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学 位 論 文 題 目 Fast Handover using Explicit Multicast for IPv6-based
Wireless LAN Networks

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論文内容の要旨

With the increasing of variable mobile terminals, more and more people desire to access Internet from anywhere, at anytime. However, current mobility support for Internet is insufficient to provide seamless service for real time multimedia traffic. Although there are many research works on the IP mobility enhancement, seamless handover is still big challenge for wireless LAN networks, since only break-before-make handover is supported in WLAN access technology.

Therefore, this thesis is devoted to improve the service performance for the multimedia traffic in wireless LAN networks. Firstly, IP-based networks and the corresponding terminology are introduced in this thesis. Then existing research works for IP-based mobility support are surveyed, and the existing problems to achieve seamless handover in wireless LAN are analyzed thereafter.

This thesis proposes an efficient seamless handover scheme -- Xcast Based Micro-mobility scheme(X&M) for the WLAN road information system. In this proposal, we use explicate multicast (X&M) routing to forward traffic and a new layer-2 trigger to get the information of list of potential access routers respectively. The information of the next potential access routers is need before hand when Xcast routing is applied. However, as in wireless LAN, mobile node cannot communicate with multiple access points at the same time, it is relatively difficult to have the information of the potential access routers for next handover. Therefore, the Service Set Identifier (SSID) of WLAN is used to map the link level information of the neighbor access routers to network level information. Xcast routing can provide the fast path (network layer) re-routing for the mobile node when handover occurs. Meanwhile, different SSIDs are assigned to denote different IP subnets, therefore, we can get the information of the potential access routers by their SSIDs. This solution offers a good method to achieve pro-active handover in wireless LAN. In addition, this new trigger can also be used in any case where the information of new AR is needed in wireless LAN networks. We also present a two-level mobility routing system based on our X&M scheme and IETF network mobility (NEMO) basic protocol to provide large bandwidth for dynamic networks. This system can be applied to the multi-homing networks, in which people may change the wireless access method even though the users do not actually move to new location. Our X&M scheme and NEMO protocol acts as mobility level one. The motion of the node behind mobile network is level two. The overall network architecture is also presented. Besides, an enhancement for mobility level two is proposed to contribute the overall end-to-end seamless handover. Finally, we validated the performance of our solutions by means of simulation, using NS-2, which required important enhancements to the publicly available code.

Our simulations are conducted under different wireless network conditions. First simulation scenario is wireless networks for road communication system. Handover latency and packet loss are focused in order to show the basic performance of our proposal. Our simulation results showed that our proposal can have nearly no handover latency and packet loss compared to other existing handover solutions without using link level information (HMIPv6 in our simulation). Meanwhile our scheme occupies small network bandwidth compared by handover enhancements applied by multicasting routing. Complicate wireless environment is also considered, where multiple wireless channels are available at the same time. Our simulation results show that our scheme can avoid packet mis-ordering problem since mobile traffic is buffered in new access router (as one of the potential access routers) before handover and then the buffered packets are delivered in sequence by

new access router in our scheme while packets are received by both old access router and new router respectively in fast handover enhanced HMIPv6 (FHMIPv6) scheme. Also our proposal has no packet loss, while FHMIPv6 scheme suffers with packet loss, since the slow establishment of the tunnel between old access router and new access router when handover happens too often. Simulations have also been conduct for two-level mobility. After analysis of the handover latency and packet loss performance, we conclude from the simulation that our proposed fast handover scheme can avoid traffic interruption by shortening the movement detection.

Finally, an abstract model of mobility framework is defined. The existing approaches can be denoted by one or several mobility frameworks. By the analysis of this model, we can classify the existing schemes easily and achieve better understanding of their merits and drawbacks, as well as our proposal.

論文の審査結果の要旨

本博士論文は、無線 LAN アクセス装置を備えた端末が複数の無線 LAN 設備を移動するとき、その端末の通信が極力途切れることなくスムーズに移動可能とする移動 IP 通信の研究に係わるものである。このような移動 IP 通信の研究に関して、従来から幾つかの実現方式が提案されているが、無線 LAN 設備を移動する際の IP パケットの消失や移動先での通信が復旧するまでの時間（ハンドオーバー遅延）等の性能において必ずしも十分な方式になっていない。近年の無線 LAN の急速な発展と VoIP 等のようなりアルタイム通信サービス要求需要の増大により、高速で高性能な移動 IP 通信の実現方式が求められている。

本論文では、先ず、従来から提案されている実現方式の問題点を明らかにし、これら問題点を解決すべく要素技術を抽出し、これらを効果的に組み合わせて移動 IP 通信を実現する一つの方式としてまとめ上げ、新しい方式を提案している。端末の移動先として可能性のある全ての無線 LAN をビーコン強度と SSID(無線 LAN を区別する識別子)を用いて事前にグループ化し、このグループ化された無線 LAN の全てに通信相手の通信を Explicit Multicast (Xcast) 技術を用いて事前に転送することによりスムーズな移動 IP 通信を実現している。

さらに本論文は上記方式の応用として、端末と無線 LAN 設備を収容するネットワークが同時に移動するネットワークモビリティの研究に発展させ、Xcast 技術を用いた 2 階層からなる移動 IP 通信方式を提案している。

提案方式の有効性の検証を、計算機シミュレーション実験を通して、ハンドオーバー遅延、移動中のパケット廃棄、網利用効率、ルーティング効率等の性能に関しての従来の実現方式との比較から行っている。網利用効率は、Xcast によるオーバーヘッドのため従来方式より劣る部分はあるものの、ハンドオーバー遅延とパケット廃棄に関しては、格段の性能改善が得られることを明らかにしており、価値のある結果を示している。

出願者は、本研究に係わる査読付きジャーナル論文と国際会議論文にそれぞれ 1 件と 3 件の発表を行っている。

本論文の提案内容は、新規性、有効性、信頼性が十分に備わっており、また学術的価値も十分に認められる。さらに、産業界への貢献も十分に期待できる。したがって、Lei Li 氏の博士申請論文は博士（情報学）を授与するのに十分な内容を備えていると判断した。