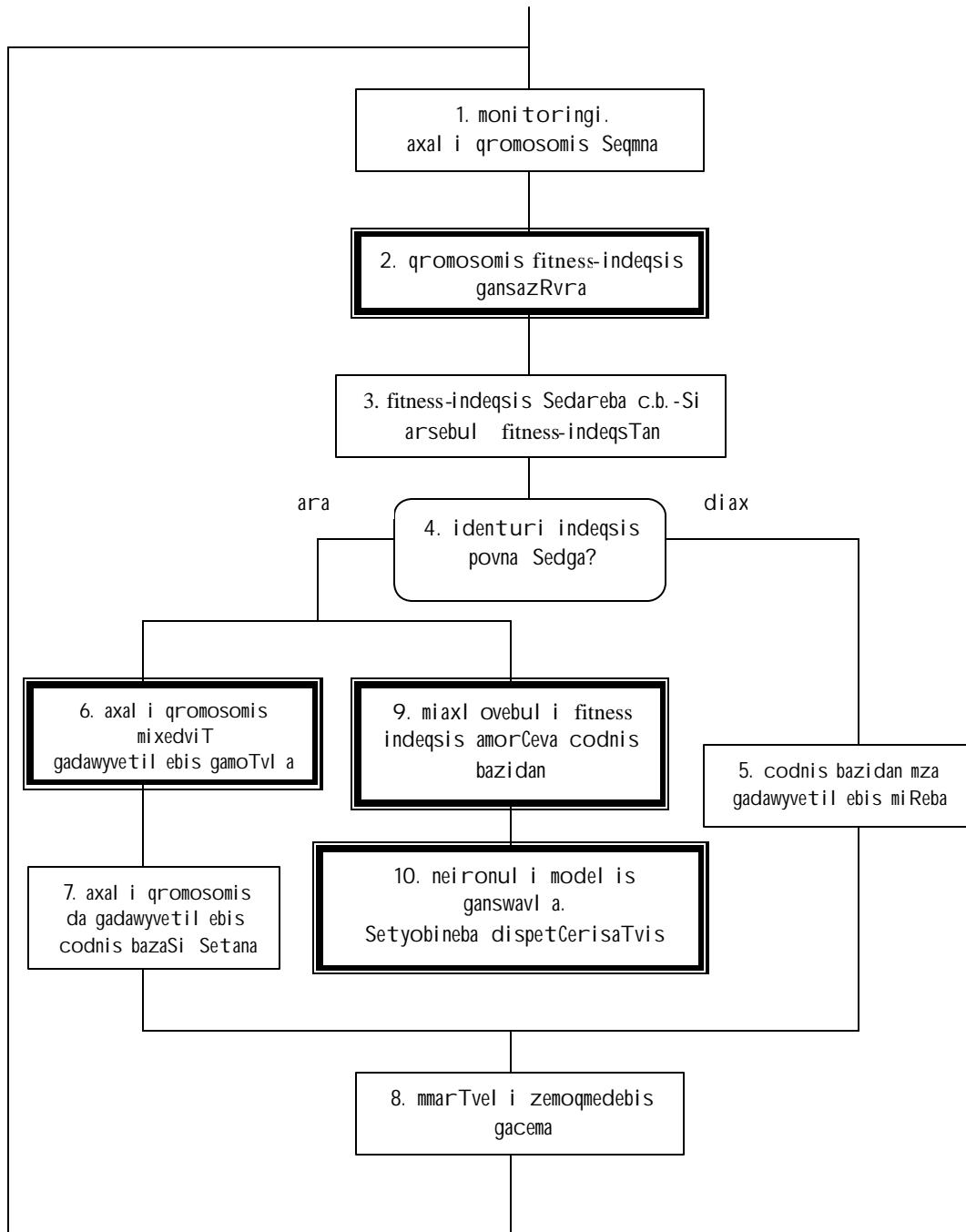
\$ 3.1. marTvis procesis intel eqtual uri al goriTmebi

rogorc zemoT iyo aRniSnul i, garda genetikuri al goriTmebis, qsel is marTvis procesSi gansakuTrebui mniSvnel obas iZens xel ovnuri intel eqtis sxva meTodebis, kerzod xel ovnuri neironul i qsel ebisa da freimebis sistemebis genetikur al goriTmebTan erTobl ivi gamoyenebis aucil ebl oba.

nax.3.1.1.-ze warmodgenil ia qsel is marTvis zogadi al goriTmis bl ok-sqema, sadac ZiriTad funqciur bl okebs Seadgenen monitoringisa da operatiul i marTvis intel eqtual uri al goriTmebi, roml ebic monacemTa bazebTan (statistikur monacemebTan) erTad codnis bazebisa (Knowledge Bases), codnis warmodgenis freimul i model isa da daskvnebis manqanis (Inference Engine) arsebobas efuzvneba. codnis baza warmodgenil ia wesebis erTobl iobis, `situaciagadawyveti` eba` strukturis freimul i `qromosomebis` simravl is saxiT, sadac TiToeul i freimis identifikators warmoadgens e.w. fitness-indeksi, rac real urad mocemul i konkretul i wesisaTvis genetikuri al goriTmebis `qromosomis` fitness-funqciis mniSvnel obis eqvivalenturia. amasTan, codnis bazaSi freimebi sortirebul ia fitness-indeksis mixdvi T[6,7].

bl oki 1. obieqtis marTvis procesis erT-erT umniSvnel ovanes etaps Seadgens qsel is uwyeti monitoringi, rac sakontrol o interval iT mTel i sistemis avtomatur skani rebas da komponentTa mmdinare mniSvnel obebis monacemTa bazaSi Setanas uzrunvel yofs.

Ti Toeul i saangari So $t = \overline{T}$ periodisatvis qsel i dan mi Rebul i informaciul i masivi qmnis axal "qromosomas", roml is "genebs" warmoadgens qsel is komponentTa mimi dinare mni Svnel obebi.



nax. 3.1.1.

bl oki 2. genetikuri al goriTmebis meSveobi T, xdeba Seqmnili axal i `qromosomis" fitness-i indeqsis gansazRvra.

bl oki 3. mimdinareobs axal i `qromosomis" fitness-i indeqsis codnis bazaSi arsebul i freimebis fitness-i indeqsebTan Sedareba da Sesabamisad, wi naswar dagrovi l i `codnis" mixedvi T mocemul i situaciis `Secnoba".

bl oki 4. ganisazRvreba moxda Tu ara identuri indeqsis povna codnis bazaSi.

bl oki 5. Tu mimdinare situaciis Secnoba moxda, maSin mocemul i fitness-i indeqsis mqone marTvis freimis Sesabamisi mza gadawyvetil eba (anu sarqvel ebis mdgomareobisa da satumbo sadgurebis muSaobis reJimebis mniSvnel obebi) gai cema qsel ze mmartvel i zemoqmedebi saTvis.

bl oki 6. Tu mimdinare situaciis Secnoba ar moixerxda, maSin axal i `qromosomis" mixedvi T marTvis al goriTmebis (genetikuri al goriTmebi, qsel is xisebri struqturabis adapturi gadawyobis al goriTmebi da sxva) gamoyenebi T xorciel deba ukve axal i mmartvel i gadawyvetil ebebis gamomuSaveba.

bl oki 7. mocemul i situacia da miRebul i Sedegebi axal i fitness-i indeqsis mqone freimis saxiT Seitaneba codnis bazaSi. garda amisa, codnis bazaSi, freimebis ganmeorebis sixSiris mTvl el is indikatoris Sesabamisad, dabal sicocxl isunariani freimeli, roml ebic TiTqmis aRar meordebian, codnis bazi dan amovardnas eqvemdebarebian anu xdeba codnis bazis ganaxl eba.

bl oki 8. gamoTvl il i mmartvel i gadawyvetil ebebi gai cema obieqtze.

bl oki 9. dispetcerizaciis Tval sazrisiT, paral el urad, unda moxdes anomal iuri situaciis identifikacia, kerZod qsel is im

monakveTis gansazRvra, sadac moxda sistemis muSaobis normaluri reJimiS darRveva an avariul i situaciis Seqmna. am mizniT codnis bazaSi xdeba axal i `qrromosomis" fitness-indeqsiTan maqsimal urad miaxl oebul i fitness-indeqsis mqone e.w. etal onuri freimis povna, romel Tanac ganTnxmeba minimaluri iqneba.

bl oki 10. axal i `qrromosomis" ganswavl is mizniT gamoiyeneba xel ovnuri neironul i qsel ebis metodi, roml is drosac axal i `qrromosoma" warmodgenil ia neironul i model is saxiT. ganswavl is procesSi mmdinareobs Y vektoris maqsimaluri adaptacia anu miaxl oeba D sasurvel (etal onur) gamomaval vektorTan, roca Secdoma $d \Rightarrow 0$, rac xdeba `farul i" el ementebis woniTi koeficientebis gamoTvl aawyobiT genetikuri al goriTmebis gamoyenebiT, sadac W wonebis vektorebi qrromosomTa registrebs qmnian.

`qrromosomis" neironul i model is ganswavl is etapebi:

bij i 1. inicializacia sawyis etapze mocemul ia `qrromosomis" sigreZe e.i. `genebis" raodenoba N , `genis" indeqsis sawysi m ni Svnel oba $i=0$, qsel is komponentebis m ni Svnel obaTa simravl e $X=\{x(i)\}$, axal i `qrromosoma" woniTi koeficientebis simravl is saxiT $W=\{w(i)\}$, D sasurvel i (etal onuri) gamomaval i vektoris m ni Svnel oba, cariel i simravl e $Q=Q=\{q(i)\}$, mutaciis koeficienti λ , `qrromosomis" fitness-funqciis sawysi m ni Svnel oba $Y(0)$.

bij i 2. ai Reba `qrromosomis" $i=i+1$ `genis" m ni Svnel oba.

bij i 3. gamoiTvl eba `qrromosomis" fitness-funqciis m ni Svnel oba $Y=F(XW)$.

bij i 4. mowmdeba piroba: $Y=D$. pirobis Sesrul ebis SemTxvevaSi gadavdivarT bij i 5-ze. sxva SemTxvevaSi bij i 6-ze.

bij i 5. neironul i model is ganswavl a dasrul ebul ia. gacema `genebis" anu qsel is komponentTa simravl e $\{q(i)\}$, sadac Seiqmna anomal iuri situaciebi. miRebul i informacia mi ewodeba dispetCers da imavdroul ad fiksirdeba monacemTa bazaSi anomal iaTa Jurnal izaciis mizni T.

bij i 6. gamoi Tvl eba Secdoma $\mathbf{d} = |Y - D|$.

bij i 7. mowmdeba piroba: $\mathbf{d}(i) = \mathbf{d}(i-1)$. pirobis Sesrul ebis SemTxvevaSi gadavdivarT bij i 8-ze. sxva SemTxvevaSi bij i 10-ze.

bij i 8. mowmdeba piroba: $Y > D$.

bij i 9. pirobis Sesrul ebis SemTxvevaSi: $w(i) = w(i) - \lambda$, xol o sxva SemTxvevaSi: $w(i) = w(i) + \lambda$; anu i-ur `genSi" srul deba mutaciis operatori. gadavdivarT bij i 3-ze.

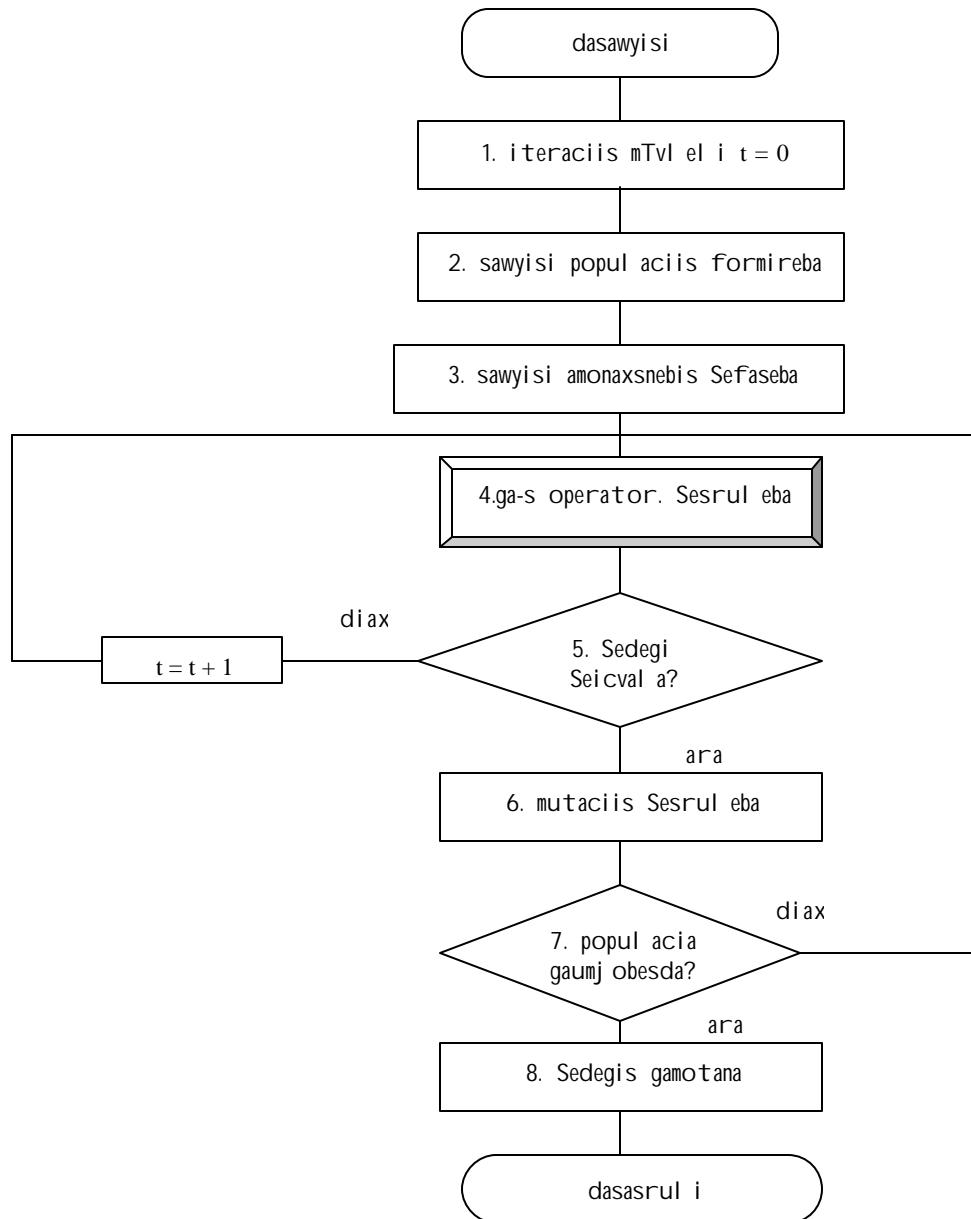
bij i 10. mowmdeba piroba: $i=N$. pirobis Sesrul ebis SemTxvevaSi gadavdivarT bij i 5-ze. sxva SemTxvevaSi bij i 11-ze.

bij i 11. Q simravl is el ementi: $q(i) = \mathbf{d}(i)$. gadavdivarT bij i 2-ze.

warmodgenil i intel eqtual uri al goritmebi principul ad cvl ian personal is anal izur da prognostul SesaZl ebl obebs, mkveTrad amari eben gadawyvetil ebis miRebis operatiul obis xarisxs, gansakuTrebit avariul i situaciebis warmoSobis dros. garda amisa, sakmaod mosaxerxebel ia arasrul i informaciis SemTxvevaSi marTvis Tval sazrisiT.

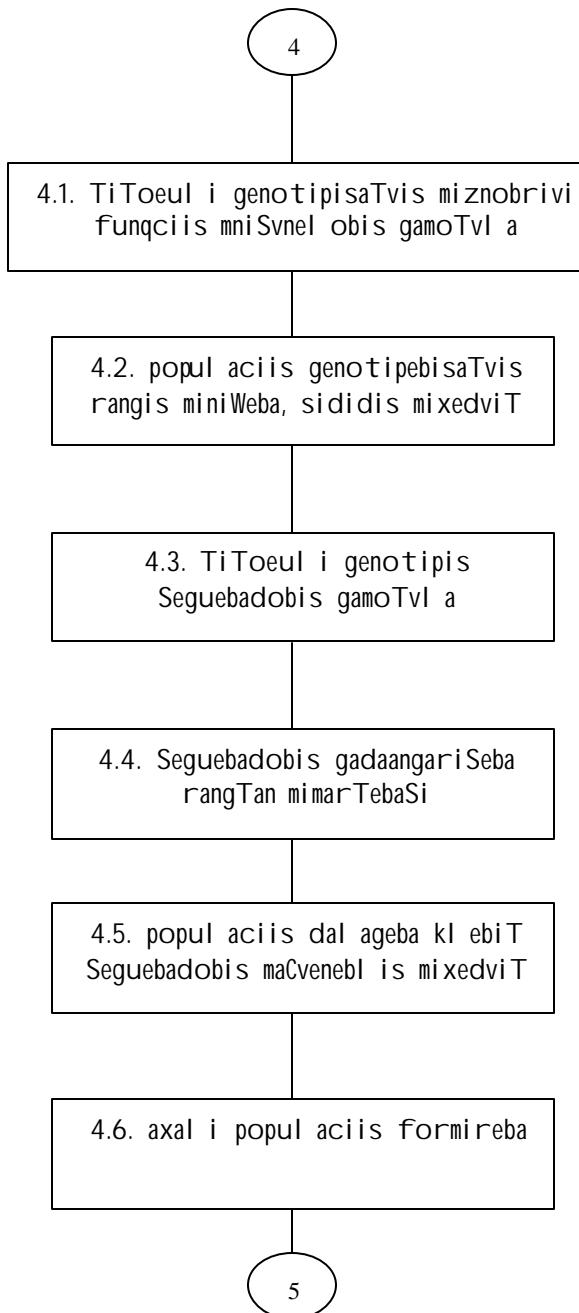
\$3.2. genetikuri al goritmis da qsel is dekompoziciis al goritmis aRwera

modificirebul i genetikuri al goritmi war modgenil i a nax.
3.2.1-ze al goritmi moicavs populaciis formirebis, kodirebis,
dekodirebis, krossoveris, mutaciis, ranjirebis bl okebs.



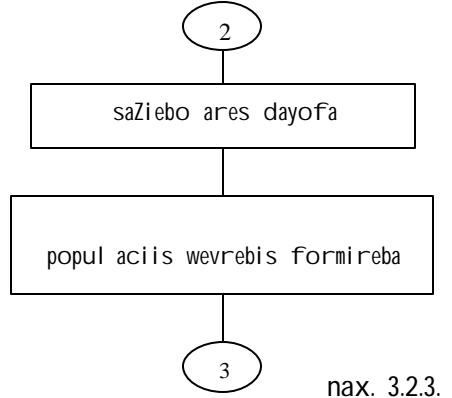
nax.3.2.1

bl oki 4. warmodgenili a nax.3.2.2.-ze, romel ic axorciel ebs genotipebis Seguebadobis gamoTvl as, genotipebisatvis rangis miniWebas, populaciis sortirebas kl ebiis mixedviT, axal i populaciis formirebas.

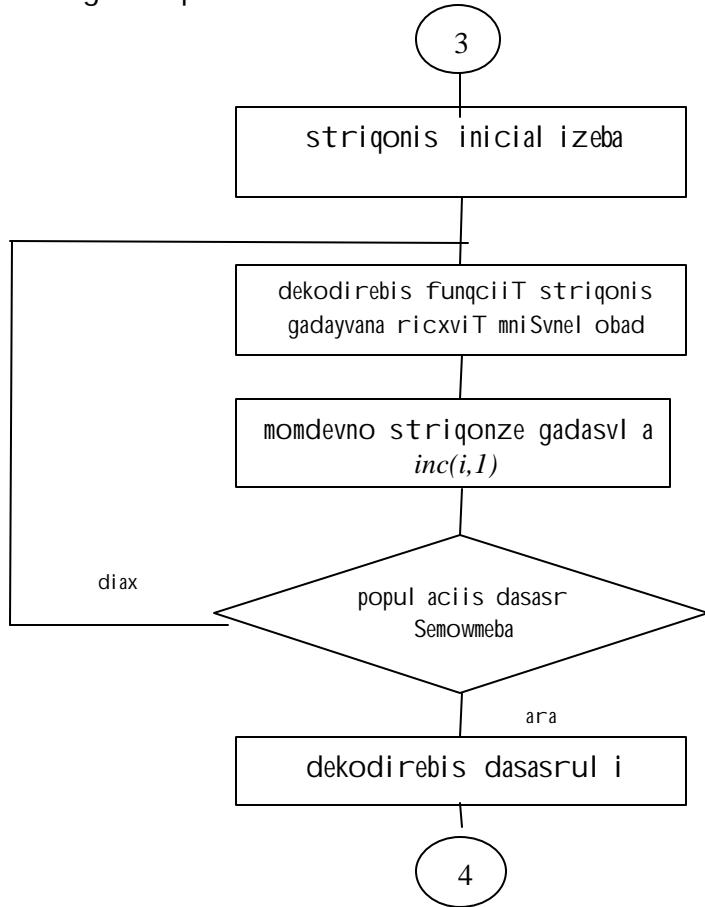


nax. 3.2.2.

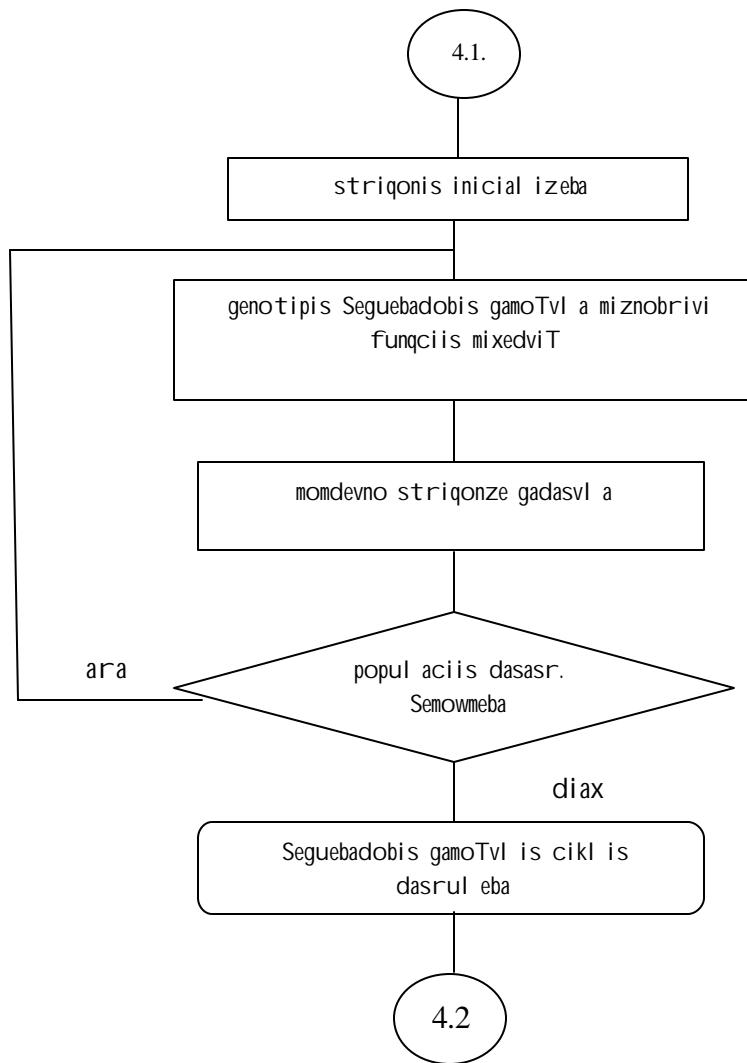
bl oki 2. warmodgenil ia Nnax. 3.2.3.-ze, romel ic axorciel ebs saZiebo ares dayofas 2' tol nawill ad da dayofil i aredan nraodenobis l Tanrigiani orobiTi S raodenobis striqonebis formirebas.



bl oki 3. warmodgenil ia Nnax. 3.2.4.-ze, romel ic moicavs dekodirebis funciis saSual ebiT Ti Toeul i striqonis ricxviT mni Svnel obad gardaqmnis bl okebs.

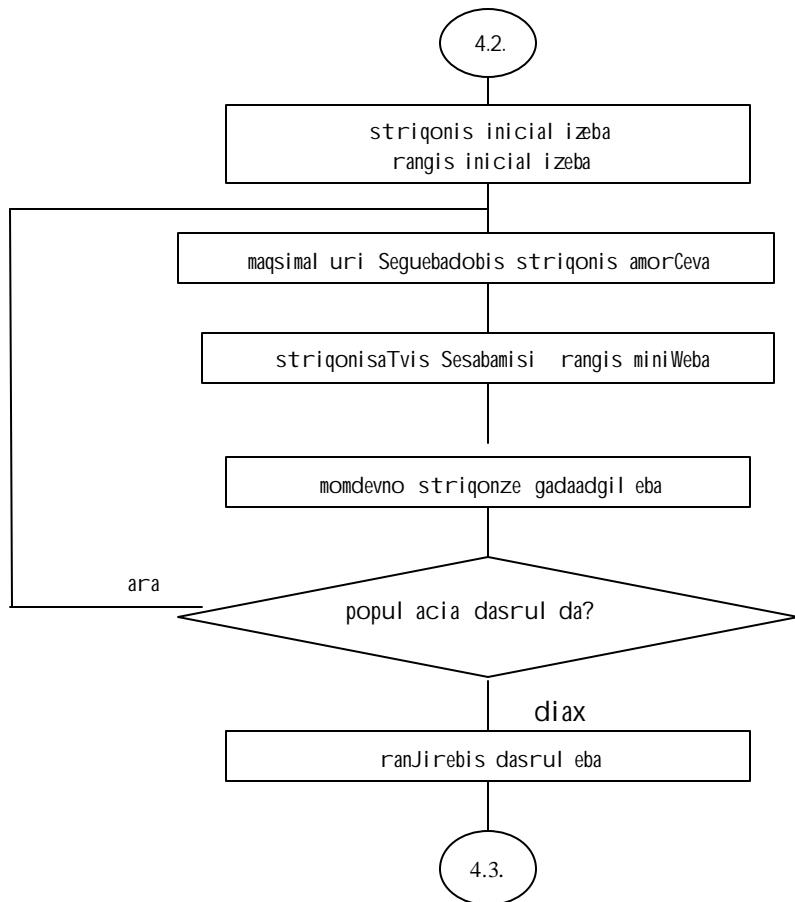


bl oki 4.1. warmodgeni l ia nax. 3.2.5.-ze, romel ic Seicavs
 Ti Toeul i striqonisatvis anu genotipebisatvis mi znobrivi
 funqciis mixedvi T Seguebadobis gamoTvl is bl okebs.



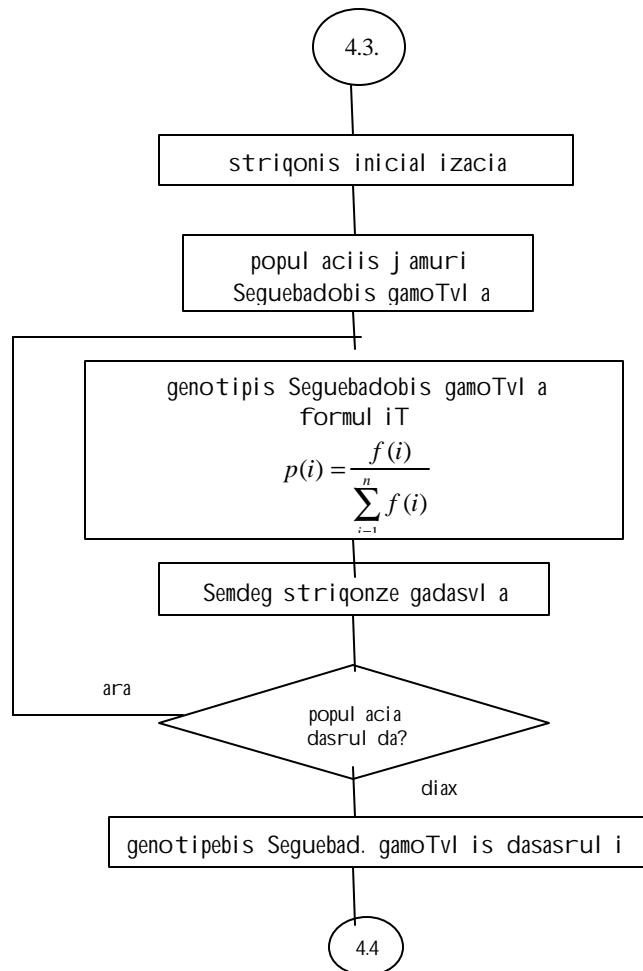
nax. 3.2.5.

bl oki 4.2. warmodgenili ia nax.3.2.6.-ze, romel ic Seicavs sawyisi rangis inicial izaciis, cal keul i striqonisatvis rangis min Webis bl okebs.



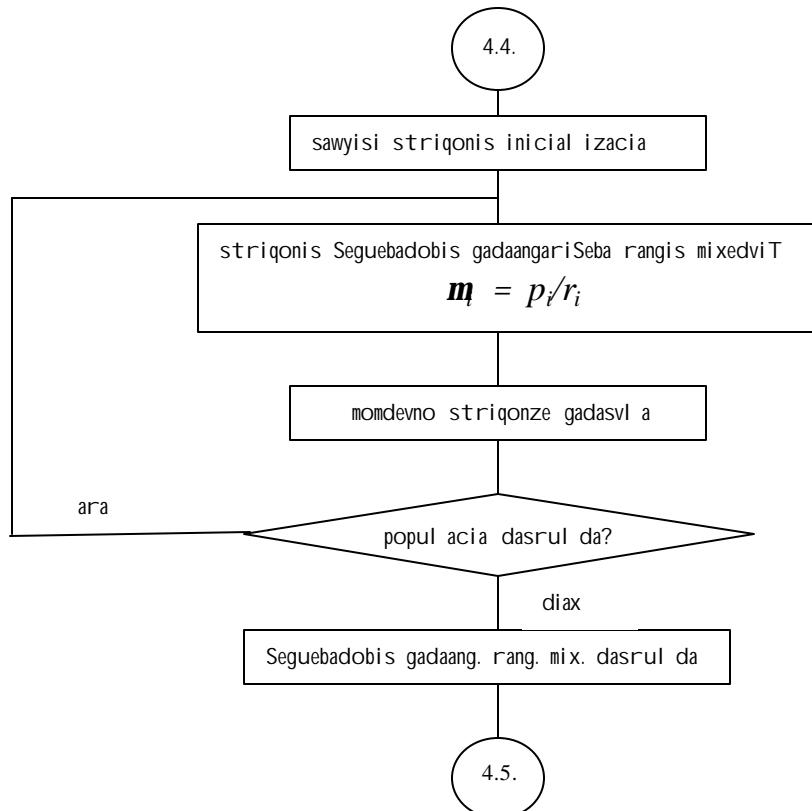
nax. 3.2.6.

bl oki 4.3 warmodgeni l ia nax.3.2.7-ze, romel ic Sei cavs pol ul aciis j amuri Seguebadobis gamoTvl is, popul aciis Ti Toeul i wevris Seguebis al baTobis gamoTvl is bl okebs.



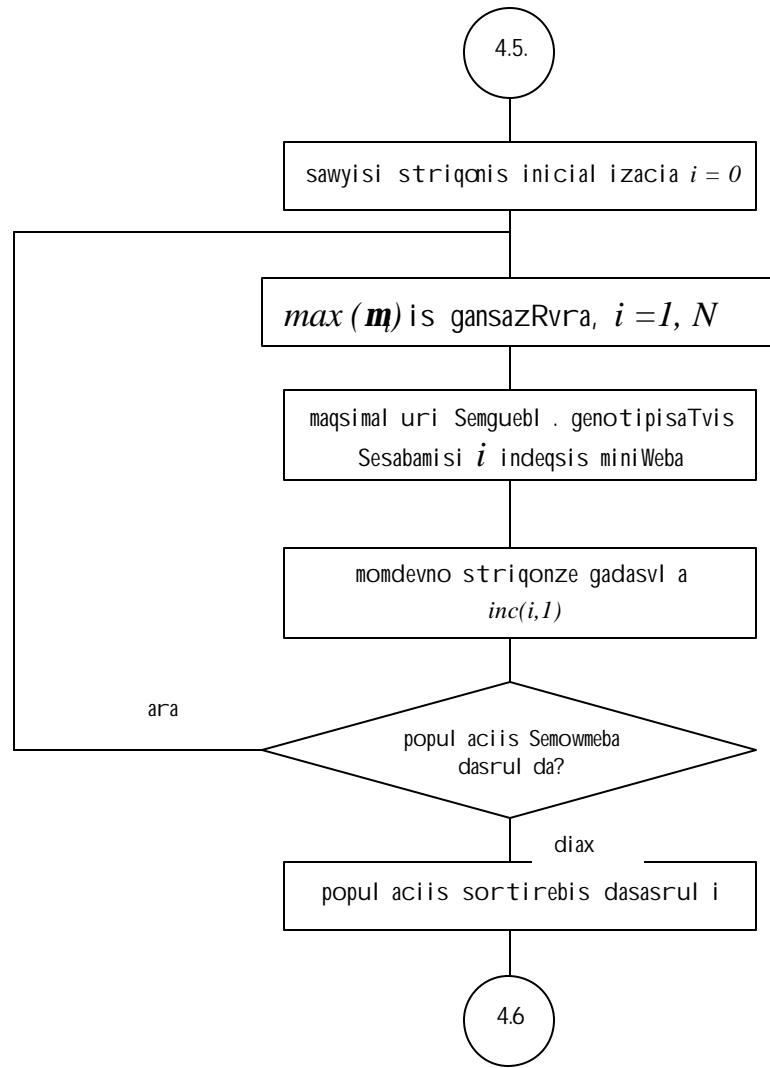
nax. 3.2.7.

bl oki 4.4. warmodgenilia nax. 3.2.8.-ze, romelic aerTianebs
 populaciis wevrebis rangis mixedviT Seguebadobis
 gadaangariSebis bl okebs, rac warmodgens populaciis daxa-
 risxebis wi napirobas.



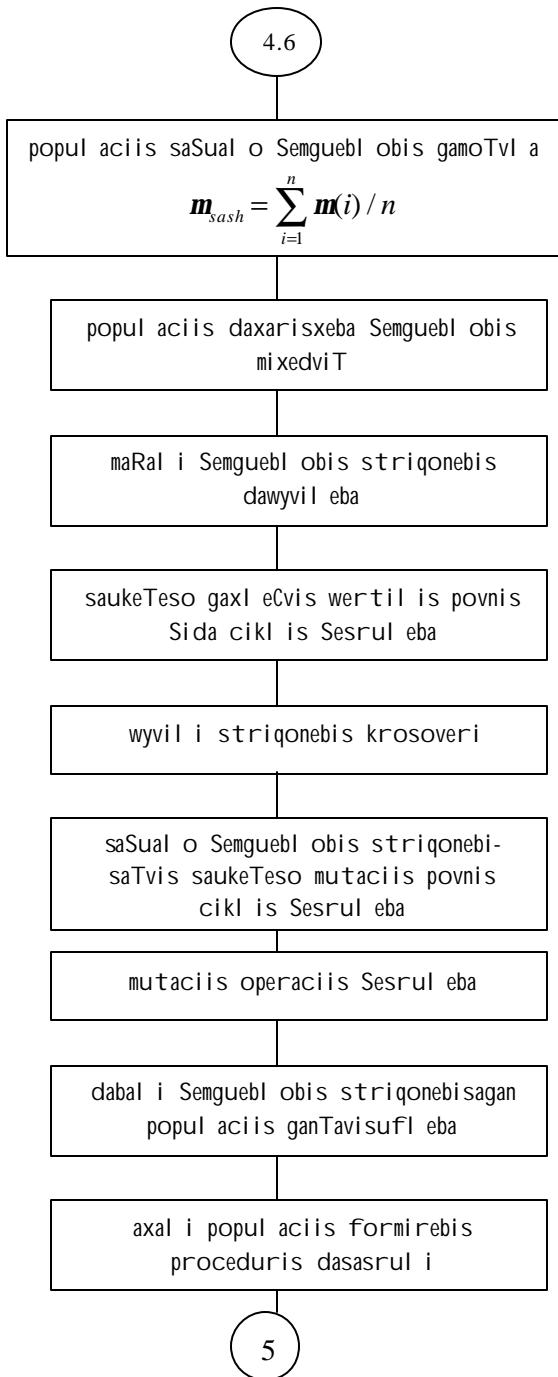
nax. 3.2.8.

bl oki 4.5. warmodgenil ia nax.3.2.9.-ze, romel ic moi cavs popul aciis wevrebis saSual o Seguebadobis mixedvi T popul aciis wevrebis sortirebis bl okebs.



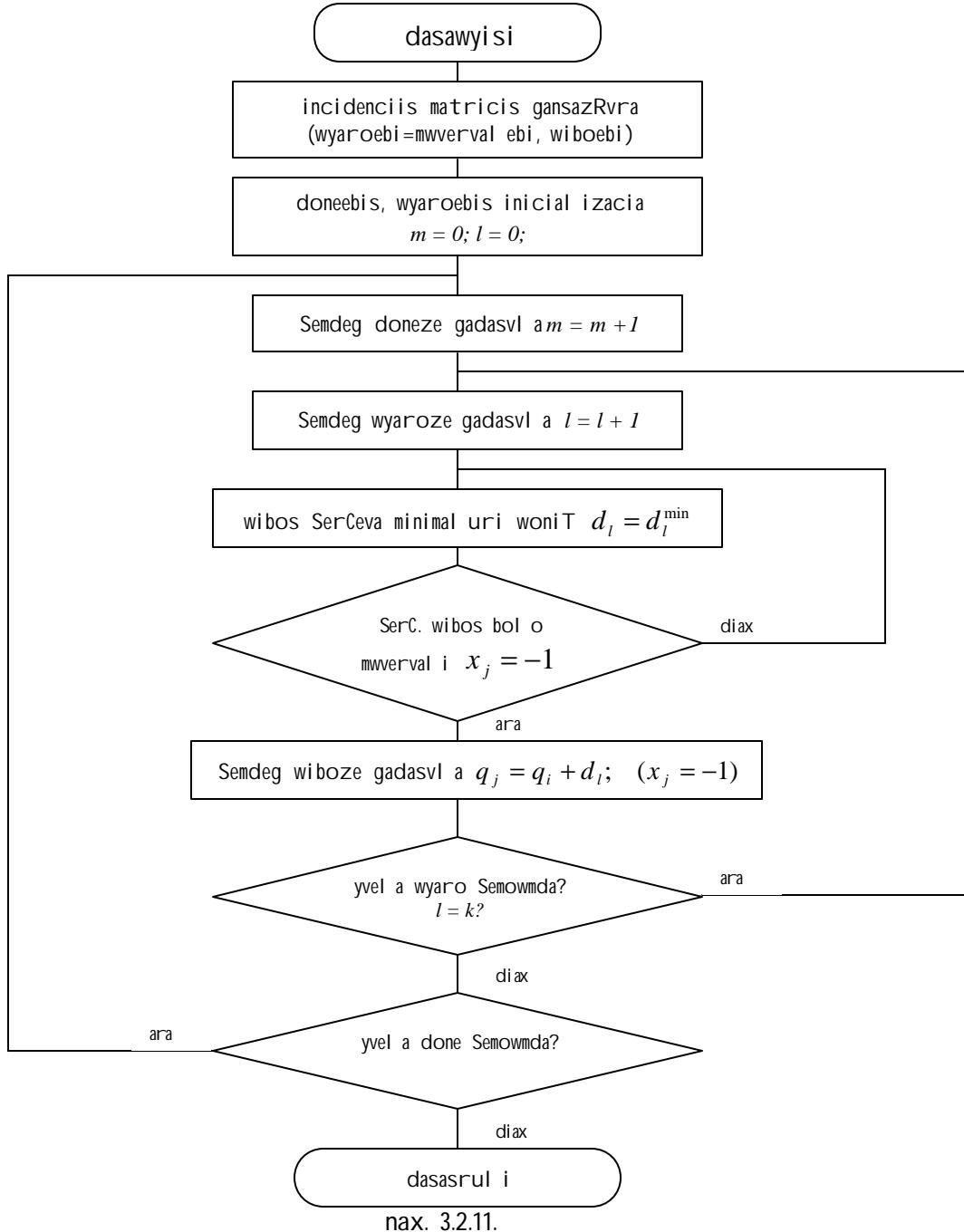
nax. 3.2.9.

bl oki 4.6 warmodgeni l i nax 3.2.10-ze, romel ic Sei cavs popul aciis saSual o Seguebadobis gansazRvris, popul aciis wevrebis daxarisxebis, krosoveris, mutaciis, bl okebs.



nax.3.2.10.

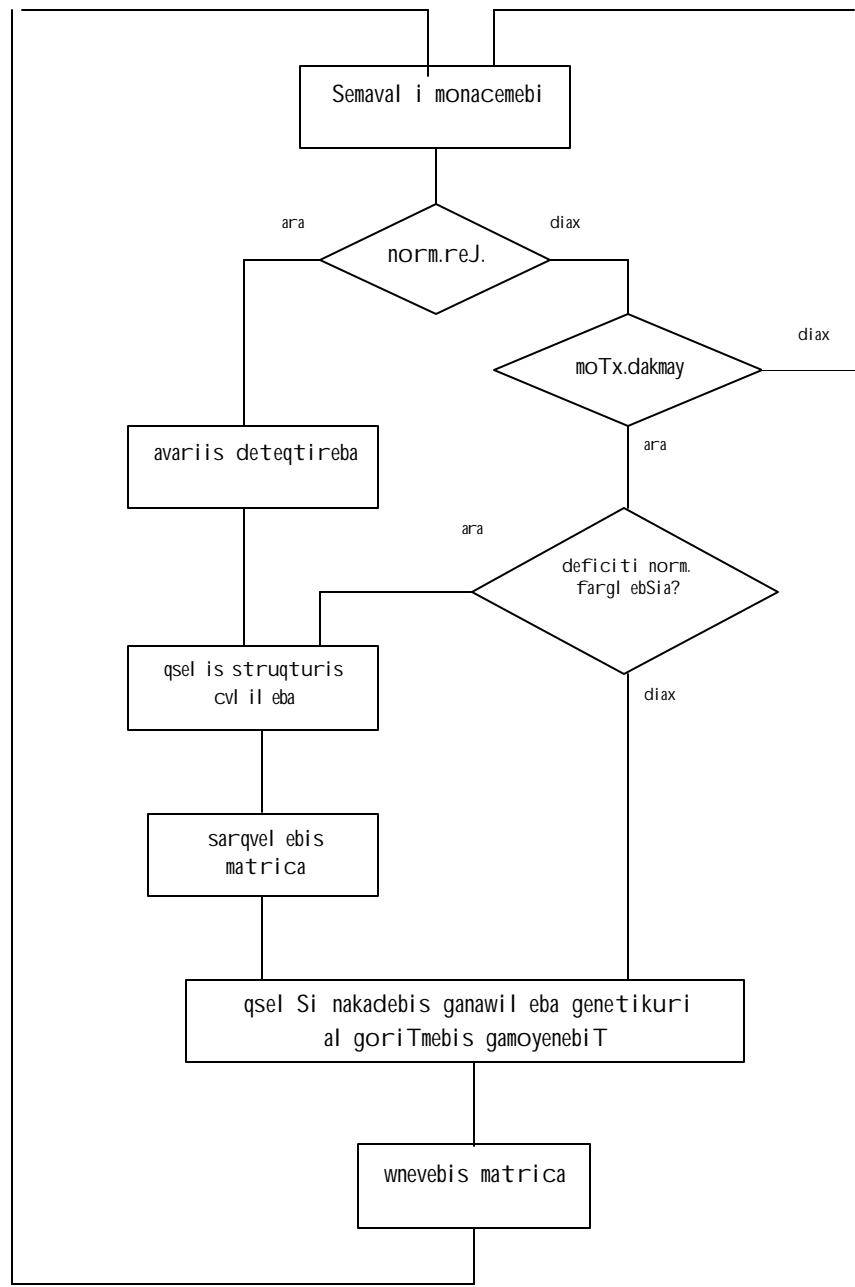
qsel is xisebr struqturebad dekompoziciis al goriTmul i sqema
 mocemul ia nax.3.2.11-ze, romel ic Sedgeba wyaroebis anu
 mwerval ebis SerCeviS, doneebis inicial izaciis, wiboebis
 SerCeviS bl okebi sagan.



\$3.3. nakadebis marTvis al goriTmebi

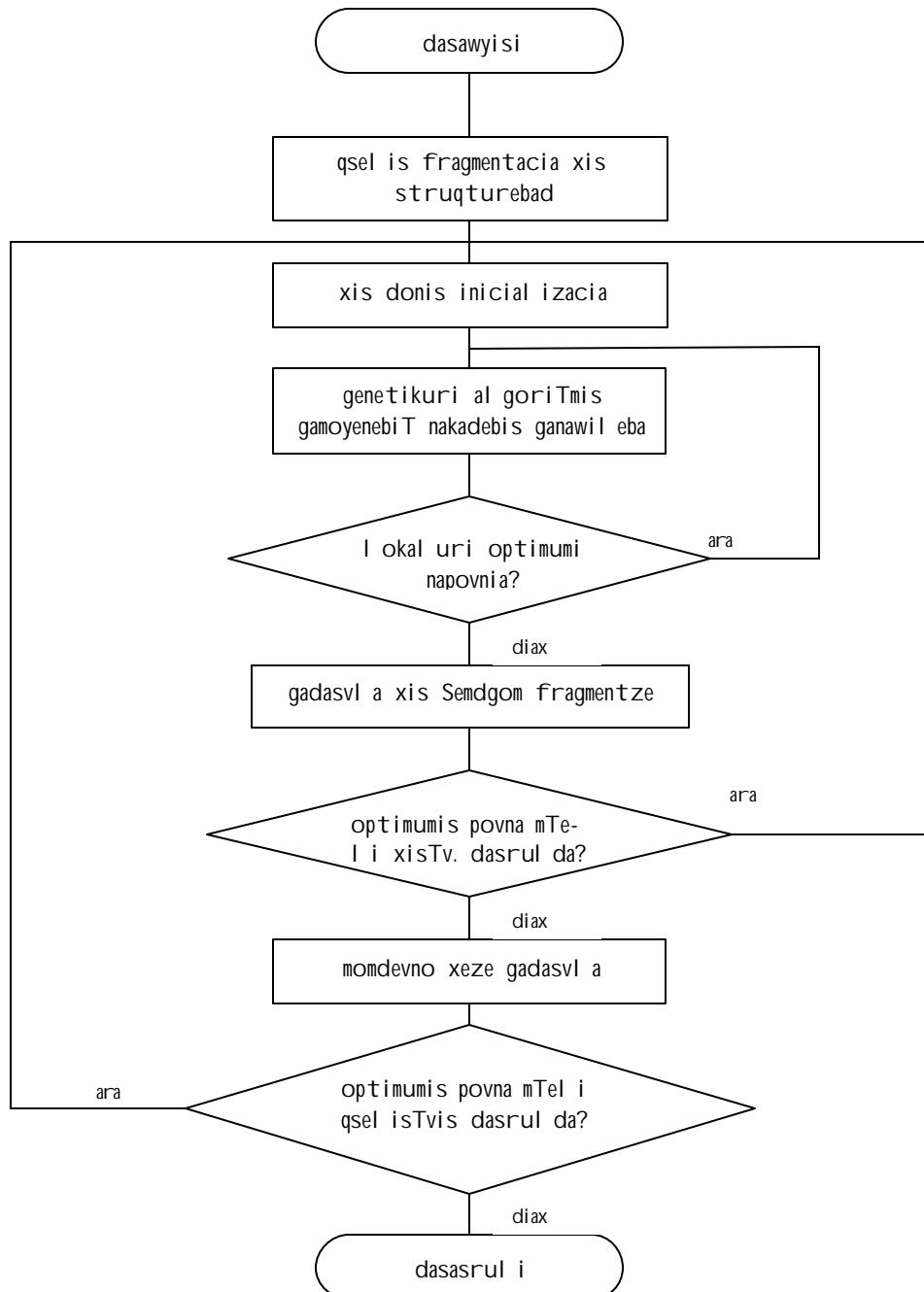
sistemis operatiul i marTvis al goriTmis ganzogadoebul i bl ok-sqema naCvenebia nax.3.3.1.-ze.

Tu moTxovna dakmayofil ebul ia sistema funqcionirebs Cveul ebriv reJiSi. Tu deficiti normis fargl ebSia, maSin nakadebi gadanawi l deba genetikuri al goriTmebi T, xis struqturebis cvl il ebis gareSe, roml is model i warmodgenil ia \$25-Si. Tu deficiti ar aris normis fargl ebSi, rac niSnavs rom wyaro ver uzrunvel yofs moTxovnaTa dakmayofil ebas, an avariul i reJimia, maSin jer mimdinareobs qsel is struqturis cvl il eba, roml is model i warmodgenil ia \$24-Si, Semdeg ki axal i struqturebis pirobebSi nakadebi gadanawi l deba genetikuri al goriTmebi T[4].



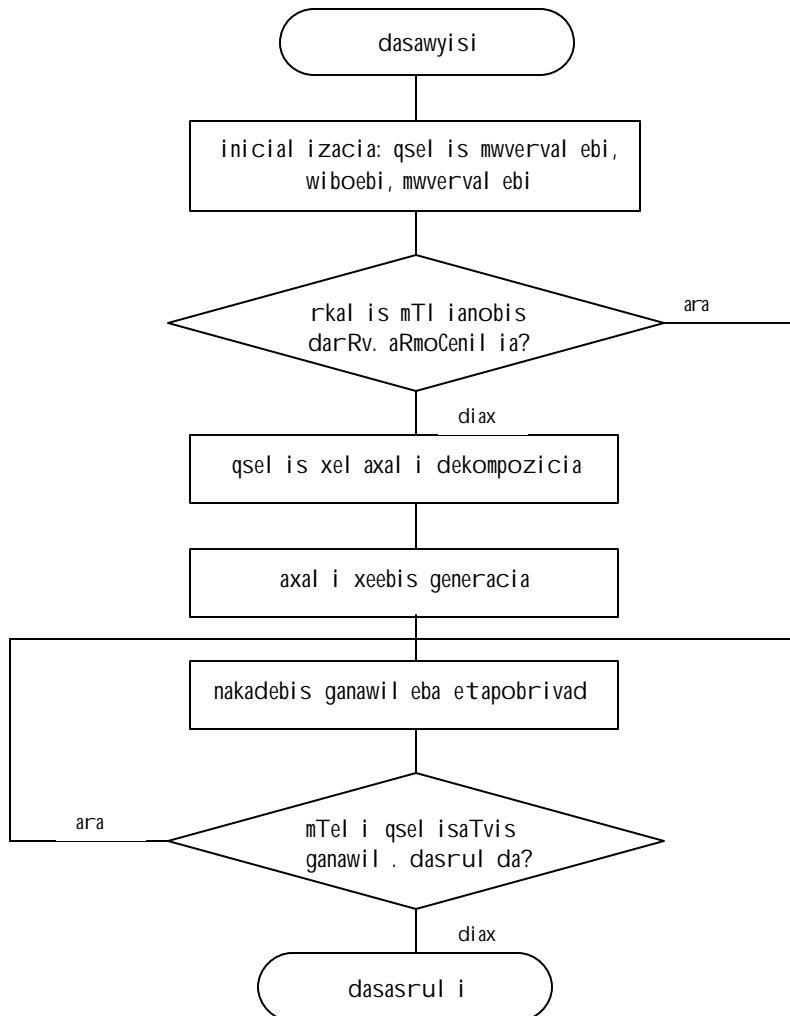
nax. 3.3.1.

nakadebis ganawil ebis al goriTmis bl ok-sqema, normal uri reJimi saTvis, warmodgenili ia nax.3.3.2.-ze, romelic moicavs xis doneebis inicial izaciis, doneebis mixedviT genetikuri al goriT-mebiT nakadebis ganawil ebis bl okebs.



nax. 3.3.2.

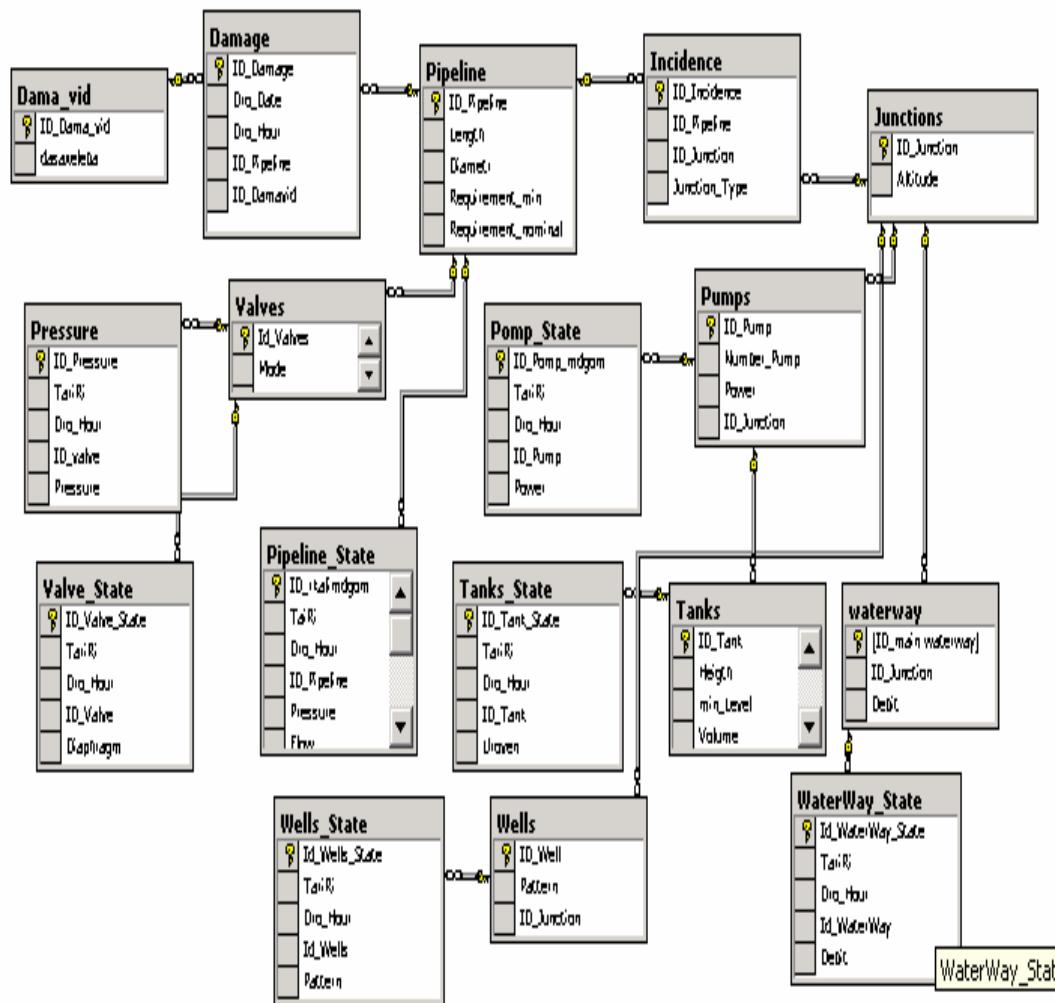
nakadebis marTvis al goriTmis bl ok-sqema, avariul i reJimsaTvis, warmodgenil ia nax. 3.3.3.-ze, romel ic moicavs avariis deteqtirebis, axal i xeebis generaciis, nakadebis etapobrivid ganawiI ebis bl okebs.



nax. 3.3.3.

**\$ 3.4 informaciul i uzrunvel yofa da
marTvis sistemis struktura**

monacemTa bazebis model is arCevisas upiratesoba mi eni Wa
rel aciur monacemTa bazebs, romel Tac moTxovnebis formirebis
ZI ieri instrumentul i saSual ebani gaaCniciA SQL enis saxiT,
agreTve Tavsebadi arian GIS-is interfeisTan da codnis
bazebTan. monacemTa bazis strukturas aqvs Semdegi saxe(nax.3.4.1.):



nax. 3.4.1.

monacemTa bazis Semadgenel i cxril ebis struqturebi:

cxril i 3.4.1. `kvanZi":

vel is dasaxel eba	Field name	Type	Size
kvanZis kodi (Primary key)	ID_Junction	Num	int
simaRI e	Altitude	Num	int

cxril i 3.4.2. `Semomaval i magistral i~

vel is dasaxel eba	Field name	Type	Size
kvanZis kodi	ID_Junction	Num	int
magistral is kodi (Primary key)	ID_main waterway	Num	int
debeti	Debit	Num	longint

cxril i 3.4.3. `mil sadeni":

vel is dasaxel eba	Field name	Type	Size
mil sadenis kodi (Primary key)	ID_Pipeline	Num	int
sigrZe	Length	Num	int
diametri	Diametr	Num	int
min. moTxovnil eba	Requirement_min	Num	int
nomin. moTxovnil eba	Requirement_nominal	Num	int

cxril i 3.4.4. `incidencia"

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_Incidence	Num	longint
mil sadenis kodi	ID_Pipeline	Num	int
kvanZis kodi	ID_Junction	Num	int
incidencia	Incidencia	bit	1

cxrill i 3.4.5. `satumbo sadguri`

vel is dasaxel eba	Field name	Type	Size
satumbos kodi (Primary key)	ID_Pump	Num	int
kompres. raodenoba	Number of Pump	Num	int
simZI avre	Power	Num	longint
kvanZis kodi	ID_Junction	Num	int

cxrill i 3.4.6. `rezervuari`:

vel is dasaxel eba	Field name	Type	Size
rezervuaris kodi (Primary key)	ID_Tank	Num	int
rezervuaris simaRI e	Heighth	Num	int
minimal uri done	min_Level	Num	int
rezerv. mocupl oba	Volume	Num	int
satumbos kodi	ID_Pump	Num	int

cxrill i 3.4.7. `adgil obrivi rezervi`:

vel is dasaxel eba	Field name	Type	Size
WaburRil is kodi (Primary key)	ID_Well	Num	int
warmadoba	Pattern	Num	longint
kvanZis kodi	ID_Junction	Num	int

cxrill i 3.4.8. `sarqvel i`

vel is dasaxel eba	Field name	Type	Size
sarqvel is kodi (Primary key)	ID_Valve	Num	longint
saTave/bol o	terminal	bit	1
mil sadenis kodi	ID_Pipeline	Num	int

cxril i 3.4.9. `mil sadenis mdgomareoba`:

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_Dynamic	Num	longint
TariRi	Dro_Date	Date	ShortDate
dro	Dro_Hour	Time	int
mil sadenis kodi	ID_Pipeline	Num	int
wneva	Pressure	Num	int
nakadi	Flow	Num	longint
moTxovnil eba	Requirement	Num	longint

cxril i 3.4.10. `rezervuaris mdgomareoba`:

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_State	Num	longint
TariRi	Dro_Date	Date	ShortDate
dro	Dro_Hour	Num	int
rezervuaris kodi	ID_Tank	Num	int
wyl is done	Uroven	Num	int

cxril i 3.4.11. `WaburRil is mdgomareoba`:

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_State	Num	longint
TariRi	Dro_Date	Date	ShortDate
dro	Dro_Hour	Num	int
WaburRil is kodi	ID_Well	Num	int
warmadoba	Pattern	Num	longint

cxril i 3.4.12. `magistral is mdgomareoba`:

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_State	Num	longint
TariRi	Dro_Date	Date	ShortDate
dro	Dro_Hour	Num	int
magistral is kodi	ID_magistrali	Num	int
debeti	Debit	Num	longint

cxril i 3.4.13. `satumbo sadguris mdgomareoba`:

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_Func_Command	Num	longint
TariRi	Dro_Dat	Date	ShortDate
dro	Dro_Hour	Num	int
satumbos kodi	ID_Pump	Num	int
simZI avre	Power	Num	longint

cxril i 3.4.14. `sarqvel ebis mdgomareoba`:

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_Struct_Command	Num	longint
TariRi	Dro_Date	Date	ShortDate
dro	Dro_Hour	Num	int
sarqvel is kodi	ID_Valve	Num	longint
mdgomareoba	Diaphragm	Num	int

cxrill i 3.4.15. `avar iul i situaciebi`:

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_Damage	Num	longint
TariRi	Dro_Date	Date	ShortDate
dro	Dro_Hour	Num	int
mil sadenis kodi	ID_Pipeline	Num	int
avariis saxeoba	ID_Damavid	Num	int

cxrill i 3.4.16. `avar iis saxeobebi`:

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_Dama_vid	Num	int
dasaxel eba	dasaxeleba	char	100

cxrill i 3.4.17. `wnevebi mil sadenebSi`:

vel is dasaxel eba	Field name	Type	Size
kodi (Primary key)	ID_Struct_Command	Num	longint
TariRi	Dro_Date	Date	ShortDate
dro	Dro_Hour	Num	int
sarqvel is kodi	ID_Valve	Num	longint
wneva	Pressure	Num	int

monitoringis sakontrol o monacemTa informaciul i masiv:

D- TariRi (Primary key);

T - dro (saTi) (Primary key);

FI - mdgomareobaTa freimis fitness-indeksi;

T1 - #1 rezervuarSi wyl is done;

.....

Tn - #n rezervuarSi wyl is done;

M1 - #1 magistral Si wyl is debeti;

.....

Mn - #n magistral Si wyl is debeti;

W1 - #1 WaburRil is paterni;

.....

Wn - #n WaburRil is paterni;

P1 - #1 satumbo sadguri simZl avre;

.....

Pn - #n satumbo sadguri simZl avre;

.....

V1 - #1 sarqvel is mdgomareoba;

.....

Vn - #n sarqvel is mdgomareoba;

VP1 - #1 sarqvel is wneva;

.....

VPn - #n sarqvel is wneva;

.....

da a.S.

garda monacemTa bazisa, informaciul i uzrunvel yofa Seicavs agreTve codnis bazas, romel ic ZiriTadar ori cxril is saxiT warmodgenil i freimisagan Sedgeba: *mdgomareobaTa freimi* da *marTvis freimi*.

mdgomareobaTa freimis struktura Sedgeba Semdegi sl otebis anu `genebi sagan":

F1 - *mdgomareobaTa freimis fitness-indeksi (Primary key)*:

T1 - #1 rezervuarSi wyl is done;

.....

Tn - #n rezervuarSi wyl is done;

M1 - #1 magistral Si wyl is debeti;

.....

Mn - #n magistral Si wyl is debeti;

W1 - #1 WaburRil is paterni;

.....

Wn - #n WaburRil is paterni;

P1 - #1 satumbo sadguris simZl avre;

.....

Pn - #n satumbo sadguris simZl avre;

.....

V1 - #1 sarqvel is mdgomareoba;

.....

Vn - #n sarqvel is mdgomareoba;

VP1 - #1 sarqvel is wneva;

.....

VPn - #n sarqvel is wneva;

.....

da a.S.

marTvis freimis struktura Sedgeba Semdegi sl otebis anu `genebi sagan":

FI'- marTvis freimis fitness-iindeqsi (**Primary key**);

P1'- #1 satumbo sadguris simZI avre;

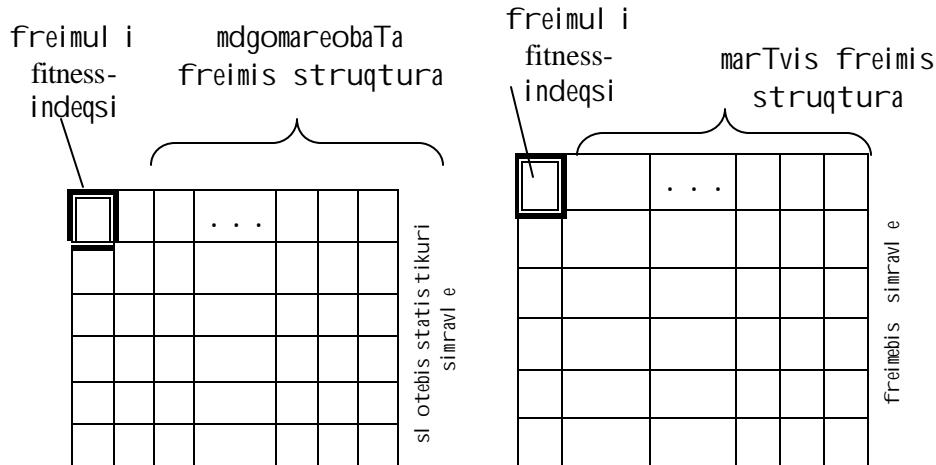
.....
Pn'- #n satumbo sadguris simZI avre;

.....
V1'- #1 sarqvel is mdgomareoba;

.....
Vn'- #n sarqvel is mdgomareoba;

.....
da a.S.

mdgomareobaTa da marTvis freimebi waroadgenen erTnairi
fitness-iindeqsi T (1:1 asociaciuri kavSiri) dakavSirebul
cxril ebs, roml ebic qmnian I ogikur mTI ianobas. mdgomareobaTa
da marTvis freimebis struqtura bi naCvenebia nax.3.4.2.-ze:



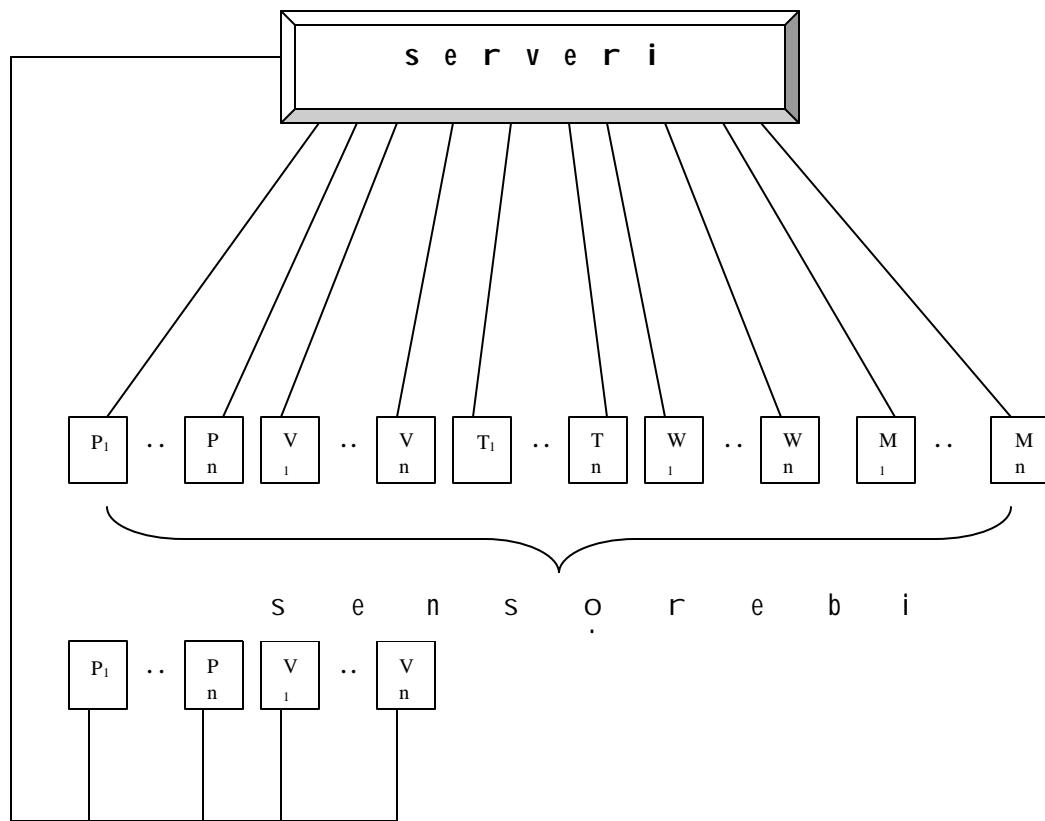
nax. 3.4.2.

```

qvemoT   mocemul ia   mdgomareobaTa   da   marTvis   freimebis
procedurebi:
    Unit Frame;
    interface
        uses Windows, Messages, SysUtils, Classes, Graphics, Controls,
            Forms, Dialogs, StdCtrls, Buttons;
        type
            TForm1 = class (TForm).
                ListBox1 : TListBox;
                ListBox2 : TListBox
            procedure FormCreate (Sender : TObject);
            procedure ListBox1(Sender: TObject);
            procedure ListBox2(Sender : TObject);
            procedure Mdg;
            procedure Mart;
            . . . . .
            Procedure TForm1.ListBox1Click (Sender: TObject);
                var i: integer;
                begin
                    ListBox1.Clear;
                    for i := 0 to Form1.MainMenu1.Items.Count-1 do
                        ListBox1.Items.Add(Form1.MainMenu1.Items[i].Caption);
                    ListBox1.ItemIndex := 0;
            . . . . .
            Procedure Mdg;
            var F1,T1,...Tn,M1,...Mn,W1,...Wn,P1,...Pn : LongInt;
                V1,...,Vn : Boolean; VP1,...,VPn : Integer;
                Begin
            . . . . .
                if (F1) and (T1...Tn) and (M1...Mn) and (W1...Wn) and (P1...Pn)
                    and (V1...Vn) and (VP1...VPn) then Mart;
            . . . . .
            Procedure Mart;
            var F1,P1,...,Pn : Integer;
                V1,...,Vn : Boolean;
                Begin
                    F1:=f1; P1:=p1;....,Pn:=pn; V1:=v1,...,Vn:=vn;
            . . . . .
            Procedure TForm2.ListBox2Click(Sender: TObject);
            var i: integer; begin
                ListBox2.Clear;
                for i := 0 to Form1.MainMenu1.Items [ListBox1.ItemIndex].Count-1 do
                    ListBox2.Items.Add(Form1.MainMenu1.Items[
                        ListBox1.ItemIndex].Items[i].Caption);
                ListBox2.ItemIndex := 0;
            . . . . .

```

.....qsel is marTvis sistemis struktura.



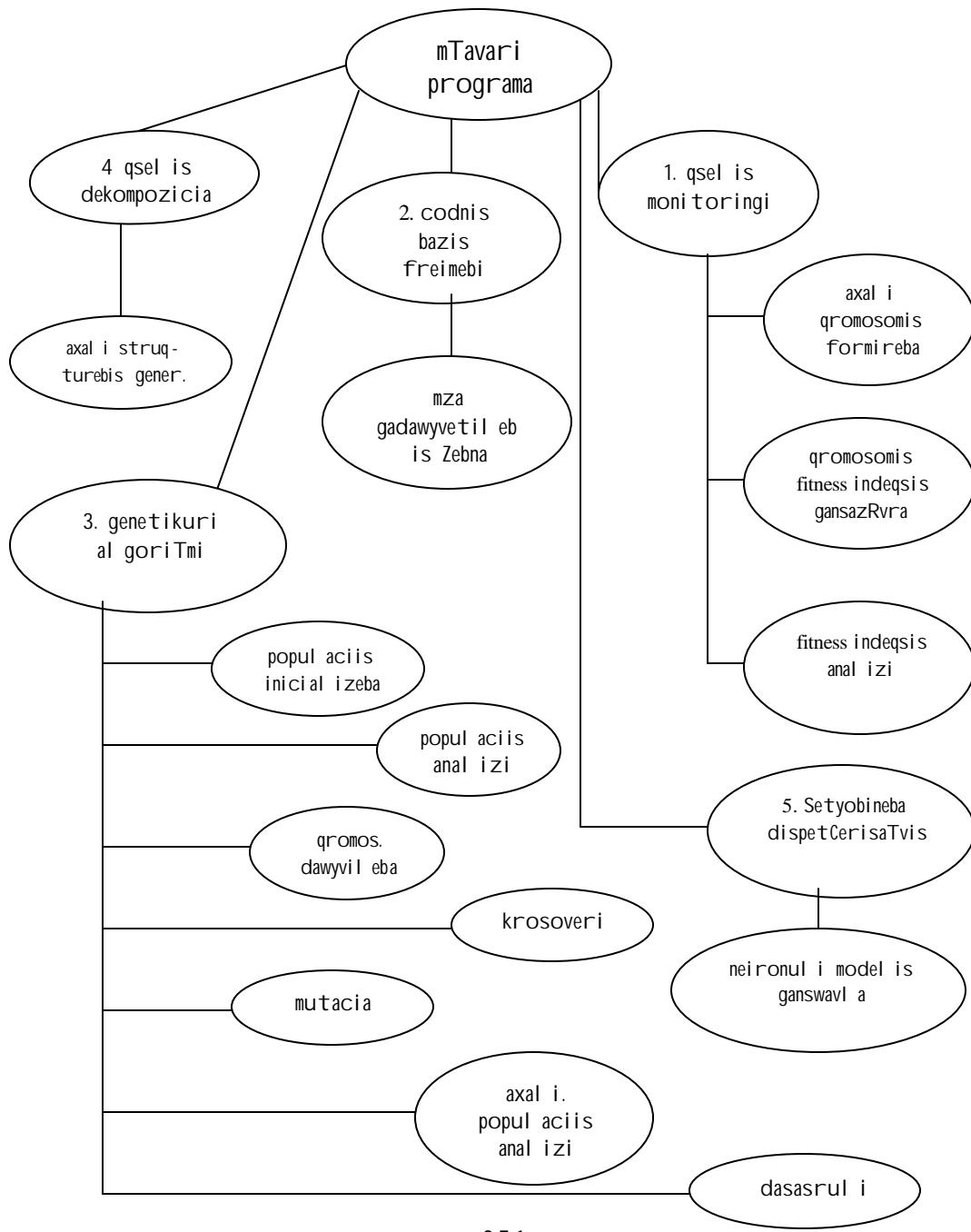
marTvis organoebi

nax. 3.4.3.

sakontrol o $t = \overline{1, T}$ interval iT xdeba mTel i sistemis avtomaturi skani reba da komponentTa mindinare mni Snel obebis ("genebis") monacemTa bazaSi SetaniT informaciul i masivis anu axal i "qromosomis" formireba.

\$3.5. programul i kompl eqsis struqtura da interfeisi

marTvis sistemis programul i kompl eqsis struqtura wamodgenil i a nax.3.5.1.-ze:



nax.3.5.1.

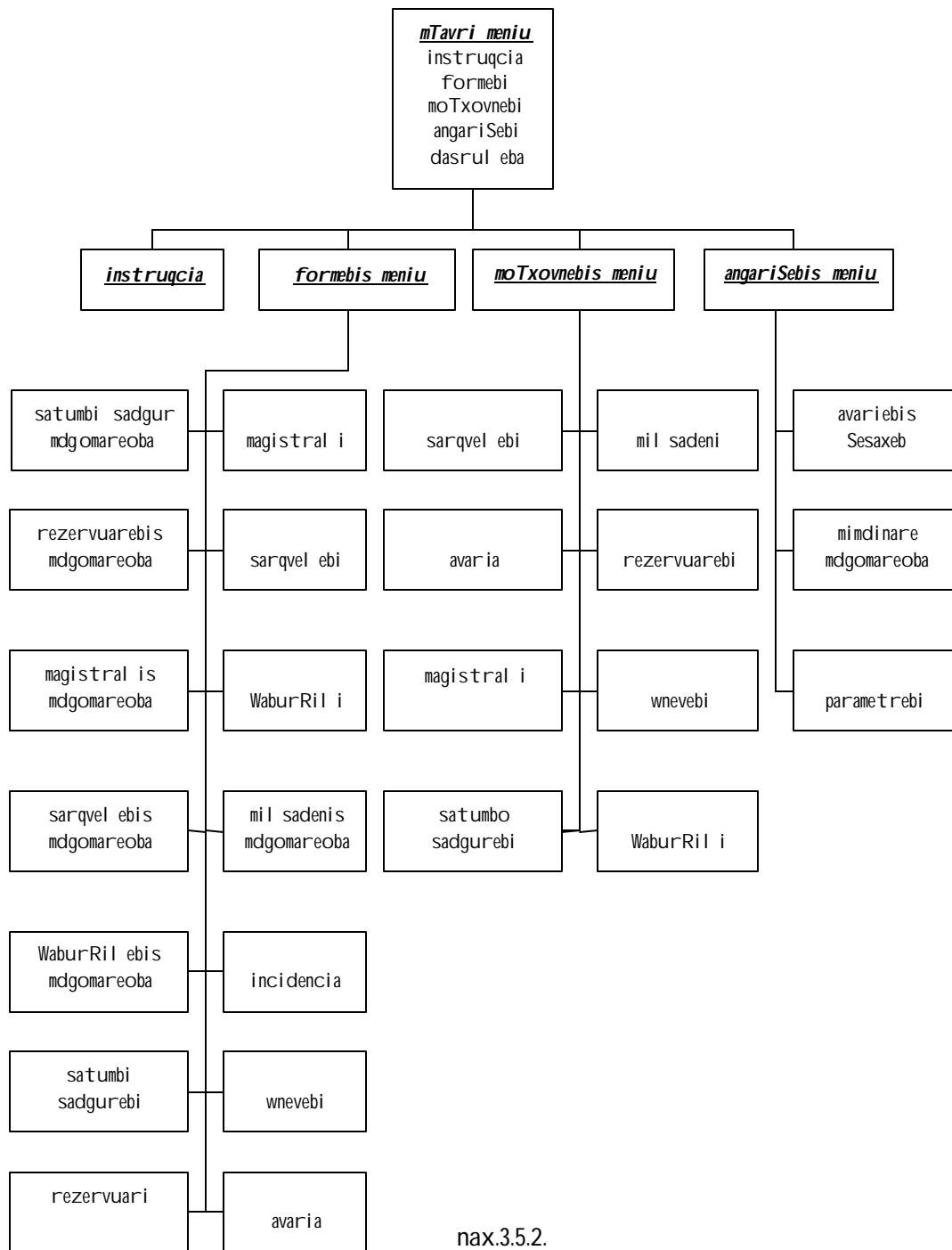
modul ebis danisnul ebis arwera:

programa daweril ia vizual ur, obiect-orientirebul programirebis enaze – Delphi, programul i modul ebis saxiT. es ena moqili i da swrafqmedia. mTavari programis saxel ia MainGeneticProgram, romel ic Sedgeba Semdegi modul ebisagan:

1. qsel is monitoringi, 2. codnis bazis freimebi, 3. genetikuri al goriTmi, 4. qsel is dekompozicia, 5. Setyobineba dispetcerisaTvis.

1. qsel is monitoringi Sedgeba procedurebi sagan:
 - axal i qromosomis formireba;
 - qromosomis fitness indeqsis gansazRvra;
 - fitness indeqsis anal izi anu fitness indeqsis Sedareba codnis bazaSi arsebul fitness indeqsebTan;
2. codnis bazis freimebi Sedgeba procedurisagan:
 - qsel Si mimidinare mdgomareobis Sesabamisi gadawyvetil ebis freimis Zebnis procedura;
3. genetikuri al goriTmi Sedgeba procedurebi sagan:
 - sawysi populaciis formireba;
 - populaciis anal izi anu sawysi populaciis gadarCeva;
 - qromosomTa dawyvill eba;
 - qromosomTa wyvill ebis krosoveri;
 - qromosomTa mutacia;
 - axal i populaciis anal izi;
 - axal iteraciaze gadasvl a an dasasrul i;
4. qsel is dekompozicia Sedgeba qveprogrami sagan:
 - xeebis axal i struqturebis generireba;
5. Setyobineba dispetcerisaTvis Sedgeba procedurisagan:
 - neironul i model is ganswvl a, romel ic moicavs mutaciis gziT qsel is dazianebl i ubnebis deteqtirebas.

marTvis sistemis interfeisis struktura.
 sistemasTan muSaobis dial oguri procedurebis strukturul i sqema
 warmodgenil ia nax.3.5.2.-ze:

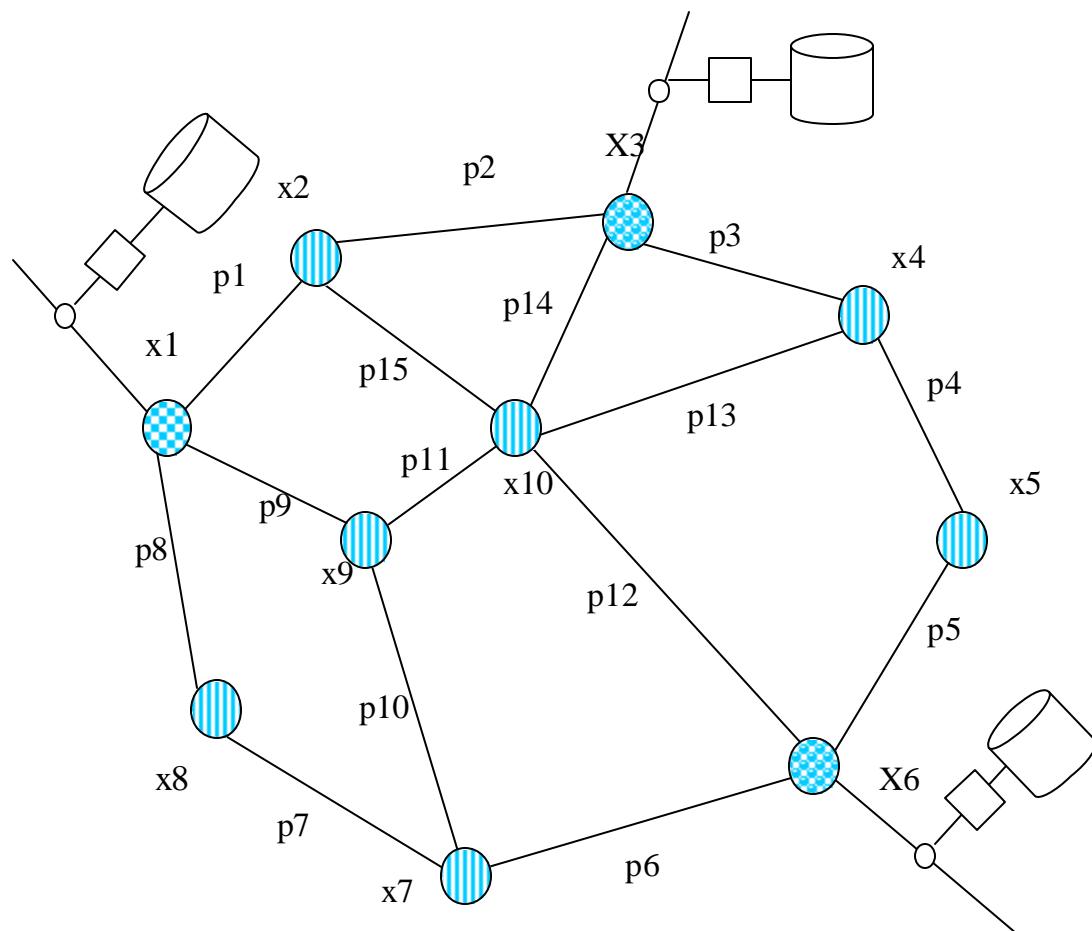


IV Tavi. materialuri nakadebis marTvis sistemis

eqsperimentul i Semowmeba

\$4.1. operatiul i marTvis imitacia

operatiul i marTvis imitaciis mizni T, magal iTisaTvis, obieqtis warmovadginoT Semdegi sqemi T, nax.4.1.1.



nax. 4.1.1.

Cvens mier warmodgeni i magal iTze, qsel i Sedgeba Semdegi obieqtebi sagan:

3-magistral i;

3-rezervuari;

3-satumbo sadguri;

18-mil sadeni (rkal i);

33-sarqvel i, romel ic ganTavsebul ia Semomaval i wyaroebis rkal ebSi da TiToeul i rkal is Tavsa da bol oSi.

sistemaSi Semaval i parametrebia:

- _ nakadebis matrica;
- _ gamtarunarianobis matrica;
- _ moTxovni l ebaTa anu datvirTvis matrica;
- _ kvanZebisa da rkal ebis incindenciis matrica;
- _ wnevebis matrica;
- _ satumbo sadgurebi;
- _ rezervuarebi;
- _ adgil obrivi hidroresursebi;
- _ sarqvel ebis matrica;
- _ dro (saaTi);
- _ Semomaval i magistral i;
- _ energiis xarjis erTeul i satumbo sadguris mier;
- _ energiis moxmareba.

gamomaval i parametrebri, romel ic dispetcers mi ewodeba rekomenadiis saxiT:

- _ sarqvel ebis mdgomareobaTa matrica;
- _ satumbo sadgurebis mier ganvi Tarebul i wnevebis matrica;
- _ avariul i situaciis Sesaxeb informacia.

konkretul moTxovna asaxavs parametrebis cvl il ebis dinamikas droSi, kerzod dReRamiS an sezonis ganmavl obaSi:

- _ moTxovna `nakadi-dro`;
- _ moTxovna `moTxovni l eba-dro`;
- _ moTxovna `wneva-dro`;
- _ moTxovna `rezervuaris donedro`;
- _ moTxovna `Semomaval i nakadi-dro`;
- _ moTxovna `adgil obrivi hidroresursi-dro`.

\$4.2. modifiцирующий генетический алгоритм Sedegebis analizi

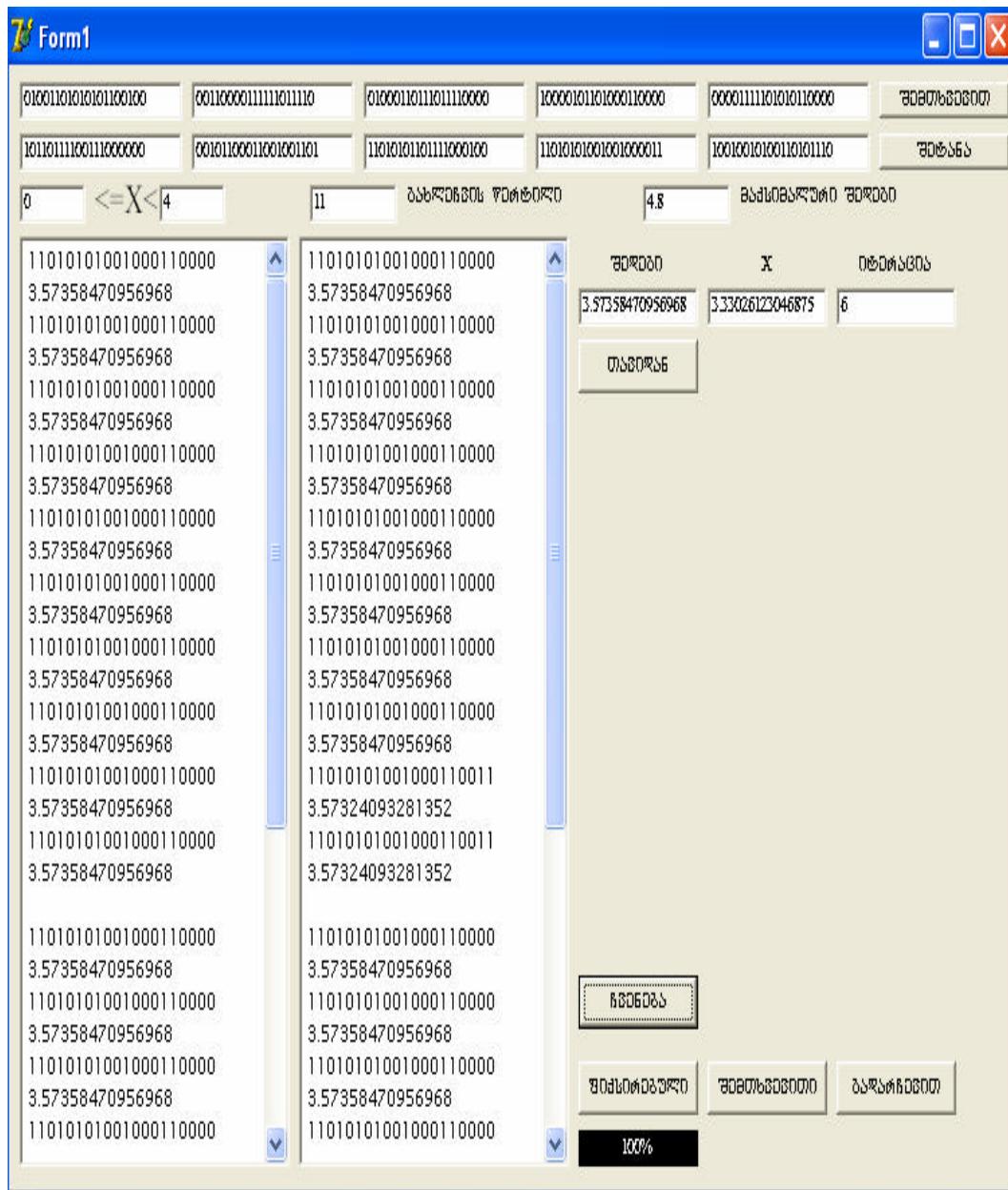
SemuSavebul i modifiцирующий генетический алгоритм Sedegebis analizi Semowmebul iqna programul ad, sxvadasxva funqciebis magal iTze. Sedarebi Ti anal izisaTvis moyvani ia erT-erTi magal iTi.

mi znobrivi funqcia: $f(x) = x + |\sin 32X|$, sadac $0 \leq X \leq 4$

programa agenerirebs sasurvel i raodenobis SemTxveviT orobiT striqonebs. magal iTisaTvis aviReT 20 Tanrigiani striqoni. CavatareT erTwertil iani krosoveri. Sedegebi davafiqsireT. amis Semdeg CavatareT amorCeviTi krosoveri, Cvens mi er SemoTavazebul i modifiцирующий генетический алгоритм Sedegebis analizi.

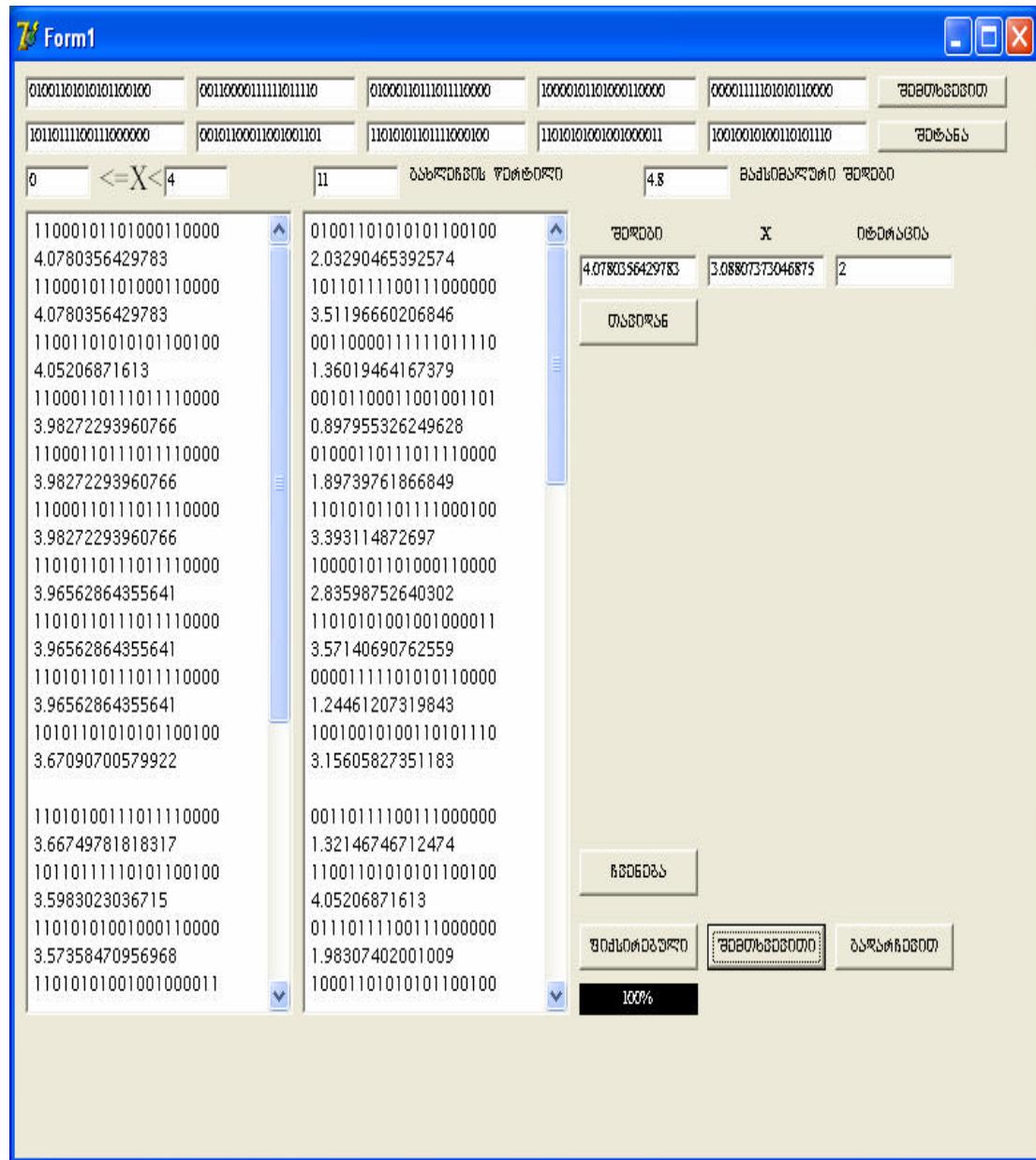
Sedegebma uCvena, rom SemTxveviTi gaxl eCvis pirobebSi optimaluri amonaxsni napovni iqna 6 iteraciaSi da amonaxsni a 3.57358. sur. 4.2.1.-ze warmodgeni ia Sedegebi, romel ic miviReT mocemul i magal iTis amoxsnis genetikuri al goriTmiT, romel Sic Catarebul ia erTwertil iani krosoveri. suraTze naCvenebia, pirobitad, bol o iteraciis Sedegebi, sadac Cans, rom amonaxsni I okal izda erT areSi, rac niSnabs, rom iteraciebis Semdgomi gagrZel eba amonaxsnis cvl il ebias aRar gamoiwevs. faqturad miRebul ia optimaluri amonaxsnis are, anu Cvens SemTxvevaSi napovnia maqsimaluri amonaxsni.

SemTxvevi Ti gaxl eCvis pirobebSi optimal uri amonaxsnis povni s programul i fanj ara:



sur.4.2.1.

modificirebul i genetikuri al goritmis SemTxvevaSi e.i. cikluri gadarçeviš gaxl ečviš dros 2 an maqsimum 3 i teraciaSi mi vi ReT Sedegi, romel ic udris 4.07803, rac gacil ebi T mi axl oebul ia optimal urTan. programul i Sedegebi načvenebia sur 4.2.2.-ze.



sur.4.2.2.

\$4.3. nakadebis ganawill ebis Sedegebis anal izi

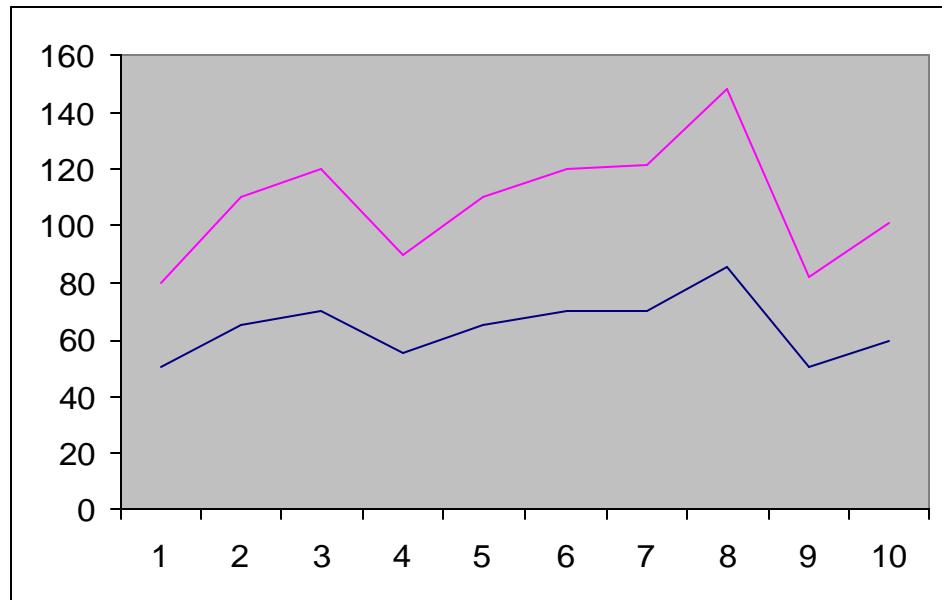
nakadebis ganawill eba Semowmebul iqna programul ad, erTi wyarosa da misi ganStoebebis magal iTze. programmaSi Semaval i monacemebia: wyarodan Semosul i nakadi; qsel is ganStoebebSi minimaluri moTxovnebi da moTxovnebi drois mocemul i momentisaTvis. programis Sesrul ebis Sedegia ganawill ebul i nakadebi. nakadebis Semaval i da gamomaval i parametrebis mni Svnel obebi mocemul ia cxril Si(cxr.4.3.1):

wyarodan Semosul i nakadi 445			
ganStoebebi	min. moTxovna	moTxovna t momentSi	ganawill ebul i nakadebi
p1	20	50	30
p2	30	65	45
p3	40	70	50
p4	25	55	35
p5	35	65	45
p6	45	70	50
p7	55	70	52
p8	60	85	63
p9	35	50	32
p10	45	60	41

cxr. 4.3.1.

sur.4.3.1.-ze gamosaxul ia ganStoebebSi drois mocemul t momentSi moTxovnaTa da ganawi l ebul i nakadebi s diagramebi .

ganStoebebi xasi aTdebi an gansxvavebul i SezRudvebi T. programa SezRudvaTa gaTval i swi nebi T kvanZSi Semosul nakads anawi l ebs moTxovnaTa kriteriumi s Sesabami sad.



sur.4.3.1.
rogorc diagramidan Cans ganawi l ebul i nakadi mi axl oebul ia drois t momentSi moTxovnasTan.

daskvna

Catarebul i Teoriul i da eqsperimentul i gamokvl evebis safuZvel ze SeiZI eba gavakeToT Semdegi daskvna:

1. damuSavebul ia material uri nakadebis optimal uri ganawil ebis model i modifificirebul i genetikuri al goriTmis gamoyenebiT;
2. dasmul ia deficitis, aseve avariul i rejimis problema da SemoTavazebul ia misi gadawyvetis optimal uri varianti. am mizniT damuSavebul ia qsel is dinamiur xeebad dekompoziciis al goriTmi;
3. sistemis operatiul i marTvis Tval sazrisiT damuSavebul ia intel eqtual uri al goriTmebi, kerZod konkretul i situaciis operatiul i identifikasiis mizniT damuSavebul ia xel ovnuri neironul i qsel ebis model i, xol o gadawyvetil ebis miRebis operatiul obis Tval sazrisiT - codnis wamodgenis freimul i model i;
4. damuSavebul ia material uri nakadebis operatiul i marTvis sistemis informaciul i da programul i uzrunvel yofa MS SQL Server, MS Access, obieqt-orientirebul i sistemebis bazaze;
5. wamodgenil ia nakadebis marTvis programul i Sedegebis analizi.

nakadebis marTvis sistemi interfisi

formebis maketebs aqvT Semdegi saxe:

<p>ავარია</p> <p>ავარიას ქოდი <input type="text"/></p> <p>თარიღი <input type="text"/> სახით <input type="text"/></p> <p>მდგრადის ქოდი <input type="dropdown"/></p> <p>ავარიას სახელი <input type="dropdown"/></p> <p style="text-align: center;">მართვა</p>	<p>მიზანი</p> <p>მიზანის ქოდი <input type="text"/></p> <p>კატეგორიას ქოდი <input type="dropdown"/></p> <p>მდგრადის ქოდი <input type="dropdown"/></p> <p>შეკრიფტის აღნიშვნა <input type="checkbox"/></p> <p style="text-align: center;">მართვა</p>
Record: [◀] [◀] [1] [▶] [▶] [*] [X] [!] of 1	

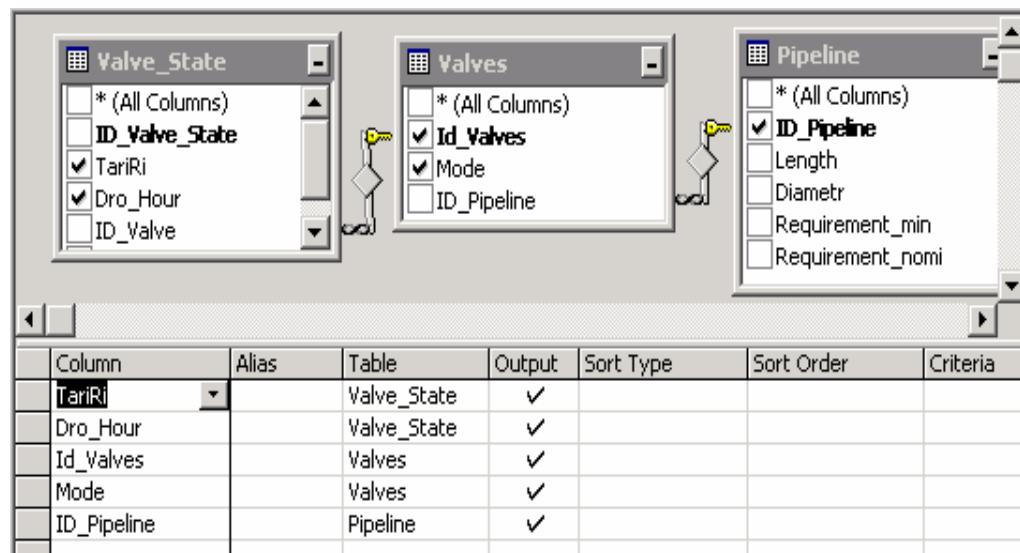
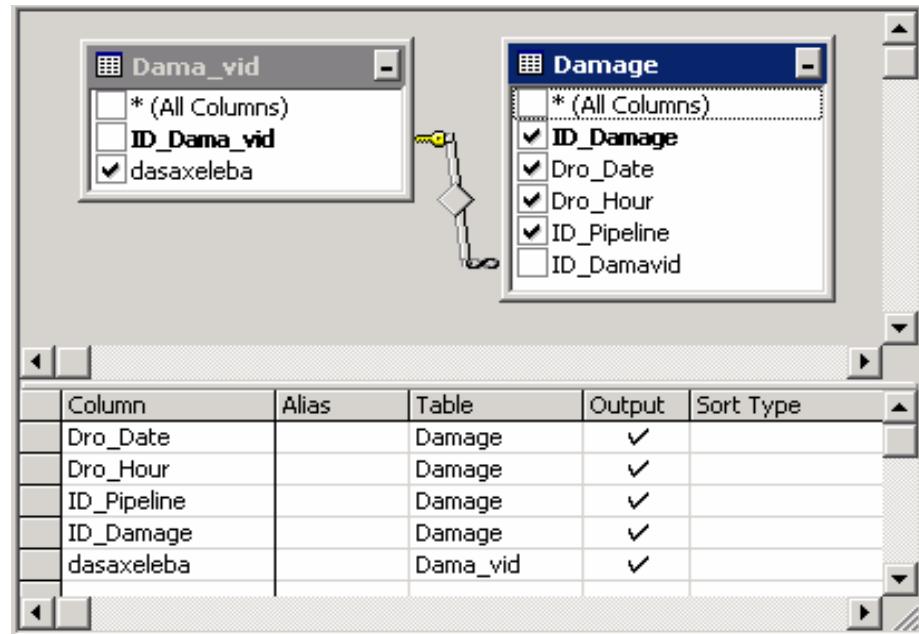
<p>უნიტა</p> <p>უნიტას ანთელი <input type="text"/></p> <p>თარიღი <input type="text"/> სახით <input type="text"/></p> <p>სამუშაოს ქოდი <input type="dropdown"/></p> <p>უნიტა <input type="text"/></p> <p style="text-align: center;">მართვა</p>	<p>მიზანის მდგრადის ანთელი</p> <p>მდგრადის მდგრადის ანთელი <input type="text"/></p> <p>თარიღი <input type="text"/> სახით <input type="text"/></p> <p>მდგრადის ქოდი <input type="dropdown"/></p> <p>უნიტა <input type="text"/></p> <p>ნაფაღი <input type="text"/></p> <p>მიზანის მდგრადის ანთელი <input type="text"/></p> <p style="text-align: center;">მართვა</p>
Record: [◀] [◀] [1] [▶] [▶] [*] [X] [!] of 1	

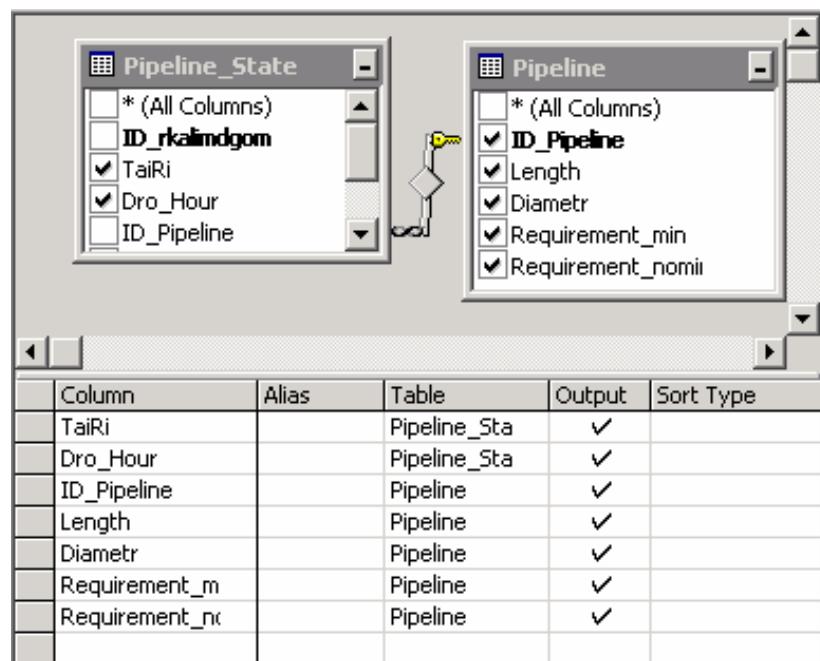
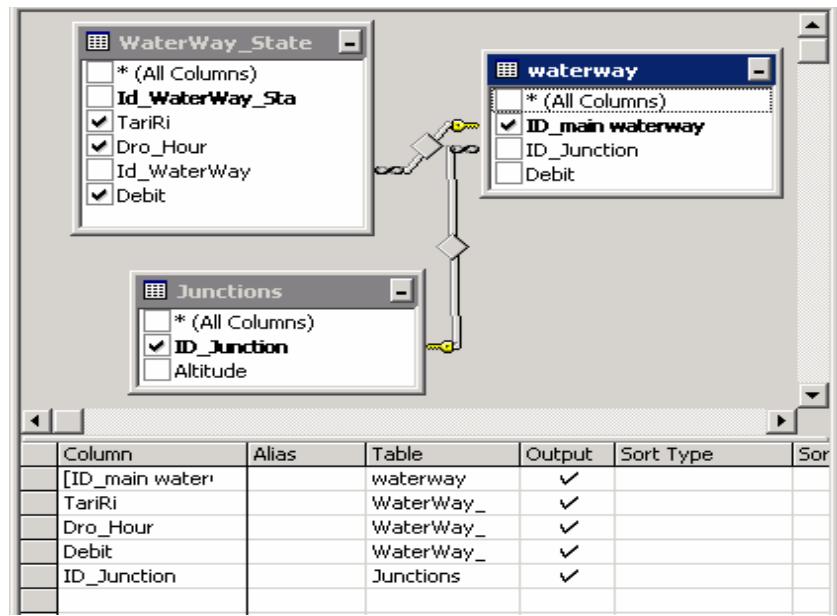
<p>სატექნიკო დანართი</p> <p>სატექნიკო დანართის ქოდი <input type="text"/></p> <p>კომპიუტერის რეიტინგი <input type="text"/></p> <p>ხდება <input type="text"/></p> <p>დანართი <input type="dropdown"/></p> <p style="text-align: center;">მართვა</p>	<p>სატექნიკო დანართის მდგრადი</p> <p>სატექნიკო დანართის მდგრადის ანთელი <input type="text"/></p> <p>თარიღი <input type="text"/> სახით <input type="text"/></p> <p>სატექნიკო დანართის ქოდი <input type="dropdown"/></p> <p>ხდება <input type="text"/></p> <p style="text-align: center;">მართვა</p>
Record: [◀] [◀] [1] [▶] [▶] [*] [X] [!] of 1	

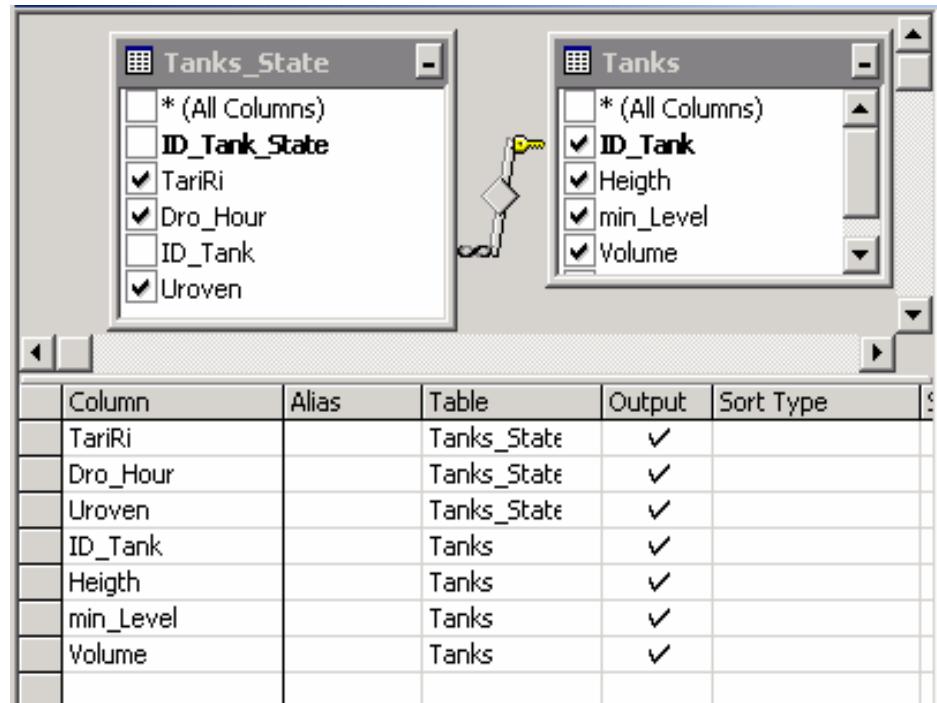
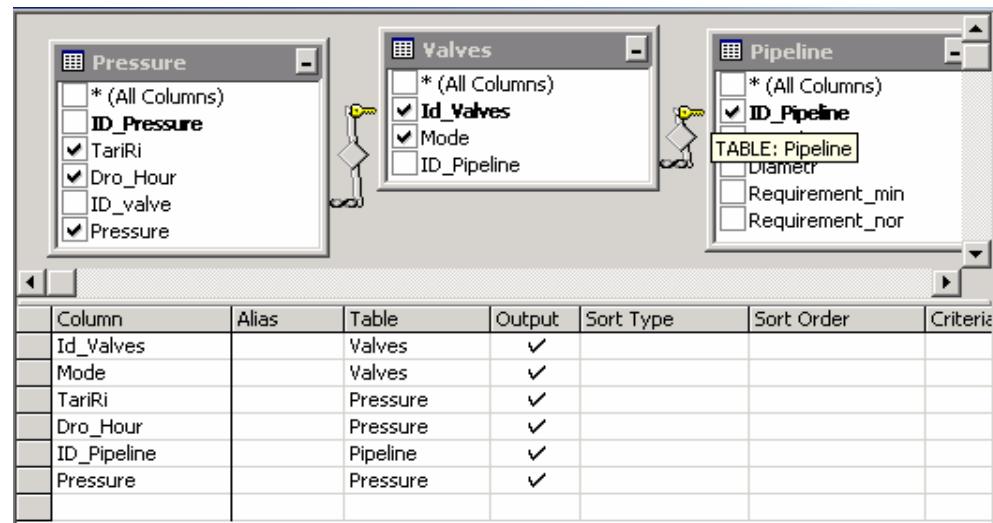
କେନ୍ଦ୍ରିତ ପାଇଁ	
କେନ୍ଦ୍ରିତ ପାଇଁ ପ୍ରକାଶ ପାଇଁ	<input type="text"/>
ବୋଲିଙ୍ଗ୍	<input type="text"/>
ମହାନୀତିକୁଳ ଅଳ୍ପ	<input type="text"/>
ମୋଟାଫଳ	<input type="text"/>
ବାତିକଣୀ ବୋଲିଙ୍ଗ୍	<input type="text"/>
ବୋଲିଙ୍ଗ୍ ପାଇଁ	
ବୋଲିଙ୍ଗ୍ ପାଇଁ ମୋଟାଫଳ	<input type="text"/>
ବାତିକଣୀ ବୋଲିଙ୍ଗ୍	<input type="text"/>
ବୋଲିଙ୍ଗ୍ ପାଇଁ ମୋଟାଫଳ	<input type="text"/>
ବୋଲିଙ୍ଗ୍ ପାଇଁ ମୋଟାଫଳ	<input type="checkbox"/>
ବୋଲିଙ୍ଗ୍ ପାଇଁ	

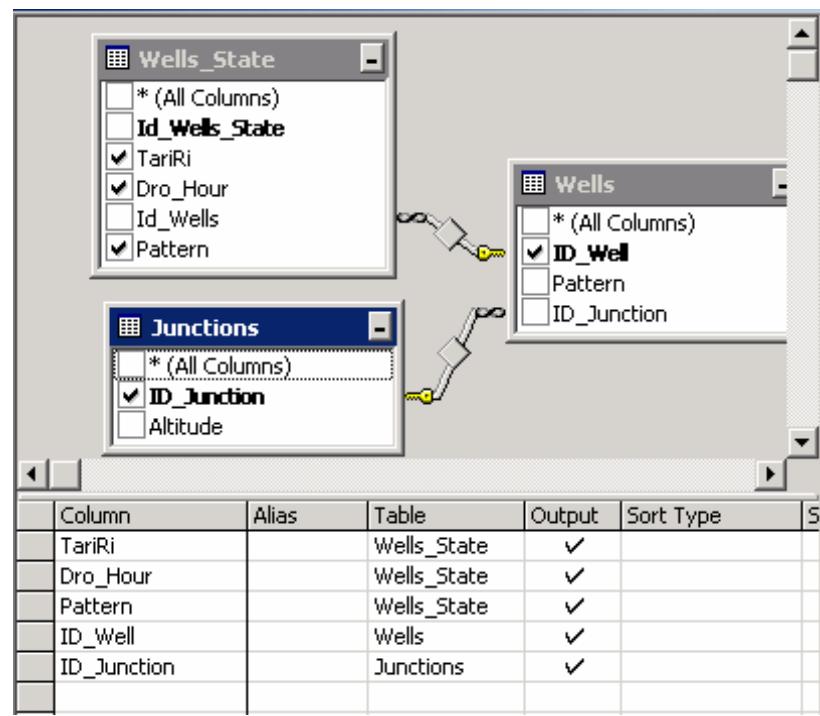
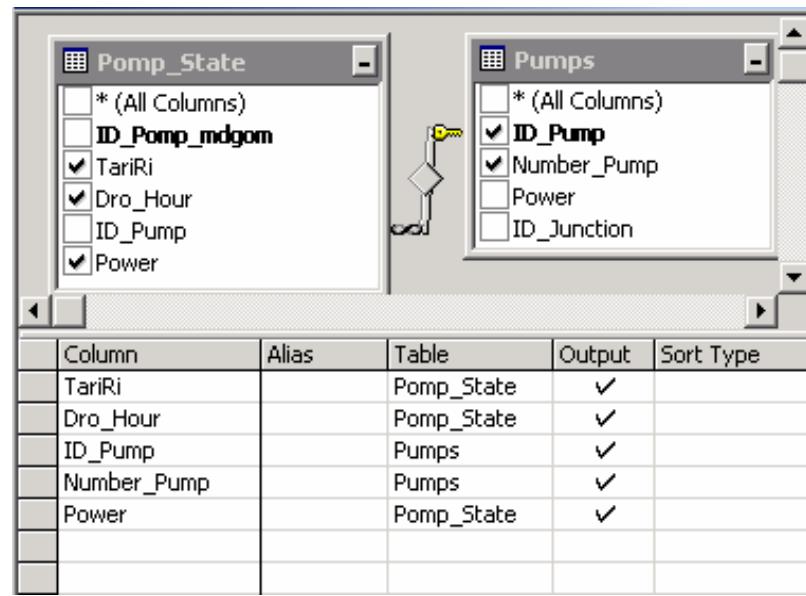
ଶାଖାନ୍ତରମୂଲକ ଅଧିକାରୀଙ୍କ ବିବରଣୀ	
ପ୍ରଦେଶିକୀୟ ପରିଷଦ କମିଶନରେ କମିଶନରୁ କମିଶନରୁ କମିଶନରୁ କମିଶନରୁ	<input type="text"/>
ନାମରେ ପରିଷଦ କମିଶନରୁ କମିଶନରୁ କମିଶନରୁ କମିଶନରୁ	<input type="text"/>
ପ୍ରଦେଶିକୀୟ ପରିଷଦ କମିଶନରୁ କମିଶନରୁ କମିଶନରୁ କମିଶନରୁ	<input type="text"/>
ପ୍ରଦେଶିକୀୟ ପରିଷଦ କମିଶନରୁ କମିଶନରୁ କମିଶନରୁ କମିଶନରୁ	<input type="text"/>
ବିବରଣୀରେ ବିବରଣୀରେ	
ବିବରଣୀରେ ବିବରଣୀରେ କମିଶନରୁ କମିଶନରୁ	<input type="text"/>
ବିବରଣୀରେ ବିବରଣୀରେ କମିଶନରୁ କମିଶନରୁ	<input type="checkbox"/>
ବିବରଣୀରେ ବିବରଣୀରେ କମିଶନରୁ କମିଶନରୁ	<input type="text"/>
ବିବରଣୀରେ ବିବରଣୀରେ	

მოTxovnebis maketebs aqvT Semdegi saxe:









angari Sebis maketebi:

avaria

TariRi	dro (sT)	mil sadenis kodi	dazianebis dasaxel eba

mimdinare mdgomareoba

TriRi	dro (sT)	sarqvel is kodi	diafragma	wneva

parametrebi

TariRi	dro (sT)	satumbo sadguris kodi	simzi av re	rezerv. kodi	done	magistr. kodi	magistr. debeti	Wabur kodi	Wabur debeti

gamoyenebul i literaturis nusxa

1. CogovaZe g., gogiCaiSvil i. g., surgul aZe g., Serozia T., Sonia o., marTvis avtomatizebul i sistemebis daproqteba da ageba, teqnikuri universiteti, Tbilisi 2001, 742 gv.
2. janeliZe g., mefariSvil i b., maval eqstremaluri optimizaciis evoluciuri al goriTmi, samecniero Jurnal i `intel eqti~ #1(24), Tbilisi, 2006. gv. 119-122.
3. janeliZe g., mefariSvil i b., xixaZe g., qsel Si materialuri nakadebis marTva, samecniero Jurnal i `intel eqti~ #1(24), Tbilisi, 2006. gv. 122-124.
4. janeliZe g., qal aqis wyal momaragebis operatiul i marTvis al goriTmi, stu Sromebi, marTvis avtomatizebul i sistemebi #1, Tbilisi 2006. gv. 54-56
5. janeliZe g., qal aqis wyal momaragebis maTematikuri model ebi, stu Sromebi, marTvis avtomatizebul i sistemebi #1, Tbilisi 2006. gv. 56-61.
6. janeliZe g., mefariSvil i b., codnis warmodgenis adapturi al goriTmi nakadebis marTvaSi, stu Sromebi, marTvis avtomatizebul i sistemebi #1, Tbilisi 2006. gv. 98-101.
7. janeliZe g., mefariSvil i b., mefariSvil i T., qsel is marTvis procesis al goriTmebi, stu Sromebi, marTvis avtomatizebul i sistemebi #1(2), Tbilisi 2007. gv. 78-82.
8. jibl aZe n., TofCiSvil i a., statikuri optimizaciis ricxviTi meTodebi, Tbilisi, 2001.
9. ??????? ???? ?, ? ?????????? ?, ? ?????????? ?, ? ??????? ?????????????? ????, ? ?????????? ?????????? , Georgian Engineering NEWS, ? 2, ???????, 2006, .211-213.
10. ?????? ?, ? ?????????? ?, ? ??????? ? ? ?????????? ? ? ?????? ??????????-? .:???, 1981. 368 ?.
11. ????. ??. , ? ???? ??????????: ? 2-?. ?. 2. ? ???? ?????????????? ??????. ?????. ?????? ??? ?????-? .: ? ?????, 1979.- 584?.
12. ? ???? ???? ??. . ?????????? ?????????? ?????? ?????? ??????. ? ???? ??????, ? 5,1986, ?. 50-58.

13. ?????, ?. ???, ?????? ?. ??????. ?????????? ?????????????? ?????? ? ?????? ????. ?????? ?????? ??????. ? ???? ??????, ? 8,1991, ?. 34-41.
14. ?????? ?. ? ????? ??????? ??????????????????????. ? ????. ?????, ? 3, 1991, ?. 12-15.
15. ?????? ?. ?????????????????? ??????. ? ????. ?????, ? 12,1991, ?.34-35.
16. ?????? .????????? ?????? ??????. ? ., ????? ? ?????,1987,?.152-165.
17. ??. ?. ?????????????? ??????????, ? .. ? ?, 1978. 558 ?.
18. ?????????? ?.?, ?????? ?.?, ?????? ?.?, ?????? ?????? -????? ??? ? ??? ? ??????????????, ??????, 1989.
19. ? ?????? ? ?????? ?. ? ?????????? ??????. ? ????. ?????, ? 7,1987,?.32-41.
20. Anuja R.K., Magnanti TL., Orlin J.B. (1993).- Network Flows: Theory, Algorithms and Applications Prentice Hall.
21. Au, Wai-Ho, Keith Chan, and Xin Yao. "A novel evolutionary data mining algorithm with applications to churn prediction." *IEEE Transactions on Evolutionary Computation*, vol.7, no.6, p.532-545 (December 2003).
22. Artificial Neural Networks: Concepts and Theory, IEEE Computer Society Press, 1992.
23. Beasley, J.E., J. Sonander and P. Havelock. "Scheduling aircraft landings at London Heathrow using a population heuristic." *Journal of the Operational Research Society*, vol.52, no.5, p.483-493 (May 2001).
24. Forsyth. R. "Expert Systems". Polytechnic of North London. 1987.
25. Gardner M.R. and Ashby W.R., *Connectance of large dynamic (cybernetic) systems* Nature, 228, 1970, p.784.
26. Goldberg D.E. (1989).- Genetic Algorithms in Search Optimization and Machine Learning, Addison Wesley, Reading, Mass.
27. Goldberg A.V., Tarjan R.E. (1989).- Finding Minimum Cost Circulations by Cancelling Negative Cycles, Journal A.C.M. 36,pp. 873-886.
28. Holland J. (1975).- Adaption in Natural and Artificial Systems, University of Michigan Press Ann. Arbor, USA.

29. Hinton, Williams, Learning internal representations by error propagation, 1986.
30. Kauffman S.A. *Metabolic stability and epigenesis in randomly constructed genetic sets* Journal of Theoretical Biology, 22, 1969, pp. 437-467.
31. Kleiner Y., Adams B., Rogers J. Water Distribution Network Renewal Planning. *Journal of Computing in Civil Engineering*, No 1, pp. 15-26, 2001
32. Minsky M. L. A framework for representing knowledge. In: The Psychology of Computer visin, McGraw_Hill, New York, pp. 34-57, 1974.
33. Miles S.B. Optimal Water Distribution Management, *Journal of Computing in Civil Engineering* ASCE, No. 3, Ca 1999;
34. Tarjan, R, “Depth-First Search and Linear Graph Algorithms,” SIAMJ. Comput., 1:146-160 (1982)(IM).
35. The Optimatics Letter, Optimization for Water Distribution System Design & Operations, Issue No. 1: Juli – September 1998.
36. www.nowhere.edu ukanasknel ad iqna gadamowmebul i 15.01.2008.
37. www.ascent.com ukanasknel ad iqna gadamowmebul i 22.01.2008.