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Packet Delay and Bandwidth Consideration for Real-time and Non-real-time Applications for QoS Oriented Network Selection in IEEE 802.16e WiMAX Networks

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Packet Delay and Bandwidth Consideration for Real-time and Non-real-time Applications for QoS Oriented Network Selection in IEEE 802.16e WiMAX Networks

ABSTRACT

The IEEE 802.16 standard WiMAX (Worldwide Interoperability for Microwave Access) network is one of the widely used 4G networks since it provides high-speed data over a wide coverage area. In this, the standard 802.16e supports both fixed and mobile nodes in which the quality of service (QoS) will get degraded due to frequent and false handoffs which should be minimized for getting uninterrupted services. The handoff is a process of disconnecting the mobile device from the old base station and reconnecting it with the new base station. Generally, the handoff will occur during the mobility when the received signal strength goes below the acceptable level. But in the recent scenario, the handoff may be triggered for many reasons such as poor QoS, monetary cost, interference, battery level, etc.

In the literature, many handoff schemes are proposed for WiMAX networks but no work considered the parameters such as mobile velocity, ongoing application type, and network status, tolerable uplink packet delay, tolerable downlink packet delay, required uplink bandwidth, and required downlink bandwidth all together. Also, most of the handoff of schemes in the literature are suitable for mobile devices and not suitable for fixed devices. In this invention, we have proposed a handoff method for selecting the best base station in the WiMAX network by considering many parameters such as RSS, the velocity of the mobile, network status, application type, tolerable uplink packet delay, tolerable downlink packet delay, required uplink bandwidth, and required downlink bandwidth. Moreover, based on the ongoing application's type (i.e., real-time or non-real-time) the preference will be given to either base station with minimum packet delay or base station with maximum bandwidth for performing a handoff. This proposed method is suitable not only for mobile devices it is also suitable for fixed devices which helps in avoiding the ungainful handoffs and in selecting the best WiMAX base station among the available candidates thereby it helps in improving the quality of service.

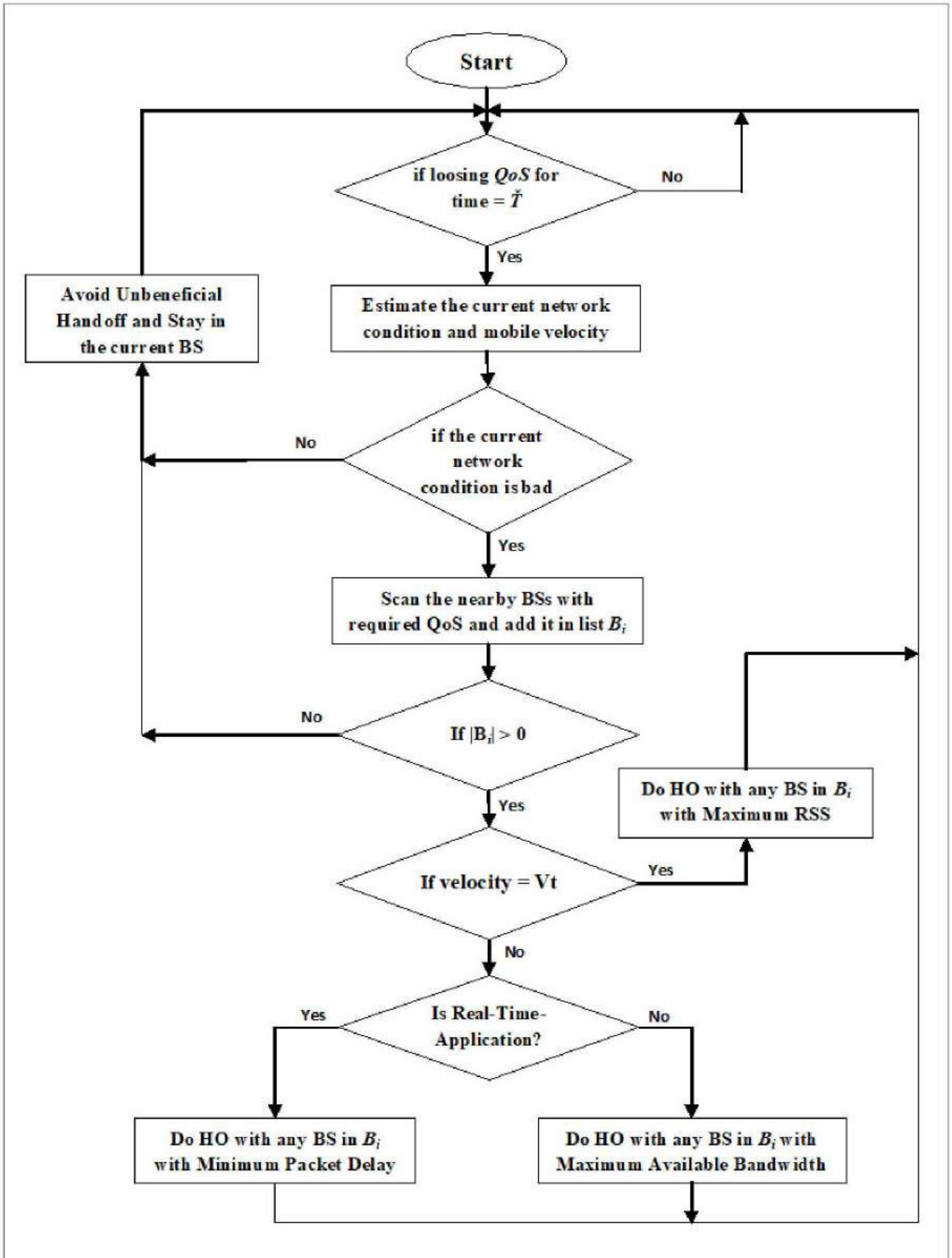
Start
if loosing QoS for time = T̆
No
Yes
Avoid Unbeneficial Handoff and Stay in the current BS
Estimate the current network condition and mobile velocity
if the current network condition is bad
No
Yes
Scan the nearby BSs with required QoS and add it in list B_i
No
If $|B_i| > 0$
Yes
Do HO with any BS in B_i with Maximum RSS
If velocity = Vt
Yes
No
Is Real-Time-Application?
Yes
No
Do HO with any BS in B_i with Minimum Packet Delay
Do HO with any BS in B_i with Maximum Available Bandwidth

Fig. 2

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TITLE OF THE INVENTION

[001]. Packet Delay and Bandwidth Consideration for Real-time and Non-real-time Applications for QoS Oriented Network Selection in IEEE 802.16e WiMAX Networks

FIELD OF THE INVENTION

[002]. The present disclosure is generally related to a Network Selection Method for IEEE 802.16e WiMAX Networks that selects a best network among the available networks by considering the parameters such as packet delay, required bandwidth, available bandwidth, and ongoing application type.

BACKGROUND OF THE INVENTION

[003]. The main objective of the invention is to develop a handover scheme for WiMAX network that should select the right base station among the available base stations such that the quality of service should be improved considerably by minimizing the number of unbeneficial handovers and by giving priority to the base station with minimum packet delay or with maximum available bandwidth based on the ongoing application type. The secondary objective of the invention is to facilitate mobile users by offering seamless services with the required quality of service.

[004]. "Packet Delay and Bandwidth Consideration for Real-time and Non-real-time Applications for QoS Oriented Network Selection in IEEE 802.16e WiMAX Networks" is a proposed work developed to minimize the number of unbeneficial handovers in WiMAX networks by estimating the network condition and velocity of the mobile device in prior to the handover process. This invention proposes a handover algorithm for handling two different application types in the form of pseudo-code which will improve the quality of service considerably by minimizing the number of unbeneficial handovers and by giving priority to the base station with minimum packet delay or base station with maximum available bandwidth based on the ongoing application type. This proposed invention will facilitate the mobile user by providing seamless mobility with the required quality of service.

SUMMARY OF THE INVENTION

[005]. The IEEE 802.16 standard WiMAX is one of the widely used 4G networks since it provides high-speed data over a wide coverage area. It is the competitive network of 4G wireless network LTE (Long Term Evolution). In every wireless network, the handoff is a common problem that can be defined as the process of disconnecting the mobile device from the old base station and reconnecting it with the new base station. Generally, the handoff will occur during the mobility when the received signal strength goes below the acceptable level. But in the recent scenario, the handoff may be triggered for many reasons such as poor QoS, monetary cost, interference, battery level, etc. In the WiMAX network, the QoS will get degraded due to frequent handoffs which should be minimized for getting uninterrupted services. This invention helps in reducing the number of ungainful handoffs and in encouraging the gainful handoffs thereby it improves the QoS. Also through this invention, both mobile and fixed devices will get benefited in the WiMAX network.

[006]. In the proposed network selection scheme, the "handoff decision manager module" is designed to sit on the MAC layer which will keep on monitoring the QoS achieved by the ongoing applications, direction of the communication (uplink (UL) or downlink (DL)) and it will trigger the handoff process whenever the QoS goes below the minimum acceptable threshold continuously for a specific duration *D*. Before performing the handoff process it will estimate the reason for the poor QoS achieved. The reason for the poor QoS will be due to any one of the three different factors as follows

1. The condition of the current base station may be bad due to reasons such as overloaded by multiple mobile/fixed devices, local interference, and malfunctioning of the base station's equipment, etc.
2. The performance of the remote server may get reduced from where the mobile/fixed devices are getting the services.
3. The performance of the intermediate network devices (between server and base station) may get degraded due to reasons like congestion.

[007]. The handoff decision manager will initiate the handoff procedure if and only if it confirms that the reason for poor QoS is due to the current base station. The handoff decision manager will find the cause for the poor QoS by estimating the ongoing packet delay (PD) and the available bandwidth. During the handoff process, the mobile/fixed devices will scan for the nearby base stations and the list of detected base stations will be added to a list 'B'. The status of every base station in 'B' will be estimated concerning the available bandwidth and ongoing packet delay. The base station whose available bandwidth is greater than the required bandwidth and ongoing packet delay is less than the tolerable delay of the ongoing applications will be grouped into another set B_i. If the set B_i contains more than one base station then the velocity of the mobile device will be estimated (for the fixed device the velocity will always be 0). If the velocity is less than the threshold Vt then the ongoing application type (real-time or non-real-time) will be considered for selecting a base station from B_i. If the application type is real-time then a base station with minimum packet delay will be selected from B_i for handoff otherwise if the application type is non-real-time then a base station with maximum bandwidth will be selected from B_i for handoff. If the velocity is greater than Vt then the base station with maximum RSS will be selected from B_i for handoff irrespective of ongoing application type. If the number of base stations in B_i is 0 then no handoff will be performed to avoid unbeneficial handoffs.

[008]. In this invented handoff scheme, the mobile velocity is measured using the longitude and latitude values retrieved periodically from the GPS. The ongoing uplink and downlink packet delay of the base stations will be calculated using simple numerical methods. The uplink and downlink available bandwidth of the base station will also be calculated using simple numerical methods with the help of UL-MAP and DL-MAP messages transmitted periodically by the base stations. This estimated uplink/downlink packet delay and bandwidth are used for detecting the network condition through which we can able to find the cause for the poor quality of service. If the cause for the poor quality of service is the current base station then the handoff will be triggered to select another base station which can able to offer the required quality of service. But if the reason for the poor quality of service is not the current base station then the handoff will be avoided since even after handoff the quality of service will not be achieved. This is how our invention eliminates ungainful handoffs.

[009]. Also, for the mobile/fixed devices with the real-time application, the preference is given to the base station with minimum packet delay and for non-real-time applications, the preference will be given to base station with maximum available bandwidth during the base station selection process. For mobile devices with high velocity, the preference will be given to base station with maximum RSS value which will help in getting services from the target base station for long duration and in avoiding the frequent handoff.

DETAILED DESCRIPTION OF THE INVENTION

[0010]. The IEEE 802.16 standard WiMAX is one of the widely used 4G networks since it provides high-speed data over a wide coverage area. It is the competitive network of 4G wireless network LTE (Long Term Evolution). The handoff is a process of disconnecting the mobile device from the old base station and reconnecting it with the new base station. Generally, the handoff will occur during the mobility when the received signal strength goes below the acceptable level. But in the recent scenario, the handoff may be triggered for many reasons such as poor QoS, monetary cost, interference, battery level, etc. In any wireless network, the QoS will get degraded due to frequent ungainful handoffs which should be minimized for getting uninterrupted services. This invention helps in reducing the number of ungainful handoffs and in encouraging the gainful handoffs to improve the QoS. Also through this invention, both mobile and fixed devices will get benefit in the WiMAX network.

[0011]. There have been many network selection algorithms in the literature for seamless mobility in which most of the works use Received Signal Strength (RSS) as the main handover decision criteria and presents various schemes for evaluating and comparing the RSS of the current Base Station (BS) with the nearby BSs. But, for maintaining the QoS requirements of the ongoing applications, RSS alone is not enough for a handoff decision. However, designing a handover decision algorithm that works efficiently in the wireless networks is still a challenging area and this invention is carried out to full fill this gap. This Invention did develop a QoS based handoff algorithm for IEEE 802.16e standard WiMAX network which performs Handoff based on many parameters such as ongoing application type, uplink (UL) packet delay (PD), downlink (DL) packet delay, uplink bandwidth, downlink bandwidth, the velocity of the mobile, and RSS.

[0012]. In the proposed network selection scheme, the "handoff decision manager module" is designed to sit on the MAC layer which will keep on monitoring the QoS achieved by the ongoing applications and it will trigger the handoff process whenever the QoS goes below the acceptable threshold continuously for a specific duration *D*. Before performing the handoff process it will estimate the reason for the poor QoS achieved. The reason for the poor QoS will be due to any one of the three different factors as follows

1. The condition of the current base station may be bad due to reasons such as overloaded by multiple mobile/fixed devices, local interference, and malfunctioning of the base station's equipment, etc.
2. The performance of the remote server may get reduced from where the mobile/fixed devices are getting the services.
3. The performance of the intermediate network devices (between server and base station) may get degraded due to reasons like congestion.

[0013]. The handoff decision manager will initiate the handoff procedure if and only if it confirms that the reason for poor QoS is due to the current base station. The handoff decision manager will find the cause for the poor QoS by estimating the ongoing UL/DL packet delay and the available UL/DL bandwidth of the base stations. The proposed handoff method is presented in the form of pseudo-code in figure 1 and the same is depicted as a flow chart in figure 2. During the handoff process, the mobile/fixed devices will scan for the nearby base stations and the list of detected base stations will be added to a list 'B'. The status of every base station in 'B' will be estimated concerning the available bandwidth and ongoing packet delay. The base station whose available UL bandwidth ($\hat{U}$) is greater than the required uplink bandwidth ($\hat{U}_{req}$), available DL bandwidth ($\check{D}$) is greater than the required uplink bandwidth ($\check{D}_{req}$), ongoing UL packet delay (ω) is less than the tolerable UL packet delay (ω_{req}), and DL packet delay (φ) is less than the tolerable DL packet delay (φ_{req}) of the ongoing applications will be grouped in to another set B_i. If the set B_i contains more than one base station then the velocity of the mobile device will be estimated (for the fixed device the velocity will always be 0). If the

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velocity is less than the threshold Vt then the ongoing application type (real-time or non-real-time) will be considered for selecting a base station from B_i. If the application type is real-time then a base station with minimum packet delay will be selected from B_i for handoff otherwise if the application type is non-real-time then a base station with maximum bandwidth will be selected from B_i for handoff. If the velocity is greater than Vt then the base station with maximum RSS will be selected from B_i for handoff irrespective of ongoing application type. If the number of the base station in B_i is 0 then no handoff will be performed to avoid unbeneficial handoffs.

[0014]. In this invented handoff scheme, the mobile velocity is measured using the longitude and latitude values retrieved periodically from the GPS as follows

$$\text{velocity} = \frac{\sqrt{(x2-x1)^2+(y2-y1)^2}}{\text{sample\_interval}} \qquad (1)$$

where x1 and y1 are the latitude and longitude value of the previous sample, x2 and y2 are the current sample's latitude and longitude value of the mobile device, and sample_interval is the time interval between the current sample and previous sample. The average speed of the mobile will be calculated by finding the mean value for the last six to ten speeds.

[0015]. The ongoing uplink and downlink packet delay of the base stations will be calculated using simple numerical methods. The uplink and downlink available bandwidth of the base station will also be calculated using simple numerical methods with the help of UL-MAP and DL-MAP messages transmitted periodically by the base stations (presented in detail in the upcoming section). This estimated uplink/downlink packet delay and bandwidth are used for detecting the network condition through which we can able to find the cause for the poor quality of service. If the cause for the poor quality of service is the current base station then the handoff will be triggered to select another base station which can able to offer the required quality of service. But if the reason for the poor quality of service is not the current base station then the handoff will be avoided since even after handoff the quality of service will not be achieved. This is how our invention eliminates ungainful handoffs.

[0016]. Also, for the mobile/fixed devices with the real-time application, the preference is given to the base station with minimum packet delay and for non-real-time applications, the preference will be given to base station with maximum available bandwidth during the base station selection process. For mobile devices with high velocity, the preference will be given to base station with maximum RSS value which will help in getting services from the target base station for long duration and in avoiding the frequent handoffs.

[0017]. **Calculating Network Condition in WiMAX:** The network condition can be estimated by calculating the available UL bandwidth, and available DL bandwidth of WiMAX BS. The condition of the WiMAX network is considered to be good if the available UL bandwidth and available DL bandwidth of WiMAX BS is sufficient enough to satisfy the requirement of the mobile device. The IEEE 802.16 WiMAX BSs will keep on broadcasting the resource allocation status to every mobile/fixed device through the DL-MAP and UL-MAP. This DL-MAP and UL-MAP message are embedded inside the downlink subframe which contains information about the number of UL and DL slots assigned to a mobile/fixed device in one frame. Using this information any mobile/fixed device can able to calculate the available UL bandwidth (Û) and available DL bandwidth (Ď) by finding the difference between the Utilized (or allocated) UL Bandwidth (UB_{ul}) and the Utilized DL Bandwidth (UB_{dl}) from the Maximum UL Bandwidth (MB_{ul}) and Maximum DL Bandwidth (MB_{dl}) respectively.

[0018]. In OFDMA (Orthogonal Frequency Division Multiple Access) the IEEE 802.16 standard base station keeps on sending the UL-MAP and DL MAP messages via broadcasting which contains the information about the status of DL and UL slots hold by a mobile or fixed device in each frame. Any mobile/fixed device can able to calculate the Û by subtracting the maximum uplink bandwidth by the occupied uplink bandwidth. The equation $MB_{ul} = (TS_{ul} X BPS_{ul})/D_f$ can be used to calculate the maximum uplink bandwidth of a base station, where MB_{ul} is the maximum uplink bandwidth, TS_{ul} is the maximum number of slots available in a UL subframe, BPS_{ul} is the bits per UL slot (depends on SINR, distance, etc.), and D_f is the time duration of an UL subframe.

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[0019]. Similarly, the equation $UB_{ul}=(BPS_{ul}\ X\ AS_{ul})/D_f$ can be used to calculate the occupied or utilized uplink bandwidth where, UB_{ul} is the uplink bandwidth utilized currently, AS_{ul} is the number of slots allocated for in the UL subframe, BPS_{ul} is the bits per UL slot, and D_f is the duration of an uplink subframe. Similarly, the Ď can be calculated by subtracting the utilized DL bandwidth from the maximum DL bandwidth. The PD in WiMAX (both downlink φ *and* uplink ω) can be divided into three components as $PD=D_{wb}+D_m+D_t$. The waiting time in the MAC layer buffer D_{wb} can be calculated as the time between the packet arrived at the MAC layer buffer and the beginning of frame allocated for transmitting the packet. The mapping delay D_m is the time between the beginning of the allocated frame and the first time slot appointed to the station. The transmission delay D_t is the time spent to transmit the packet.

[0020]. Thus "Packet Delay and Bandwidth Consideration for Real-time and Non-real-time Applications for QoS Oriented Network Selection in IEEE 802.16e WiMAX Networks" is a proposed invention developed to minimize the number of unbeneficial handovers in WiMAX networks by estimating the network condition and velocity of the mobile device in before the handover process. This invention proposed an over algorithm for handling two different application types in the form of pseudo-code which could improve the quality of service considerably by minimizing the number of unbeneficial handovers and by giving priority to either packet delay or available bandwidth based on the application type. This proposed network selection method will facilitate the mobile user by providing seamless mobility with the required quality of service.

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CLAIMS:

We Claim:

1. The present disclosure is generally related to a Network Selection Method for IEEE 802.16e WiMAX Networks that selects a best network among the available networks by considering the parameters such as packet delay, required bandwidth, available bandwidth, and ongoing application type.
2. This invention facilitates the mobile users by offering seamless services with the required quality of service.
3. This invention developed handover scheme for WiMAX network that could select the right base station among the available base stations such that the quality of service can be improved considerably.
4. As claimed in 2 and 3, this invention helps in improving the quality of service by minimizing the number of unbeneficial handovers and by giving priority to the base station with minimum packet delay or with maximum available bandwidth based on the ongoing application type.
5. This invention proposes a handover algorithm for handling two different application types in the form of pseudo-code which will improve the quality of service considerably by minimizing the number of unbeneficial handovers and by giving priority to the base station with minimum packet delay or base station with maximum available bandwidth based on the ongoing application type.
6. This proposed method is suitable not only for mobile devices it is also suitable for fixed devices which helps in avoiding the ungainful handoffs and in selecting the best WiMAX base station among the available candidates thereby it helps in improving the quality of service.

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Algorithm:

If *ul* or *dl* application is losing *QoS* for time >*D*
get the $\hat{U}_{req}$, $\check{D}_{req}$, ω_{req} and φ_{req};
if the condition of current BS β ? B is bad enough
scan the nearby BS β;
for each β ? B detected by scanning
calculate $\hat{U}_{\beta}$, $\check{D}_{\beta}$, ω_{β} and φ_{β};
if $\hat{U}_{\beta} > \hat{U}_{req}$ & $\check{D}_{\beta} > \check{D}_{req}$ & $\omega_{\beta} < \omega_{req}$ & $\varphi_{\beta} < \varphi_{req}$
add BS β to subset B_i;
end if
end for
if $|B_i| > 0$
if velocity = Vt
$b = \max \beta \{RSS_{i,\beta} \mid \beta ? B_i\}$;
else velocity < Vt
if non-real-time-application
$b = \max \beta \{\hat{U}_{i,\beta} + \check{D}_{i,\beta} \mid \beta ? B_i\}$;
else if real-time-application
$b = \min \beta \{PD_{i,\beta} \mid \beta ? B_i\}$;
end if
end if
perform gainful handoff with *b*;
else
stay back in current BS to avoid ungainful handoff
end if
else
stay back in current BS to avoid ungainful handoff
end if
end if

Fig. 1

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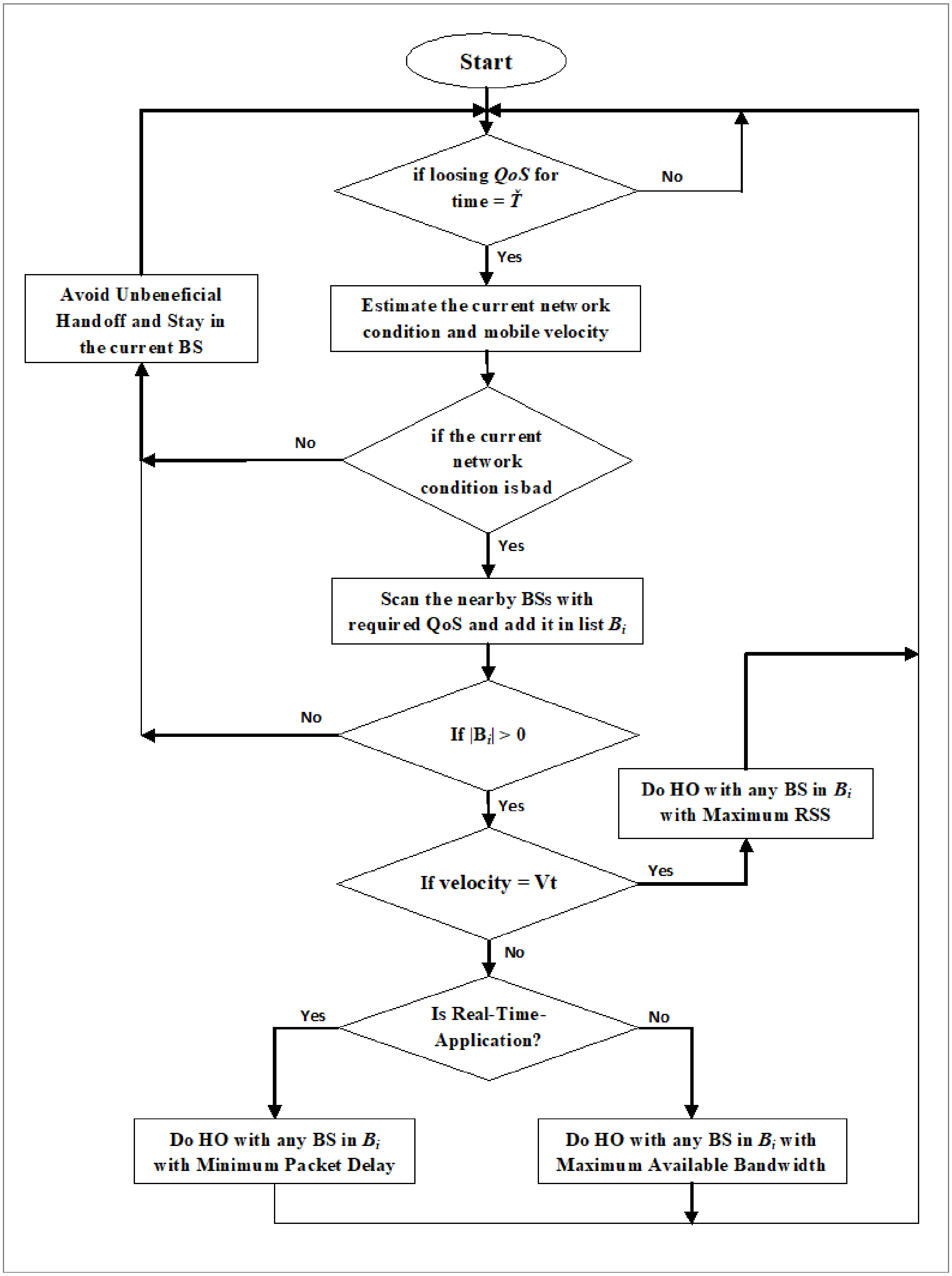

Fig. 2