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Suboptimal Solution of the Problem for Non-Conflict Scheduling in Radio Networks*

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Introduction

The problem of non-conflict scheduling in radio networks has always been actual, since it determines the quality of the messages and the cycle of the radio network. The smaller time slots define a smaller cycle of the radio networks, which influences positively the time fди messages delivery.

A suboptimal solution of the problem for non-conflict scheduling is suggested in the paper. The solution is suboptimal, because some repetitions are obtained as a result of it, i.e., some of the nodes are represented in more than one time slot, which is a solution of the problem with redundancy. It is important to note that in order to have a non-conflict scheduling, neighbouring nodes should not be present in one and the same time slot.

Fig. 1 shows the matrix of connections for a n-nodes radio network. Xij=1 if there is a connection between the nodes Vi and Vj and it is 0 respectively for connection absence. The matrix is quadratic and symmetric with respect to the main diagonal.

	$V1$	$V2$	$V3$	$V4$.........	Vi..........	Vn
$V1$	$X11$	$X12$	$X13$	$X14$	$X1i$	$X1n$
$V2$	$X21$	$X22$	$X23$	$X24$	$X2i$	$X2n$
$V3$	$X31$	$X32$	$X33$	$X34$	$X3i$	$X3n$
$V4$	$X41$	$X42$	$X43$	$X44$	$X4i$	$X4n$
Vi	$Xi1$	$Xi2$	$Xi3$	$Xi4$	Xii	Xin
…						
…						
…						
…						
Vn	$Xn1$	$Xn2$	$Xn3$	$Xn4$	Xni	Xnn

Fig. 1

We form the sums Zi for i=1, ..., n according to the following formula:

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$$Zi = \sum Xij \text{ for } j = 1 \text{ upto } n \quad (1)$$

Zimax is determined which corresponds to node Vi with the maximum number of neighbouring nodes. We define also the next in extent sum Zk, corresponding to the next in neighbouring nodes number node Vk. The third sum is denoted by Zm.

Si denotes the vector $Xi1$, $Xi2$, ...Xii....Xin and Ni – the vector $\tilde{X}i1$, $\tilde{X}i2$....$\tilde{X}ii$.....$\tilde{X}in$, i.e. $Ni = \bar{S}i$ for i=1 upto n.

The set of neighbouring nodes of Vi – (Msi) is defined by a rank conjunction of the vector $V1\,V2$........Vi............Vn with vector Si and by a rank conjunction of the set of non-neighbouring nodes of Vi – (Mni) with vector Ni. We proceed in the same way with the next in neighbouring nodes number Vk, obtaining the sets Msk and Mnk respectively.

Formation of a suboptimal non-conflict scheduling

When forming a suboptimal scheduling, the following is done:

1. Node Vi is that, for which Zi=max, then the neighbours of Vi are represented in the slot P1, Vi being absent at that. The cancelling procedure of the neighbouring nodes in P1 is important. A strategy is chosen to cancel the nodes with the smaller numbers.

Xii is replaced by zero in the vector corresponding to node Vi, because Vi is not included in P1. The so called vector of the neighbours of V1, candidates for representation in P1 – $Xi1 \wedge V1$, $Xi2 \wedge V2$, $Xi3 \wedge V3$ ...$Xin \wedge Vn$, is obtained by a rank conjunction between the vector thus obtained and $V1\,V2$....Vi....Vn. The cancelling of the neighbouring nodes, candidates for P1 is executed with this vector in the following way:

The vector of the node with the smallest number among the neighbouring to Vi nodes is taken from the matrix of connections, for example Vq and it is subjected to rank conjunction with the vector of neighbours Vi, candidates for P1 and in case the result vector contains Vq only, it obviously remains in the slot, but if it contains two or more nodes, Vq is cancelled in P1, writing null at its place in the vector of neighbours of Vi. The same is done with the next in number node among the neighbours of Vi and thus all the candidates for P1 are depleted. As a result of the cancelling of the nodes with smaller numbers in the set of neighbours of Vi, only those remain in the candidates vector at last, that are represented in P1 as Vi and the cancelled from P1 go to the field obligatory absent of P1.

2. Vi is represented in P2, and the cancelled from P1 nodes – in P3.

3. In the slot P4 the neighbours of the second in neighbours number node Vk are represented, Vk being absent in it. The procedure of cancelling the neighbouring nodes in P4 is the same as in p.1, i.e, the ones with the smaller number are cancelled.

4. Vk is represented in P5, the cancelled from P4 nodes – in P6.

5. In the slot P7 the neighbours of the third in neighbours number node Vm is represented, Vm being absent in it. The procedure of cancelling the neighbouring nodes in P7 is the same as in p.1, i.e, the ones with the smaller number are cancelled.

6. Vm is represented in P8, and the cancelled from P7 nodes – in P9.

7. From the set of the nodes not distributed in the time slots, the node with the largest number is selected and it is checked in which time slots it can be represented starting from P1. The fact should be noted that the addition of a new node to a given time slot causes a change in the field obligatory absent in this slot. This iteration continues until the last one, i.e., the node with the smallest number. It is possible some nodes to remain undistributed in the slots thus defined.

8. If undistributed nodes are available, new time slots are added until the depletion of all the nodes in the networkwork. It is evident, that the process is always convergent.

It is important to note that the fields obligatory absent nodes for a given slot from the so called suboptimal solution of the scheduling are formed from the sets Msi for each one of the represented nodes in the slot at a given stage of the sheduling formation. This circumstance is particularly important in the distribution of the undistributed nodes, described in p. 7.

The suboptimal solution of the problem with non-conflict sheduling in radio networks is illustrated by an example for a 22-nodes radio networkwork.

Fig. 2 shows such a 22-nodes radio network.

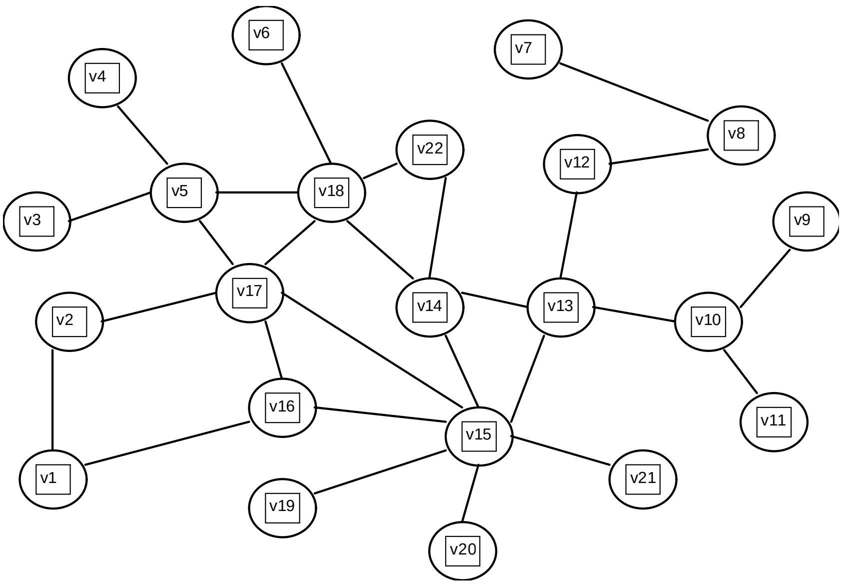

Fig. 2

The connection matrix is given in Fig. 3.

1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1

Fig.3

$Z1=3$, $Z2=3$, $Z3=2$, $Z4=2$, $Z5=5$, $Z6=2$, $Z7=2$, $Z8=3$, $Z9=2$, $Z10=4$, $Z11=2$, $Z12=3$, $Z13=5$, $Z14=5$, $Z15=8$, $Z16=4$, $Z17=6$, $Z18=6$, $Z19=2$, $Z20=2$, $Z21=2$, $Z22=3$.

Hence $Zi=Z15=8$, $Zk=Z17=6$ and $Zm=Z18=6$.

The primary form of the time table is given in Table 1.

Table 1

Slot	Nodes represented	Obligatory absent
P1	V14,V17,V19,V20,V21	V15,V13,V16
P2	V15	V13,V14,V16,V17,V19,V20V21
P3	V13, V16	V14,V17,V15
P4	V2,V16,V18	V17, V5, V15
P5	V17	V2,V5,V15,V16,V18
P6	V5,V15	V3,V4,V17,V18,V13,V14,V16,V17,V19,V20,V21
P7	V6,V17,V22	V18, V5, V14
P8	V18	V5,V6,V14,V17,V22
P9	V5,V14	V3,V4,V17,V18,V13,V15,V18,V22

V1, V3, V4, V7, V8, V9, V10, V11, V12 have remained undistributed. The distribution starts from V12 and P1. It can be represented in this slot, for it is absent in the field "obligatory absent". We do the same with the rest of the undistributed nodes.

The suboptimal form of the non-conflict scheduling is given in Table 2.

Table 2

Slot	Nodes represented	Obligatory absent
P1	V14,V17,V19,V20,V21, V12, V11,V9, V7,V4, V3, V1	V15, V13,V16, V8, V13, V10, V10, V5, V5, V2
P2	V15, V10,V8	V13,V14,V17,V19,V20,V21,V9,V11, V13, V7,V12
P3	V13, V16	V14,V17,V15
P4	V2,V5,V15,V16,V18	V17
P5	V17	V2,V5,V15,V16,V18
P6	V5,V15	V3,V4,V17,V18,V13,V14,V16, V17,V19,V20,V21
P7	V5,V6,V14,V17,V22	V18
P8	V18	V5,V6,V14,V17,V22
P9	V5,V14	V3,V4,V17,V18,V13,V15,V18,V22

It can be easily seen that the non-conflict scheduling thus obtained is suboptimal– one and the same node is represented into several slots (for example V15 is represented in three time slots – P2, P4 and P6).

After the application of an optimizing strategy of the type one-fold representation of every node, the non-conflict scheduling gets the form in Table 3.

Table 3

Slot	Nodes represented	Obligatory absent
P1	V19,V20,V21,V12, V11,V9, V7,V4, V3, V1	V15,V13,V16, V8, V13, V10, V10, V8, V5, V5, V2
P2	V10,V8	V9,V11,V13, V7,V12
P3	V13, V16	V14,V17,V15
P4	V2	V17

Table 3 (continued)

P5	V17	V2,V5,V15,V16,V18
P6	V15	V17,V13,V14,V16,V17, V19,V20,V21
P7	V6,V17,V22	V18
P8	V18	V5,V6,V14,V17,V22
P9	V5,V14	V3,V4,V17,V18,V13,V15,V18,V22

Suboptimal non-conflict scheduling in using a topologic decomposition

It is possible to do topologic decomposition of a given radio network with the purpose to achieve more easily a suboptimal non-conflict scheduling. Partial non-conflict scheduling is defined for each part in the decomposition, and the schedules thus obtained are united in non-conflict scheduling of the networkwork, which is suboptimal. There exists direct proportional correlation between the number of the time slots and the number of the network parts obtained after the decomposition. In the decomposition some nodes are cancelled, which facilitates the obtaining of the suboptimal partial non-conflict schedules. It is important to note that the loss of nodes does not lead to conflicts, since the nodes from the broken connections enter different time slots.

Fig. 4 shows an example decomposition of the 22-nodes network from Fig. 3, and Table 4 – the suboptimal non-conflict scheduling for it. The comparison between the schedules from Table 3 and Table 4 is profitable for the decomposition method.

Table 4

Slot	Nodes represented	Obligatory absent
P1	V3, V4, V18, V2	V5, V1, V17, V6
P2	V5, V6	V3, V4,V17, V18
P3	V14, V16, V19, V20, V21	V13, V15
P4	V15	V13, V14, V16, V19, V20, V21
P5	V13, V22	V14, V15, V14
P6	V8, V10	V7, V12, V9, V11
P7	V7, V12, V9, V11	V8, V10

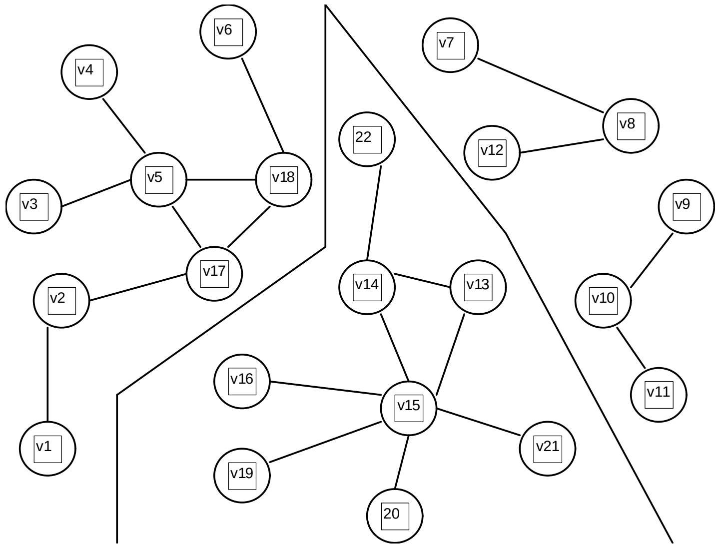

Fig. 4

Conclusion

The comparison between the suboptimal schedules of one and the same 22-nodes networkwork shows that the use of topological decomposition of the network leads to non-conflict scheduling with smaller number of the slots. The advantage of the suboptimal solution of the problem of non-conflict sheduling in radio networks is that it is always convergent, and the application of topological decomposition facilitates the obtaining of non-conflict sheduling for networks with a large number of nodes.

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Субоптимальное решение проблемма бесконфликтного расписания в радиосетях

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(Резюме)

Предлагается субоптимальное решение получения бесконфликтного расписания в радиосетях при помощи нахождения трех из узлов радиосети, имеющих наибольшее число соседных узлов и их представления в отдельных моментах времени в расписании. Топологическая декомпозиция применяется в радиосетях с большим числом узлов и сложная матрица связей. Приводится пример с радиосети с двадцати двумя узлами. Сделано сравнение между бесконфликтными расписаниями, полученные с или без топологической декомпозиции сети.