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Using Quorum for Solving Channel Allocation Problem

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Abstract: The bandwidth allocated for a cellular wireless network is crucial and has to be used efficiently for better performance. To improve the utilization of channels, the channels need to be allocated to various cells in a dynamic way. The dynamic channel allocation schemes can be classifieds in to centralized schemes and distributed schemes. The centralized channel schemes are not reliable not scalable. The fault tolerance is more significant in case of cellular networks due to mobility, poor quality of links and other constraints. Additionally, most of the existing channel allocation algorithms which are fault tolerant have been designed in a way so that these can be used with hexagonal cells, therefore, for the reuse distance of one cell only. Hence, in this exposition, we proposed a quorum based algorithm to solve channel allocation system. We also proposed a new quorum system named as cellular quorum system specifically designed for channel allocation.

Keywords: Resource allocation, Quorum System, Reuse Distance, Base Station, Fault Tolerance

I. INTRODUCTION

The bandwidth is considered as a scarce resource in cellular wireless networks whereas the number of users is increasing rapidly; hence, the frequency channels available have to be used effectively to ensure quality of service. If the distance between two cells is such that there will not be any interference between two cells, a frequency channel can be reused,. The minimum channel reuse distance can be defined as the minimum distance which should exist between any two cells so that these cells may simultaneously use the same channel.

The channel allocation schemes in wireless cellular networks can be classified in to distributed schemes and centralized schemes [1]. But, the major drawback of centralized schemes is single point of failure due to which these lack of scalability. The distributed schemes can be further classified in to static schemes, dynamic schemes, and hybrid schemes [2].

In case of static schemes, the channels are allocated statically to every cell. Despite being simple, these schemes shows a poor performance in case the call distribution is not uniform. Hence, dynamic channel allocation schemes were proposed to solve the problem of non-uniform distribution of calls. Dynamic channel allocation schemes allow that any channel can be used by any cell. Hybrid channel allocation schemes are a combination of dynamic and static channel allocation schemes. In these, few channels are statically allocated to cells and other channels are used for dynamic sharing.

The dynamic channel allocation schemes are further classified in to update based and search based schemes [1]. In case of search based schemes, a base station requires a channel it searches all of its neighboring cells for computing the set of presently available channels. However, In update based schemes, each base station has to maintain a set of channels which are available. Each cell sends message to its neighbors on acquiring and releasing a particular channel and the neighbors of the channel update their respective sets accordingly on receiving this information. The time required by search algorithms is consumed more in selecting a channel for setting up a call. However,, the number of messages required is much higher in case of update based schemes in comparison to search based schemes. Moreover, these messages will also use channel(s) for the communication.

In the present exposition, we present a channel allocation scheme for cellular wireless networks using search based technique. The scheme is able to handle faults because it can tolerate message failure and link failure. The rest of the paper is organized as follows. The related work and the system model have been discussed in section 2 and section 3 respectively. The cellular quorum system has been discussed in section 4. The channel allocation algorithm and its correctness have been presented in Section 5 and section 6 respectively. The fault tolerant capabilities of the proposed quorum system have been shown in section 7. Section 8 finally concludes the paper and discusses future work.

II. RELATED WORK

Over the years, several channel allocation algorithms have been presented by the researchers. But in this section, only dynamic channel allocation algorithms will be discussed which are generally fault tolerant in nature. The first fault-tolerant channel allocation algorithm was proposed by Prkash-Shivartri-Singhal [3] in 1999. Prakash-Shivratri- Singhal algorithm was able to handle the failure of MHs and MSSs. Additionally, the author assumed fail- stop failure of MSSs. Yang et al. [2] in 2005, proposed a fault tolerant algorithm to solve channel allocation problem. Their algorithm was able to work efficiently even if the network congestion, link failures and/or mobile service station failures exists,. Yang et al. [2] made the assumption that cellular network was divided in to cells and the reuse distance was considered to be r (the radius of a cell). In [2] algorithm, authors divided 6 cells in to 5 groups of varying size. The request for a channel can be granted if the requesting cell receives the reply from all members of a group. However, this algorithm does not work if the replies received by the requesting cell do not satisfy the criteria above mentioned. The algorithm is successful in case the area of coverage is divided in to hexagonal cells and the reuse distance is fixed which is r (radius of the cell). However, it is not practical to divide the area in to hexagonal cells in some cases, and the reuse distance may also significantly vary. Additionally, the messages required to be sent by the cell is equal to the number of all interfering neighbors even in case of fault free scenario. However, The message complexity is not significant when the number of neighbors is small.

When the reuse distance is large and number of interfering neighbors significantly high, the message complexity of Yang et al.'s algorithm may severely affect the performance. Yang-Manivannan [4] proposed another fault tolerant algorithm which divides the set of cells in to k disjoints subsets such that the distance between any two cells in a subset is at least the reuse distance. Moreover, the channels are also divided in to k disjoint group PC_0, PC_1---PC_{k-1}. The channels in PC_i are called Primary channels for group i and secondary channels for other cells. When a cell needs a channel it gives priority to its primary channels and tries for secondary channel in case no primary channel is available. Yang-Manivannan [4] applied the timeout mechanism for finding a failure and considered the reuse distance equal to 2D where D is the radius of the hexagonal cell. Boukerche-Abrougui-Huang [5] presented a Quality Of Service oriented and fault tolerant channel allocation algorithm based upon the mutual exclusion problem where the channels are divided in to 3 equal sized groups and each group cannot be shared concurrently within the same cluster. The algorithm is able to handle BS, MH and link failure, Chen-Huang [6], in 2007 proposed an adaptive and fault tolerant strategy for handling channel allocation problem. The algorithm is capable of handling traffic adaptation successfully. Additionally, it achieves some degree of fault tolerance also. Kim [7] proposed a fault tolerant model for channel assignment in cellular environment using resource channel techniques, borrowing/lending and locking techniques. Cho et al. [8] used eccentric fault tolerant path grouping scheme for achieving the fault tolerance in channel allocation.

III. SYSTEM MODEL

In this exposition, the assumption is that the area under the cellular network is divided in to cells, however, these cells may or may not be hexagonal and may be of different size. There is a BS (base station) in the centre of each cell. BS serves the mobile hosts which are present in the cell. The frequency spectrum available is divided in to channels which are further sub-divided in to communication channels and control channels. A communication channel is generally used for communication between an BS and MH, on the other hand a control channel is used for sending control messages which are required by the channel allocation algorithm.

The scarcity of the frequency spectrum forces us to use the frequency channels efficiently. Hence, a frequency channel may be used by two or more cells simultaneously, incase the distance between these cells is more than the allowed reuse distance. Any Two cells can be called neighbors, in case the distance between these cells is less than the assumed reuse distance. Therefore, two neighboring cells cannot use the same channel at the same time.

When a mobile host wishes to communicate, it sends a request to its BS (using a control channel) then the BS needs to allocate a communication channel to allow this communication. In case, BS has any channel unused, it will allocate it to MH. Otherwise, it initiates the search mode and tries to borrow a channel from the neighboring cells. In case BS is not able to allocate a channel the call fails.

A mobile host can move from one cell to another (say cell C_i to cell $C_{j)}$, this situation is termed as handoff. Whenever a handoff occurs while a call is going on, the mobile host has to release the acquired channel in cell C_i and in order to support this ongoing call, cell C_j has to try to allocate a communication channel. If Base Station of cell $C_{j,}$ is successful in allocating the channel to the moving mobile hosts, that the handoff is considered successful. Otherwise, the call has to be dropped. Some channels may be reserved for handoff purpose only so that the number of calls dropped during handoff may be reduced.

IV. CELLULAR QUORUM SYSTEM

Maekawa [9] used quorum system for reducing the message complexity of mutual exclusion algorithm. Later on, the researchers used the quorums effectively to achieve the fault tolerance in various distributed problems for the distributed systems [10, 11, 12]. For cellular wireless networks Skawratannanond-Garg[13] used quorums in channel allocation problem to reduce the message complexity. The algorithm proposed in [13] was an update based algorithm, hence, the message complexity was still significantly high. They assumed hexagonal cells, fixed reuse distance, and six neighbors of each cell and fixed request set. In the present paper, a quorum system is presented which is used to design fault tolerant channel allocation algorithm for cellular wireless network having cells of irregular shape and size.

A quorum system Q, also known as *coterie,* is considered a set of quorums which satisfies following two properties:

1) Intersection: $\forall Q_i, Q_j \in Q \rightarrow Q_i \cap Q_j \neq \emptyset$

2) Minimality:

$$\forall Q_i, Q_j \in Q \;\&\; Q_i \neq Q_j \rightarrow \; Q_i \textit{ is not a subset of } Q_j$$

The quorum system helps in reducing the message complexity in DME (distributed mutual exclusion) and other resource allocation problems, since, a requesting node need to send the request message to the members of the selected quorum. The size of a carefully designed quorum is O(√n). Additionally, the quorum system helps in handling faults because if a member of the selected quorum does not respond the requesting node is free to select another quorum.

If $IN(C_j)$ is the set of interfering neighbors of a cell C_j then a quorum system C for cell C_j can be defined as a set of subsets of $IN(C_j)$. Let us assume C= $\{Q_1, Q_2 \ldots.\}$. The cellular quorum system must satisfy below additional property named as neighbor cover property

$$\forall Q_i \in C \rightarrow IN(Q_{i1}) \cup IN(Q_{i2}) \ldots = IN(C_i) \textit{ where } Q_{i1}, Q_{i2} \ldots \textit{are the members of } Q_i$$

The neighbor cover property ensures that in case a BS C_j requiring a channel request, receives permission from all members of quorum Q_i which satisfy the neighbor cover property does not have any problem in fulfilling the request of C_j.

The proposed quorum system can be utilized for designing fault tolerant channel allocation algorithms in cellular wireless networks with arbitrary cell shapes and arbitrary reuse distance. The requesting cell may borrow a channel even if it does not receive reply from its neighbors till it receives reply from all members of a quorum.

This is a generalization of the idea of the group proposed by Yang-Jiang-Manvinnan [1] which can only be applied for hexagonal cells and a fixed reuse distance. In the next section, it has been shown how the proposed neighbor quorum system can be used in channel allocation. Moreover, the new quorum-based algorithms with better message complexity and fault- tolerant capabilities may also be designed using the neighbor quorum system.

V. ALGORITHM

In section V, the brief description of a search based algorithm using cellular quorum system for channel allocation in cellular wireless system has been presented. To the best of our knowledge, this is the first algorithm in which the quorum systems is used in search based algorithms for channel allocation The brief description of the algorithm is presented below.

When a call is generated in any cell C_i, BS first checks whether any local channel allocated to C_i is available, in case there exist such channels it select a channel from available channels. Otherwise, in search mode, BS sends a request message to all of its neighbors and initiates a timer. Following two possibilities are there:

(a) All its neighbors send reply to C_i: C_i finds the channels which have not yet been allocated to any neighbors or Ci. In case such channels are there; it finds a channel and adds this channel to the list of allocated channels. On the other hand, it tries to find the set of channels which have been allocated to one of its neighbors but not in use currently. If this set is not empty, C_i selects any channel from this and consults the cell C_j to which the selected channel was allocated previously and use the selected channel on receiving permission from C_j. However, if both the above mentioned sets are empty, C_i drops the call.

(b) C_i fails to get replies from all neighbors: When the timer expires, if C_i has not yet received reply from all neighbors, Ci may still borrow a channel from its neighbors provided that the following condition is satisfied:

Let R be the set of neighbors from which the cell C_i has received reply on expiry of timer.

If$\exists Q_i \in C \rightarrow \quad Q_i \subseteq R$ then C_i will be able to borrow a channel from neighbors provided that there is a set of channels that have been allocated to all members of Q_i but are not being currently used by any member of Q_i. Q_i may select any channel from this set, however, before this channel can be used, C_i has to consult all members of quorum Q_i and inform accordingly since any member of Q_i may start using this channel just after sending the reply to C_i. Hence, C_i will be able to use this channel only after all members of Q_i allows C_i to use this selected channel. However, If C_i fails to receive permission Q_i, it will select another channel from the set, in case such a channel exists. On the other hand, C_i tries to find another quorum Q_j satisfying the conditions mentioned above. C_i drops the call only if all possibilities are exhausted.

Once a cell C_i receives a request from cell C_j, it immediately sends its channel uses information to C_j, if C_i is not in search mode or its priority is lower than that of C_j's priority (Priorities may decided using Lamport's logical time stamps [14]). A cell can allow several borrowers' request for the same channel concurrently provided that no two of them are neighbors. Once a cell has allowed to requesting cell (s) for a particular channel, it can no longer use this channel for its own purpose and the borrower does not return the channel to the lender.

VI. CORRECTNESS PROOF

Theorem 1: Two neighboring cells are not allowed to borrow the same channel.

Let us assume the opposite that two cells C_i and C_j have successfully borrowed a channel n_k. Now, there are following four cases possible:

(a) C_i and C_j have received reply from all of their neighbors: In this case, C_i and C_j should have received reply from C_j and C_j must have received reply from C_i. However, due to use of the priority scheme only one of these two permissions is possible; therefore, case (a) is not feasible.

(b) C_i has received reply from all neighbors and C_j has received reply from a quorum Q_x .Beacuse, C_i has received reply from all neighbors;it should have received reply from C_j also. However, C_j will allow C_i to use the channel n_k only if it is not using n_k. Hence, case (b) is not feasible.

(c) C_j has received permission from all neighbors whereas C_i has received permission from a quorum $Q_{x:}$ this case is similar to case (b).

(d) C_i has received permission from all members and channel n_k is allocated to all members of Q_l as well as that of Q_y. Beacuse, C_i and C_j are neighbors C_j there will be a common member in Q_x and Q_y and the selected common member is known to the fact that C_j and C_i are neighbors. Hence, the common member of Q_x and Q_y will pallow only one cell to borrow the channel n_k. Hence, case (d) is also not feasible.

It is evident from all the four cases that our assumption is wrong; hence, theorem 1 it is proved.

VII. FAULT TOLERANT CAPABILITIES

The communication link in cellular wireless systems have higher probability of failure in comparison to static systems. Hence, the fault tolerance is more relevant in cellular wireless networks. Yang-Jiang-Manvinnan [1], used group to allow a cell to borrow a channel even if the cell has not received the replies from all of its neighbors. Moreover, there approach is to network specific for networks in which cells are having regular hexagonal and reuse distance is fixed R (where R is the radius of a hexagonal cell).

Generally, it is not possible to divide the cellular networks in to regular hexagonal shaped cells of equal area. In cities, the number of users per unit is significantly higher in comparison to villages. Hence, the area of rural cell(s) may be larger than the area of a cell in the city. Moreover, the cells may not be hexagonal due to geographical problems. Therefore, in the present exposition, we presented a quorum system named as cellular quorum system which can be utilized for any type of shape (or irregular shape) for cells and for any flexible reuse distance. Additionally, the quorum system is free from deadlock because of intersection property and its message complexity is also low.

The fault tolerant capability of cellular quorum system is increased because a cell C_i is successfully available to borrow a channel from its neighbors in case some replies are lost due to a link failure or BS (base station) failure. A cell can borrow a channel correctly, if it has received replies from all members of. Due toe neighbor covering property added to the cellular quorum system which requires that the quorum Q_l covers all interfering neighbors of the cell C_i.

VIII. CONCLUSIONS AND FUTURE WORK

In the present exposition, we presented a quorum system named as cellular quorum system which is specifically designed to solve channel allocation problem of cellular networks with fault tolerant capabilities. The advantage of using the cellular quorum system is that this can be utilized with any shape of cells and with any flexible reuse distance. An algorithm using cellular quorum system has been presented. As a future work one can plan to develop new search based algorithms for channel allocation with lower message complexity and compare their performance with the existing algorithms.

REFERENCES

[1] J.Yang, Q. Jiang, D.Manivannan, M. Singhal, “A fault-tolerant distributed channel allocation scheme for cellular networks”, IEEE transactions on computers, vol. 54, no. 5, pp. 616-627, 2005.

[2] A. Boukerche, K. El-Khatib, T. Huang, “A performance comparison of dynamic channel and resource allocation protocols for mobile cellular networks”, In proc. of MobiWac’04, 2004.

[3] R. Prakash, N. Shivaratri, M. Singhal, “Distributed dynamic fault-tolerant channel allocation for mobile computing”, IEEE transactions on vehicular technology, vol. 48, no. 6, pp. 1874-1888, 1999.

[4] J. Yang, D. Manivannan, “An efficient fault tolerant distributed channel allocation algorithm for cellular networks”, IEEE transactions on mobile computing, vol. 4, no. 6, pp. 578-590, 2005.

[5] A. Boukerche, K. Abrougui, T. Huang, “QoS and fault-tolerant based distributed dynamic channel allocation protocol for cellular networks”, In proc. IEEE conference on local computer networks, 2005.

[6] J. Chen, Y. Huang, “An adaptive fault-tolerant channel allocation strategy for cellular networks”, In proc. of IWCMC’07, 2007.

[7] V. Kim, “An improved fault-tolerant model for channel assignment in cellular networks”, In proc. of Wireless communication, networking, and mobile computing (WiCOM) , pp. 1-5, 2010.

[8] J. Cho, K. Park, J.G. Kim, H. Kim, “A fault-tolerant channel allocation scheme for mobile hosts in GMPS

based wavelength-switched optical networks" In proc. of International conference on information science and application 2011, pp. 1-7, 2011.

[9] M. Maekawa, "A √n algorithm for mutual exclusion in decentralized systems", ACM transactions on computer systems, vol. 3, no. 2, pp. 145-159, 1985.

[10] M. Toyumura, S. Kamei, H. Kakugawa, "A quorum-based distributed algorithm for group mutual exclusion", In the proceedings of the 4th intentional conference on parallel and distributed computing applications, and technologies, pp. 742-746, 2003.

[11] J.R. Jiang, " A distributed group *k*-exclusion algorithm using *k*-write-read coteries", In the proceedings of the international computer symposium 2004, pp. 1346-1351, 2004.

[12] A. Swaroop, A.K. Singh, "An improved quorum- based algorithm for extended GME problem in distributed systems", Journal of information science & engineering, vol. 26, no. 1, pp. 68-79, 2010.

[13] C. Skawratananond, V.K. Garg, "A Quorum-based distributed channel allocation algorithm for mobile systems" In proc. of PIMRC 99, Japan, 1999.

[14] L. Lamport, "Time, clocks, and the ordering of events in a distributed systems", Communications of the ACM, vol. 21, no. 7, pp. 558-565, 1978.

