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Efficient Network Selection Algorithm for Heterogeneous Networks

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ABSTRACT

Considering the need of better quality and more reliable network with appropriate data rate for a continuous and ubiquitous connectivity. The paper presents the reliability scheme for interworking of existing networks like Wireless Local Area Network (WLAN), Universal Mobile Telecommunication System (UMTS), Wireless interoperability Microwave Access (WiMAX) and Long Term Evolution (LTE) Network. The main objective is to define the network handover requirements based on the required parameters associated with the critical nature of Mobile User (MU) and following the optimum network selection technique that leads to a seamless connection without any distortion of all critical signals. An efficient scheme for selecting the best network based on required data rate, cost, received signal strength intensity (RSSI), reliability, coverage area and various parameters of a Mobile User (MU) that includes text, voice, video signals, surfing and downloading from internet is being approached for effective handover of network.

Keywords: Data Rate, Long term evolution(LTE), Received signal strength intensity(RSSI), Reliability, WiMAX.

I.INTRODUCTION

However, Communication technology has come a long way since its initial establishment in 20th century. It has witnessed a major growth with the exponential advancement in the area of communication and related technologies like multiple access networks and multimode terminals. As the communication technology has shifted from GSM (Global System for Mobile Communication) to a newer means such as WiFi (Wireless Fidelity), WLAN (Wireless Local Area Network), UMTS (Universal Mobile Telecommunications Systems), WiMAX (Worldwide Interoperability for Microwave Access) and LTE (Long Term Evolution System).It has become possible to transmit data at faster rate with least error, from one place to another. Wireless technology is one of the revolutionary advancements providing users with ubiquitous data and telephony access anywhere and anytime without any physical connection. The device with multi-mode terminals can be either be a setup with multiple radio interfaces or with one single reconfigurable interface [1] capable to communicate using any existing wireless access network protocol.

However, communication technologies also face the major challenges of connecting always, anywhere and anyone (3A) with the network. Further it is also a major challenge to select and implement the best suited network which can support the requirement of bandwidth, data rate, Signal-to-Interference-plus-Noise Ratio(SINR) and Received signal strength intensity(RSSI) for any application. None of the available remote access techniques can alone fulfill the wide diversity of channel and network requirement this attracts the designing and implementation of a network selection scheme in a heterogeneous network environment which can select the best suited or optimum network as per the user choice or need for an error free and reliable transmission of data.A variety of access network characteristics have been identified as potential network selection criteria [2] – [7].

Network Selection is a scheme of selecting the best suitable network for a seamless handover among a group of 'n' available networks. The concept of network selection among heterogeneous network evolved with the emergence of a wide variety of new wireless technologies. In our study we have kept our focus on WIFI, WLAN, WiMAX, UMTS and LTE. The reason behind selection of these four technologies for our model was the growing trend of use of these wireless technologies.With this paper, we aim to suggest a network selection method for medical data transmission, which will contribute to an efficient patient monitoring system in a heterogeneous environment. In this Paper we have proposed an algorithm that suggests the reduction in complexity and the number of handovers between different available networks to the user.

II.PROPOSED SCHEME OF NETWORK SELECTION

The system model of the proposed scheme consists of four modules:

(i) Network Discovery Module
(ii) Data collection module
(iii) Network list sorting module
(iv) RRT & ARTT Estimation module &
(v) Network selection module.

2.1 Network Discovery Module

The velocity of the MU has its physical property constraint, and the future speed is not affected by the previous one, we adopt gauss-Markov model as to describe the mobility model. In wireless environment, shadow fading and the MU's mobility may cause signal attenuation. In discrete time, the RSS is defined as (in dB)

$$RSS(t) = T*L - 10*\log(d) + \mu \qquad (1)$$

where t is the discrete time index, T is the transmission power of AP, L is the fixed pass loss, n is the pass loss factor, d is the distance between the MU and the AP in the WLAN, and μ is the shadow fading. The MU can communicate with the current network if the RSS value is above the threshold.

2.2Data collection module

The main aim is to choose among N several available networks, having *n* different QoS parameters, the one that meets the best application k € K's QoS requirements. Hence, for each application k, we frame this selection problem with a QoS decision matrix called U^k_{QoS}, defined as follows:

$$U^k_{QoS} = \begin{matrix} U^k_{11} & U^k_{12} & \dots & U^k_{1n} \\ U^k_{21} & U^k_{22} & \dots & U^k_{2n} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ U^k_{N1} & \dots & \dots & U^k_{Nn} \end{matrix} \qquad (2)$$

where n is the number of QoS attributes (in our case $n\tilde{}$ = 4) and $U_i{}^k{}_j$ represents the utility of the mobile user (MU) when choosing the alternative wireless network *i* with respect to the QoS attribute *j*. The main challenge faced by the heterogeneous wireless networks is to provide cost-effective services to the mobile users with guaranteed QoS and minimum handover rate. Here, selection of optimal network is based on parameters such as network conditions, MU characteristics, QoS requirements and user preferences. The proposed scheme is implemented with two main streams i.e.pedestrianusersandhigh velocityusers,inorderto enjoythebenefitsofdiversenetworks.Averagepedestrian speed, i.e., 1.6 m/s, is used to categorize the users. For pedestrian users, network selection is performed only based on multiplicative utility function consideringQoS(delayanddatarate),energyconsumptionand cost. However, for high velocity users (v > 1.6m/s),RRTandARTTarecalculatedinordertocheckforthenecessity ofhandover.IftheresidencetimeisgreaterthanARTT,thenahandoverisperformedtothetargetnetworkforhigh velocityusers.If the network through which the MU is connected shows the maximum utility function then it remains connected with the serving network to provide trade-off between service qualityandcontinuityinheterogeneousenvironment.

Whenever handover is initiated, multi-interface MT discovers available networks in the coverage area and collects the information about the network conditions (data rate, delay, cost and energy consumption) for the discovered networks, mobility characteristics, QoS profile and user preference. The two main functions of the algorithm are network evaluation using multiplicative weighted utility function and RRT estimation for the integration of UMTS, WiMAX and WLAN networks.

2.3Network list sorting module

Utility function from [8] determines the ability of the network to satisfy the QoS requirements of a particular service. It can be expressed mathematically as a function of attributes and user preferences. User preference reflects the importance of each metric in the selection process according to the requirements of running application (e.g., voice over IP, video streaming applications) and the type of user. In this work, a service-adaptive multiplicative weighted utility function is proposed, which exploits the S-shaped sigmoid function to model the elasticity of applications and to provide optimization among QoS, energy consumption and cost. The elementary utilities of decision metrics 'x' such as delay, data rate, energy consumption and cost of service are calculated using sigmoidal function [13] given by Eq. (3) with threshold value (xm) and lower (xl) and upper (xu) limits. For each application, there is a minimum and maximum requirement for each criterion (x). The maximum and minimum values of data rate for voice application are 64 and 32 kbps, respectively.

$$u(x)=\begin{cases} 0,\ x \le x_l \\ \dfrac{\left(\frac{x-x_l}{x_m-x_l}\right)^{\zeta}}{1+\left(\frac{x-x_l}{x_m-x_l}\right)^{\zeta}},x_l \le x \le x_m \\ 1-\dfrac{\left(\frac{x_\mu-x_l}{x_\mu-x_m}\right)^{\zeta}}{1+\left(\frac{x_\mu-x}{x_\mu-x_l}\right)^{\zeta}},x_m \le x \le x_\mu \\ 1,\ x \ge x_\mu \end{cases} \tag{3}$$

whereζ determines the user sensitivity to the variation of network characteristics according to the requirements of applications. It should be high for inelastic real-time application to show higher user sensitivity, but small for elastic non-real-time applications. Elementary utility value of QoS is calculated by combining the utility values of delay and data rate. Elementary utility values for the cost of service and energy consumption are also calculated for each network in order to achieve trade-off among QoS, cost and energy consumption during the network selection process.

The existing additive multi-criteria utility function is given by [9],

$$U(x)= \sum_{i=1}^{n} w_i\, u_i(x_i) \qquad ,\text{such that } \sum_{i=1}^{n} w_i = 1 \tag{4}$$

where 'i' is the number of criteria considered in the network selection and $w_i$are the user preference weights. From this utility model, it can be shown that

$$\lim_{u_i(x_i)\to 0} U(x) \ne 0 \tag{5}$$

2.3.1 Calculation Of Network Sorting Function Module

In this module Network Sorting Function(NSF) is calculated for integration of UMTS, WIFI, WLAN and LTE based on the user preference and other multiple attributes required for evaluating QoS.

The NSF is calculated using following formulae.

$NSF_{j} = W_d(1- Dj) + W_bB_j + W_rR_j + Wc(1-Cj)$ (6)

Where j=1,2,3…

2.4. RRT and ARTT Estimation module

As per paper [10] in order to calculate of residence residual time (RRT) and adaptive residence threshold time (ARTT) we first need to get velocity of mobile terminal(MT).

2.4.1 Calculation of Velocity of Mobile Terminal

The point C & E be the current and exit locations of MT in the network as shown in Fig. 2.1 and a straight line path is assumed for movement of MT. Points C & E are arbitrarily chosen with equal probability. Then, the angle θ_c and θ_e are uniformly distributed in the interval [0, π] and residue angle:

$$\theta = \theta_c - \theta_e \tag{7}$$

The distance is given by S using cosine formulae in Δ COE:

$$S = \sqrt{r^2 + d^2 - 2rd\cos\theta} \tag{8}$$

The RRT 't' of the MT in the network can be written as:

$$t = \frac{S}{v} \tag{9}$$

Here, 'v' is the velocity of MT.

Substituting (8) in (9), we get:

$$t = \frac{\sqrt{r^2+d^2-2rd\cos\theta}}{v} = g(\theta) \tag{10}$$

Thus, (10) gives the RRT of the MT in a particular access network. To estimate the ARTT, the PDF of't' should be calculated.

The derivative of g(θ), $g'(\theta)$, is obtained as follows:

$$g'(\theta) = \frac{rd\sin\theta}{v\sqrt{r^2+d^2-2rd\cos\theta}} \tag{11}$$

Using the theorem stated in Kay and Jay Kerns,:

$$f(T) = \sum_{i=1}^{no.of\ roots} \frac{f(\theta)}{|g'(\theta)|} \tag{12}$$

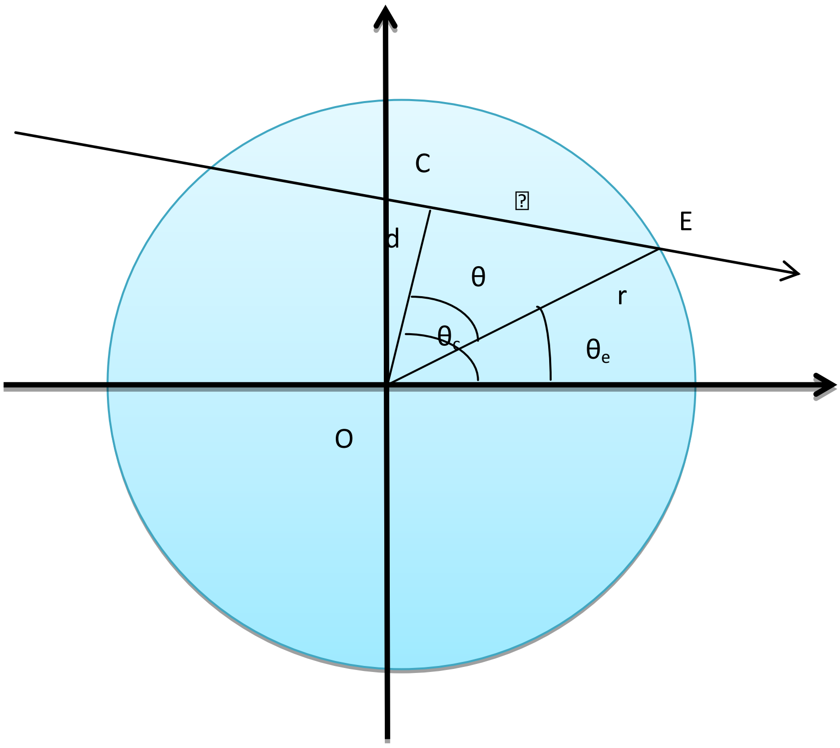

Fig 2.1. Schematic diagram of RRT calculation[12]

There is a single root for θ as θ lies in the interval $[0,\pi]$. Hence, substituting the value of θ from (10), f(θ) and g'(θ) is obtained as follows:

$$f(\theta) = \frac{2}{\pi}\left(1 + \frac{\cos^{-1}\left(\frac{r^2+d^2-v^2T^2}{2rd}\right)}{\pi}\right) \tag{13}$$

$$g'(\theta) = \frac{rd\,\sin\left(\cos^{-1}\left(\frac{r^2+d^2-v^2t^2}{2rd}\right)\right)}{vr^2+d^2-2rd\,\cos\left(\cos^{-1}\left(\frac{r^2+d^2-v^2t^2}{2rd}\right)\right)} \tag{14}$$

g'(θ) can be written as using [13],

$$|g'(\theta)| = \frac{\sqrt{4r^2d^2-(r^2+d^2-v^2t^2)^2}}{2v^2t} \tag{15}$$

Substituting (13) and (15) in (12), the PDF of RRT is obtained as,

$$f(T) = \frac{2v^2 t\left(1+\frac{\cos^{-1}(r^2+d^2-v^2T^2)}{\pi}\right)}{\pi r d\sqrt{1-\frac{(r^2+d^2-v^2T^2)^2}{(2rd)^2}}} \tag{16}$$

ARTT (T_1) is obtained as

$$T_1 = \frac{\sqrt{r^2+d^2-2rd\cos\left(-\pi \pm \sqrt{k_h^2+2\pi k_h+(2-P_h)\pi^2}\right)}}{v} \tag{17}$$

$$\text{where}\, k_h = \cos^{-1}\left(\frac{r^2+d^2-v^2T_{min}^2}{2rd}\right)$$

Using (14), ARTT (T_1) is calculated a function of velocity (v), minimum residence time MT in a network (T_{min}) and given value of P_h. Thus, the use of ARTT (T_1) as a decision metric minimizes the probability of handovers for high-velocity user.

2.5 Network selection module.

Check if Current network is same as the TOP of Stack, if condition is true handover is not performed. Else, next move on to estimation of Residence Residual Time (RRT) and Adaptive Residence Threshold Time (ARTT). After estimation we check condition if RRT is greater than ARTT. If it is true, the network listed at TOP of STACK is chosen else, the network at TOP is popped out and next network listed i.e; at TOP-1 is selected to estimate and check if value of RRT for the network is greater than ARTT or not.

III.PROPOSED ALGORITHM FOR NETWORK SELECTION SCHEME

The efficient algorithm for proposed scheme is shown below in the Fig. 3.1.

At first for initiation of the scheme networks are discovered, information about all the available heterogeneous networks whose signals are reachable to the MT is collected. The network list is prepared based on RSSI value. Next the information about velocity of mobile terminal is collected. Depending upon velocity of MT the preferable networks are selected from the list prepared earlier. If velocity of MT is greater than 1.6 m/s the networks with large coverage area are selected like UMTS and LTE. If velocity of MT is less than 1.6 m/s the networks with small coverage areas are also included like WIFI and WiMAX.

Utility Function Matrix is prepared for all the selected networks and after that Network Sorting Function (NSF) is evaluated. Based on NSF value the selected networks are sorted in a STACK in ascending order value. Then we check if Current network is same as the TOP of Stack, if condition is true handover is not performed. Else, next move on to estimation of Residence Residual Time (RRT) and Adaptive Residence Threshold Time (ARTT). After estimation we check condition if RRT is greater than ARTT. If it is true, the network sorted at

TOP of STACK is chosen else, the network at TOP is popped out and next network listed i.e; at TOP-1 is selected to estimate and check if value of RRT for the network is greater than ARTT or not.

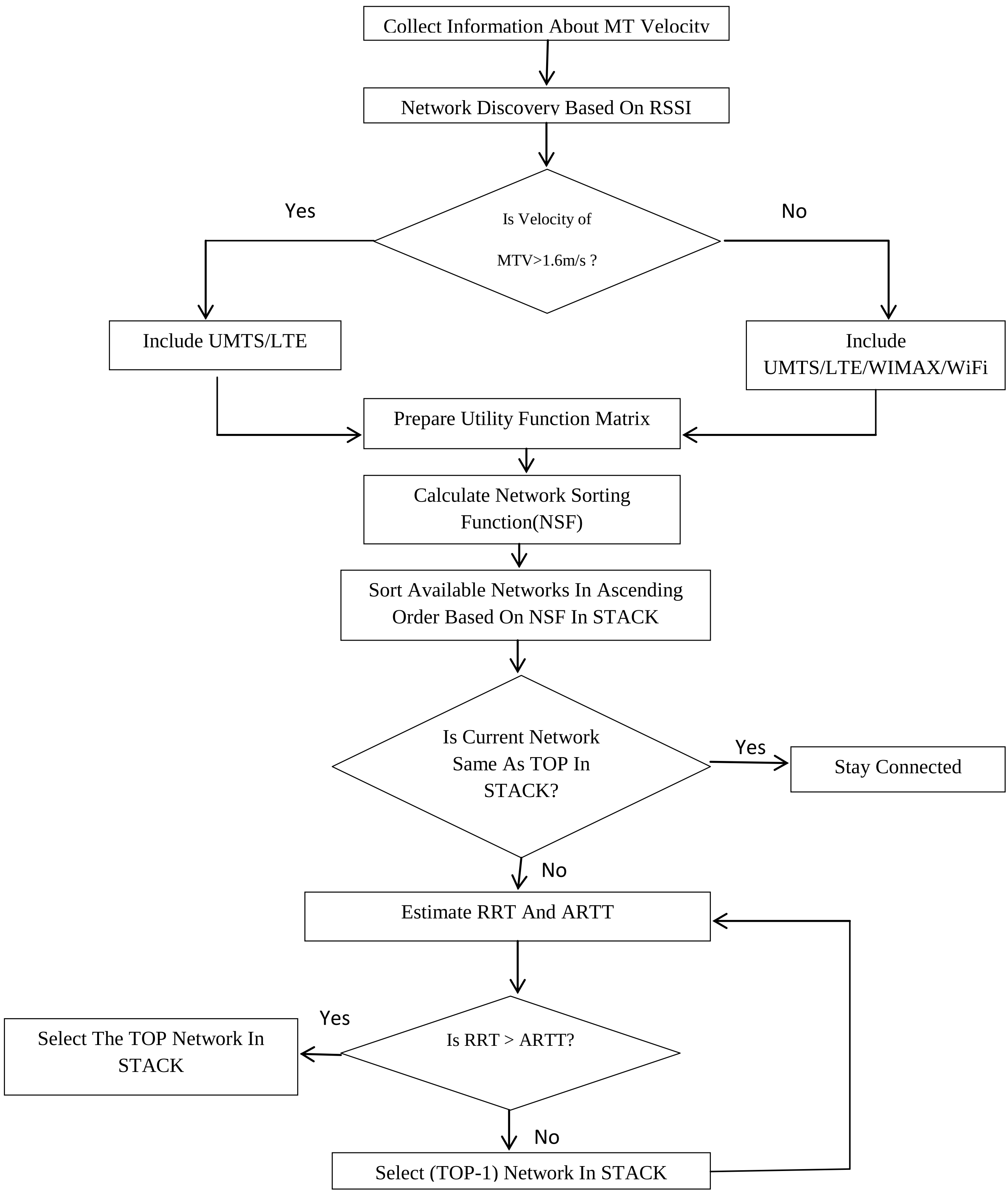

Fig. 2. Algorithm for Proposed Network Handover Scheme

IV. CONCLUSION

This paper suggests the selection of a more reliable network based on the velocity of MT, utility function, Network Sorting Function and RRT estimation. Depending upon the velocity of the Mobile Terminal (MT) and utility function, we proposed an algorithm to address the issue related with network selection and handover and effectively reduce the no. of handovers. The algorithm considers the discovery of all available networks based on RSSI measurement and then measure the velocity of MT. All the available networks are sorted in a stack in ascending order based on the Network Sorting Functions (NSF) value after that the best network is chosen.

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