Handoff strategy for Multi-tier IP-based Wireless Network

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Abstract

The developments of wired network technologies are significant rapidly, such as the IP-based network. These technologies can be used to develop wireless network directly. Recently, there are many communication systems brought up in order to offer mobile users with the best services. The combination of wired network and wireless network could be used to access data mutually. In this paper, the multi-tier architecture is based on IP network. Combining all these systems in a multi-tier IP-based wireless network is an important issue. In this paper, we propose a novel handoff algorithm of wireless communication for multi-tier IP-based network; the handoff algorithm is divided into two parts, which are Old-tier priority and New-tier priority algorithm. Making programs by C for simulating, and making sure that the algorithm is workable. The results of simulation show 11.99% of handoff frequency has been decreased and 8% of using rates of resource has been increased.

Keyword: handoff algorithm, multi-tier IP-based wireless network, mobile control handoff (MCHO), New-tier, Old-tier

1. Introduction

In the recent year, the number of mobile users has increased much faster than anticipated. According to the Universal Mobile Telecommunication System (UMTS) Forum, there will be around 1800 million mobile users worldwide in the year 2010. [1] Under the situation that limited resources and more and more users, handoff algorithm becomes very important for mobile users remove seamlessly of wireless communication.

There are many communication systems brought up to provide mobile users with the best services. For example, cellular IP is suitable for indoor or pedestrian environment; Mobile IP is suitable for vehicle environment and satellites communication system is suitable for boat or plane environment. To aid users in connecting wireless communication network anywhere, the multi-tier IP-based network that presented by ITU is imperative. The multi-tier IP-based network is the combination system of covering different region and supporting different transmitted speed of network.

In this paper, a handoff algorithm is addressed for multi-tier IP-based network. We hope to decrease the time of handoff, increase the use of resource and make users always in the best state.

The paper is structured in following statement. In section 2, some background information will be introduced. In section 3, the algorithm will be described by using flow-chat. In section 4, simulations and analysis will be revealed, and the conclusion is listed in section 5.

2. Handoff Algorithm For Multi-tier Network

I. To classify layer

According to the state of mobile hosts (MHs), MHs be divided into the four kinds of cell. Table 1 shows the parameter of a multi-tier cell. [2][3][4][5][6]

Cell	Speed of data transmission	Radius of cover	Range of it's speed (km/hr)
Pico-cell	2M/S	5M	<5
Micro-cell	<2M/S	1KM	5 ~30
Macro-cell	<384KB/S	35KM	30 ~200
Satellite-cell	<4.8KB/S	100~500KM	>200

Table 1: To classify layer

II. Algorithm

Mobile host (MH) will request a handoff, as it will go out the range of BS's signal. In this paper, mobile controlled handoff (MCHO)[7] and soft-handoff are the main framework of research. Traditional handoff algorithm is modified to achieve the request of handoff.

In this paper, when a MH requests a hand-off, MH is allotted different layer dynamically according to the speed of MH and the request of resource. The algorithm will determine to change the layer or not when the MH

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requests the handoff. If the speed or resources isn't suitable the MH, the layer should be changed. The algorithm will be active working, the workable process of algorithm is called new-tier priority algorithm. If the layer won't be changed, it work algorithm, which is called old-tier priority algorithm. Combining the two algorithms to one, that is our multi-tier handoff algorithm.

i. New-tier Priority Algorithm

MH checks the signal from the new-tier BSs when it determines to change layer. To permute the strength of signal from new-tier-1's BSs from the strong stage to the weak stage, and then to request resource from the strongest signal BS. It will handoff, if the BS has enough resource for the MH. If not, MH will ask resource for the second stronger signal BS. Moving in circles until handoff succeeds. If all of BSs have not enough resource, MH checks the sign-al from new-tier-2's BS from the strong stage to the weak stage. New-tier-2 means that higher than new-tier-1. Example one, Pico-cell is old-tier of the MH A. Micro-cell is new-tier-1 for MH A, if MH A increase the speed. And then, new-tier-2 is macro-cell of MH A. Example two; old-tier is macro-cell of the MH B. New-tier-1 is micro-cell of MH B, if MH decreases the speed. And then, new-tier-2 is Pico-cell of MH B. Example three; old-tier is macro-cell of the MH C. New-tier-1 is satellite cell of MH C, if MH C increases the speed. And then, there is no new-tier-2 of MH C. MH asks for resource from new-tier-2's BS, when the new-tier-1 doesn't satisfy the MH. Moving in the same circle in the new-tier-1, until handoff succeeds. If all BS of new-tier-2 didn't have enough resource for MH, MH would request resource from old-tier's BS and move the same circle in the new-tier-1, until hand-off succeeds. If all BS of old-tier didn't have enough resource, the request of handoff from the MH would be rejected.

It just has four layers in each multi-tier cell. It will not be suitable for the MH, if we across too much layer for the MH. So MH just has new-tier-2. The flow-chart of algorithm shows as figure 2.

ii. Old-tier Priority Algorithm

It works the old-tier priority algorithm and checks the signal strength from the same tier when it doesn't to change layer. To permute the signal strength of BSs from the strong stage to the weak stage, and then ask for the resource from the strongest signal BS. It will handoff if the BS has enough resource. If not, MH asks for resource from the second stronger signal BS. Moving in circles until handoff succeeds. If all of BSs have not enough resource, MH checks the signal from new-tier's BS from the strong stage to the weak stage. New-tier means that speed of MH A is closer to old-tier based on the range of speed. For example, speed of MH A is in 32 km/hr. Macro-cell is old-tier of the MH A. Micro-cell is New-tier of MH A. MH requests resource from new-tier's BS, when the old-tier can't satisfy the MH. Moving the same circle in the old-tier, until handoff succeeded. If all BS of new-tier didn't have enough resource for MH, the request of handoff from the MH would be rejected. The reason is the same as above. The flow-chart of algorithm shows as figure 3.

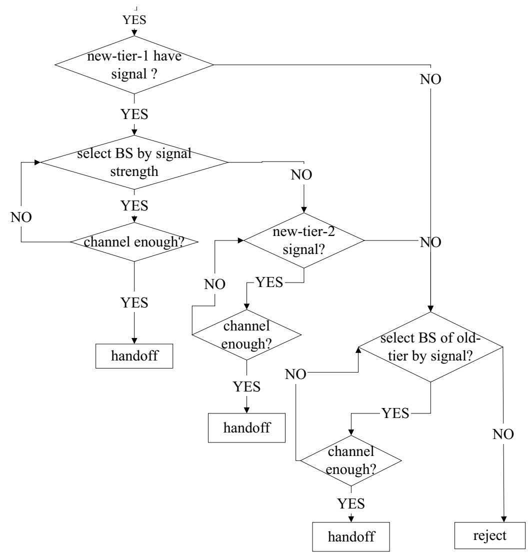

Figure 2: New-tier priority algorithm

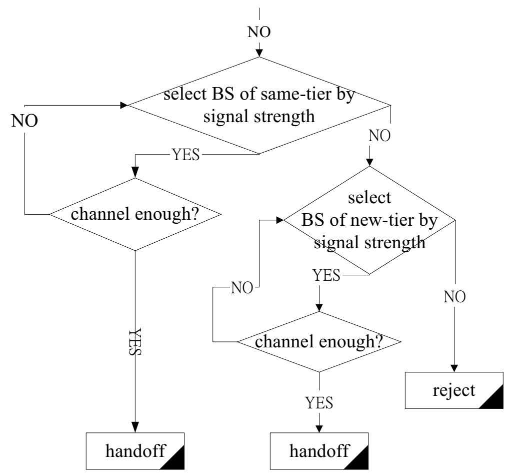

Figure 3: Old-tier priority algorithm

3. Simulation

I. Simulate Circumstances

There are some assumptions for simulation of algorithm. The first, the cell is infinite. The maximum cell is satellite cell, which deliver data by satellite. The assumption is reasonable because only three GEO satellite can cover all the earth. The second, each cell has 5M resources. It means that a multi-tier cell has 20M resources. Table 4 shows that each cell transports data in a limited speed and limited cover range. According to pico-cell, each cell is assumed that each cell has 5M resources. The third, MH requests a handoff when it's moving distance more than the cell's diameter. In face, MH can move in any passage. Diameter is an average of move trajectory. The fourth, the top of speed is in 1000km/hr, because the speed of an aircraft is between 1000km/hr and 2500km/hr. It is too large of the range of specimen, if the range of speed is between 0km/hr and 2500km/hr. The fifth, the number of user in micro and macro-cell are more than the number of users in pico-cell and satellite cell. So MHs's speeds in macro and micro-cell have larger weight. Then, the rate of user in pico-cell is 15% and in micro-cell is 37.5% and in macro-cell is 42.5% and in satellite cell is 5%. The simulation will more conformable to fact the reality.

Cell	Top of transport speed	Distance for handoff	Range of speed (km/hr)
Pico-cell	2M/S	10M	<5
Micro-cell	<2M/S	2KM	5 ~30
Macro-cell	384KB/S	70KM	30~200
Satellite-cell	4.8KB/S	200KM	200 ~1000

Table 4: Compares of multi-tier

There are four programs in C to simulate the algorithms.

II. Simulation

i. Simulation for handoff

The system gives random time T [i] and random speed S [i] for each MH. MH's layer is allocated according S [i]. It means that MH i will in micro-cell if S [i] lower than 30km/hr. And i moves in the speed S [i] during time T [i]. After the time T [i], the MH moves on distance D [i]. MH ask for a handoff when D [i] over the distance of diameter and add one to handoff variable H. MH i get a new time T [i]' after T [i]. Moving in circles for one hour and to record the times of handoff of forty MHs. Time continued to count two, three …until ten hours and record them. There are some differences between the two programs for handoff simulation. One of the two programs is for the experimentation and the other is for the comparison. After handoff, MH i will change its layer in new speed S [i]' in experimentation. After the first layer allocation, the layer will not change in comparison. Working the two programs ten times. The number will be deleted when it has much difference with the others. The average of the rest numbers is the result.

ii. Simulation for the rate of resource used

There are one hundred MHs in a multi-tier cell. System gives random time T [i] and random speed S [i] and random resource R [i] for each MH. MHs' layer is allocated by S [i] and requests the resource R [i] from the cell's BS. If the BS has the resource R [i], MH i will be served. Else MH i will be rejected in comparison. But, the MH will to change layer and request the resource R [i] from the new-tier again in experimentation, according to the old-tier priority algorithm. When handoff succeeded, the variable u[i], which is show the used of resources, will be add-ed R [i]. Until one hundred MHs achieve the request of resource and then recording the rate of resource used. Increasing the number of MH to 200,300…1000 and then re-cord its rate of resource used. Working the two programs ten times, the number will be deleted when it large difference with the others. Averaging of the rest numbers, it is the result.

III. ANALYSIS

Table 5 shows the number of handoff in experimentation. Table 6 shows the number of handoff in comparison. To permute the data in table 5 and table 6 increasingly, it can be find that the result in the first two hours in comparison is better than in experimentation, sometimes. Observing the time of MHs in the first random time in experimentation and comparison. It can be found that the time is longer than one or two hours. It means that the MH in the best state in the first random time in comparison, because they are distributed in the best state in the first time.

According to the table 5 and table 6 the new-tier priority algorithm throughput performance is 11.99%, it is better than the traditional algorithm. It means that the new-tier priority algorithm can reduce 11.99 times for per 100 handoffs. Figure 7 shows a diagram of curves of an average for comparison. The X axle shows the times of handoff and Y axle shows the time of handoff.

HR \ Time	1	2	3	4	5	6	7	9	9	10	Ave
1	29675	91814	67823	64176	52683	73951	35718	74481	43062	43563	57695
2	70309	174745	143017	120174	91263	136883	67977	150020	94382	93603	114237
3	112260	247154	217678	165754	127348	191085	96861	236492	146566	120389	166159
4	155886	349976	287467	201436	161634	244097	119345	318095	207007	146087	219103
5	200292	462199	357799	219981	198815	297906	141457	395703	267979	177495	271963
6	265131	553968	440613	232928	224423	344261	163266	475584	314552	225941	324067
7	320554	665905	492349	257114	254893	386723	198225	545397	363943	272230	375733
8	366901	756867	520767	288236	301419	419851	243191	602649	414340	326262	424048
9	413275	855768	542330	324278	359605	441324	299748	656181	480218	383158	475589
10	455805	974208	572609	366788	414599	455045	361954	715765	548236	445804	531081

Table 5: Frequency of handoff in experimentation

HR \ Time	1	2	3	4	5	6	7	8	9	10	Ave
1	49126	48648	35193	47514	78053	48407	84729	84729	41866	46909	55102
2	98222	97303	65158	95055	173287	111927	172755	172755	118615	93847	116838
3	147366	118431	95377	140154	246892	221147	302031	302031	187573	146407	178371
4	201746	175734	125529	189759	384647	330622	405353	405353	256839	165689	248866
5	256366	280785	152405	247643	513939	390585	436699	436699	345101	184902	306444
6	311792	312853	213390	346112	665129	504113	536260	536260	440197	225078	383384
7	324278	404935	262145	442749	772385	601876	636001	636001	501790	273843	452552
8	355515	490992	310738	479968	856005	679879	725236	725236	562087	279223	515731
9	398383	580098	401510	607676	880619	831107	828911	828911	613273	303682	602092
10	449165	720248	429290	692917	890507	904822	883972	883972	677870	339187	672644

Table 6: Frequency of handoff in comparison

Table 8 shows the rate of use in resource in experiment and Table 9 shows in comparison. The rate doesn't change as the MH's number are between 400 to 900 in the fourth executing of program (rate 3) in comparison. It is special condition, so we delete the result. The result that the eighth execute of program (rate 7) in comparison and the fourth execute of program (rate 3) in experiment, we

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have deleted them in the same reason. The rate in the seventh execute of program (rate 6) for one hundred MHs is too large than any other results in experiment. It is special condition, so we delete the result.

According to the Table 8 and Table 9 it can be found th-at the new algorithm throughput performance is 8% better than the old algorithm. It means that the new algorithm in-crease the use of resources. Figure 10 shows a diagram of curves of an average for comparison. The X axle shows the number of MHs and Y axle shows the rates of resour-ces. When the numbers of MH over seven hundred, there is only little improvement of the algorithm. The rate of used resources get to 98% in comparison. But it promotes 99% in experiment. No matter how much the number of MH, it can keep in high rate of used resource in our algorithm. But it will have high rate of used resource in comparative unless there are over six hundred of MHs.

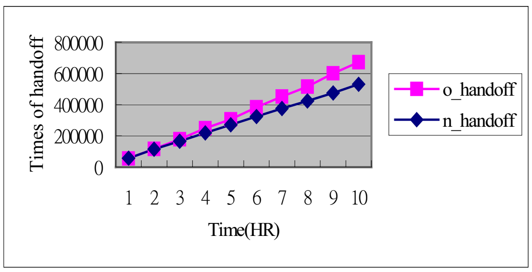

Figure 7: Diagram of curves for comparatively for handoff

MH#	Rate 0	Rate 1	Rate 2	Rate 3	Rate 4	Rate 5	Rate 6	Rate 7	Rate 8	Rate 9	Average
100	98.33	94.89	98.42	96.27	93.65	96.61	98.055	98.87	97.865	98.005	96.979
200	99.68	98.67	98.75	99.52	99.595	98.6	98.405	99.4	99.37	98.87	98.993
300	99.68	99.74	99.61	99.67	99.855	99.175	99.565	99.845	99.45	99.62	99.588
400	99.78	99.74	99.78	99.88	99.9	99.805	99.685	99.985	99.72	99.77	99.773
500	99.95	99.88	99.90	99.88	99.92	99.805	99.895	99.985	99.76	99.85	99.871
600	99.97	99.88	99.90	99.88	99.945	99.895	99.905	99.985	99.76	99.93	99.899
700	99.97	99.89	99.90	99.88	99.965	99.905	99.905	99.985	99.76	99.965	99.908
800	99.98	99.89	99.93	99.88	99.965	99.905	99.96	99.985	99.845	99.975	99.932
900	99.98	99.89	99.93	99.88	99.965	99.91	99.96	99.985	99.94	99.995	99.947
1000	99.98	99.89	99.93	99.92	99.965	99.93	99.975	99.985	99.94	99.995	99.951

Table 8: Used rate of resource in experiment

MH#	Rate 0	Rate 1	Rate 2	Rate 3	Rate 4	Rate 5	Rate 6	Rate 7	Rate 8	Rate9	Average
100	86.885	66.625	81.13	74.105	69.41	72.475	98.365	85.715	68.89	54.83	73.245
200	88.945	82.515	81.41	97.335	74.65	72.475	98.61	88.24	69.08	72.54	78.732
300	89.48	88.065	87.845	99.245	75.815	94.835	98.65	89.025	72.335	83.945	85.168
400	89.48	91.915	87.91	99.42	92.505	95.66	99.03	89.025	93.76	96.755	92.126
500	94.78	91.915	97.655	99.465	92.585	97.11	99.185	92.345	98.36	97.465	95.277
600	98.95	94.895	99.11	99.465	92.6	97.11	99.5	95.075	98.41	98.835	96.873
700	98.96	98.52	99.11	99.475	92.6	97.11	99.595	98.815	98.61	99.545	97.909
800	99.085	98.52	99.155	99.475	95.605	97.11	99.615	99.295	98.61	99.585	98.371
900	99.085	98.55	99.155	99.475	95.605	97.96	99.705	99.47	98.76	99.77	98.544
1000	99.085	98.55	99.155	99.475	96.795	97.96	99.74	99.595	98.76	99.77	98.709

Table 9: used rate of resource in comparison

4. CONCLUSION

Sometimes, the MHs changes state when MH ask for a handoff. For example, the increasing of speed in MH and the layer is no more suitable for the MH. In this paper, the MH can change the layer anywhere and any time to suita-ble for the MHs' speed in multi-tier IP-based network. It will reduce times of handoff. Sometimes, MH will be rej-ectted because it does not have enough of resource. It can change the layer to get resources. So the rate of used reso-urce will increase, too. For this reason, the QoS is raised.

In this paper, a handoff algorithm of Multi-tier IP-bas-ed network is brought up for wireless communication. The algorithm is divided into new-tier priority and old-tier pri-ority handoff algorithm. Making the programs for simula-ting and make sure that the algorithm is workable. The simulation results show the decreasing of 11.99% freque-ncy in handoff and increasing 8% using rate of resource.

In the future, resource reservation protocol (RSVP) will be used in multi-tier. Dynamical resource disposed for multi-tier is a very good issue. They will heighten the quality of service (QoS) for multi-tier IP-based network.

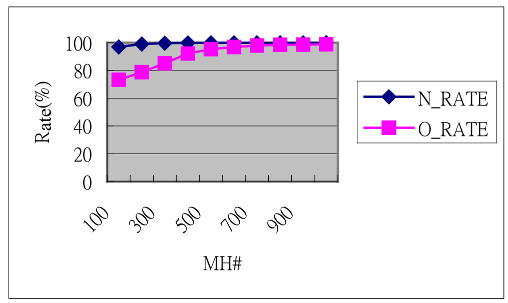

Figure 10: Diagram of curves in comparatively for the rates of used of resource

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