HCRAS: A novel hybrid internetworking architecture between WLAN and UMTS cellular networks

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Abstract—The seamless internetworking among various communication networks is in demand to provide anywhere, anytime connectivity with high data rate and enhanced service quality. In this paper, we propose a novel internetworking architecture between WLAN and UMTS cellular networks, Hybrid Coupling with Radio Access System (HCRAS), based on IPv6, Mobile IP, and Fast Handoff techniques. Inheriting loose coupling internetworking techniques, HCRAS utilizes IEEE 802.16 standard air interface to set up direct wireless communication between base stations in UMTS cellular networks and local WLAN. In particular, we propose two new algorithms for intersystem communications and vertical handoff management in HCRAS system. The HCRAS can dynamically distribute traffic among the internetworking networks and reduce signaling cost and handoff latency significantly. Through mathematical analysis and numerical results, it is shown that HCRAS outperforms the tight-coupling and loose-coupling in various scenarios in terms of system routing efficiency, signaling cost, and handoff cost.

Key Words—Network Architecture, internetworking, coupling, HCRAS, IPv6, Mobile IP, Fast Handoff

I. Introduction

Recent research has intensively focused on the next-generation communication systems that aim to meet the increasing demand for services with higher data rates and enhanced service quality. Instead of developing a new uniform standard for wireless communications systems, the next-generation communication networks strive to seamlessly integrate various existing wireless communication networks, such as wireless data networks and cellular wide area networks. As the most popular wireless data network, the wireless local area network (WLAN) is a cable replacement technology in which a mobile user can connect to a local area network (LAN) through a wireless (radio) connection. WLANs make use of unlicensed free frequency band to provide low-cost, high-data-rate wireless services in hotspots area such as school, airport, etc. UMTS is one standard of Third-Generation (3G) cellular systems, providing wide coverage and universal roaming service, but limited data rate up to 2 Mbps.

Though WLANs provide higher data rate than UMTS cellular network, they do not provide architecture beyond basic radio access, i.e., universal roaming ability. Thus, the integration of the two systems can combine their best features to provide ubiquitous access while mediating weakness of both systems. One major challenge in seamless integrating WLAN with UMTS cellular networks is the design of reliable, robust, and efficient internetworking architecture. Currently there are two major existing proposals for internetworking architecture, namely tight coupling and loose coupling.

As a direct integration scheme, tight coupling [1-3] connects the WLAN network to the rest of the core network in the same manner as other UMTS radio access technologies. From the view of UMTS core network, 802.11 WLAN service area works like another Serving GPRS Support Node (SGSN) coverage area. As a result, all the traffic, including data and signaling, generated in the WLAN networks, are injected directly into the UMTS core network. On the other hand, the loose coupling [1-3] approach separates the data paths for the 802.11 WLAN and UMTS networks. WLAN gateway connects to Internet and all data traffic is transmitted into the core Internet, while signaling may optionally go through either the UMTS network or through core Internet. Loose coupling is more preferable than tight coupling because loose coupling has less complexity in internetworking architecture and needs less revision in the configuration of core UMTS networks.

Although promising, both tight and loose coupling schemes have some inherent drawbacks in common. First, since all signaling and data transmission pass through either UMTS core networks or core Internet, this increases the burden of core networks and even results in bottleneck congestion or reconfiguration of network load when the interchanging traffic is too much. Second, when a coupling scheme is chosen, the routing for traffic is fixed or static. Although these routing schemes are stable in common situations, it may result in communication disruption if the only routing path breaks down or congests. Third, Mobile IP protocols [4] are adopted by both tight and loose coupling for terminal mobility management and handoff management. The
binding process between Home Agent (HA) and Foreign Agent (FA) introduces latency and packet loss during intersystem roaming, especially during the process of vertical handoff.

In this paper, we propose a novel architecture, Hybrid Coupling with Radio Access System (HCRAS) to resolve the above drawbacks. Based on loose coupling architecture, IPv6 technology, and radio access technique, HCRAS creates a new wireless link using IEEE 802.16 standard between base station (BS) in UMTS network and 802.11 WLAN within a same cell area. Based on this new architecture, two algorithms are developed for intersystem communications and vertical handoff management. In addition, the architecture is analyzed mathematically and numerical simulations are also conducted to validate the proposed architecture. Compared with the existing coupling techniques, HCRAS has advantages including dynamically reducing signaling cost and handoff latency due to the wireless communications and the adoption of a fast handoff technique [5], relieving the burden of core networks through dynamically distributing traffic in low level network, and enhancing the robustness of the integrated networks through adding a new wireless link between WLAN and UTRAN in UMTS networks.

The rest of paper is organized as follows: Section II describes basic design of HCRAS. Then, in Section III and IV, we present two new algorithms and the analysis for intersystem communication and vertical handoff in HCRAS. In Section V, numerical results are presented to compare performances of HCRAS with that of tight coupling and loose coupling. We conclude this article in Section VI.

II. Basic Design of HCRAS Architecture

HCRAS architecture adopts IPv6 technology, that is, both WLAN and UMTS cellular network considered are IPv6-based networks, and each element in the internetworking networks has a distinct ID number corresponding to the network routing address. Furthermore, we assume that the IP address of each mobile node (MN) also includes information of network infrastructure as shown in Figure 1.

Compared with the loose coupling, HCRAS, shown in Figure 2, creates a new air interface named WLAN-to-Cellular Inner-Cell Transceiver (WCICT) added to a WLAN. WCICT is in charge of receiving and transmitting data and signaling from and to the base station of the “macro” cell. Similar to cell hopping techniques [6], both WCICT and BS make use of IEEE 802.16 air interface to communicate directly between WLAN and RAN of UMTS cellular networks. Besides WCICT, the WLAN(s) also are equipped with a WLAN-to-Cellular Direct Controller (WCDC), which bridges WLAN router and WCICT. WCDC can translate radio signal into IPv6 data packets when receiving message from BS, and also translate IPv6 format data packets into base band signal when WLAN sends data to BS. In addition, WCDC can buffer and signal, originating from both WCICT and router in 802.11 WLAN, in Uranus-W when there is not enough bandwidth available for data transmission or when there is incoming handoff activity. In this way, Uranus-W can reduce packet loss rate and protect data packet in flight.

Based on this new HCRAS architecture, we are able to design the algorithms for intersystem communications and handoff. In following sections, two new algorithms will be presented and analyzed when compared with Tight Coupling and Loose Coupling in terms of costs.

![Figure 2. HCRAS architecture](image)

Figure 2. HCRAS architecture
III. Intersystem communications in HCRAS

In this section, we will show how HCRAS achieves intersystem data communications. We categorize the communication as two kinds: 1. U_WL calling process, in which an MN initializing a intersystem call is in UMTS cellular network and the correspondent node (CN) locates in WLAN; and 2. WL_U calling process, in which a call is initialized in WLAN and the CN is in UMTS cellular networks. In both situations, we assume the caller nodes have the knowledge of IP address of the destination nodes before starting a calling process.

Both processes are shown in Figure 3. In HCRAS, an MN can perform three types of intersystem communications: a. Intra-cell communications; b. Intra-RNC communications; c. Inter-RNC communications. In Intra-cell Communications, the calling node in WLAN is in the same macro cell as the CN, and the one-way traffic flows as follows: MN→WLAN→BS→CN. If the CN is not within the same cell, but in the same area managed by a RNC in UMTS network, we refer this communication as Intra-RNC communications. The one-way routing path can be expressed as MN→WLAN→BS→RNC→BS→CN, as RNC can transfer data packets to the destination cell (BS) directly within RNC serving area. If CN is neither within the same cell nor in the same RNC coverage, we call this Inter-RNC communications. In that case, Loose Coupling scheme is used: MN→WLAN→Internet→Core UMTS→RNC→BS→CN.

WLAN become dynamically distributed, that is, data and signaling can be transferred through wireless link or wired link, instead of only through core Internet or UMTS core networks. In this way, the burden of core networks can be reduced, and robustness of internetworking is also improved.

The intersystem communication cost for internetworking system is defined as \( C_{icc} \) which consists of two parts: the transmission cost of data packets \( C_s \), which is associated with the distance or link type between two network entities, and the processing cost \( C_p \), which is determined by each entity’s functionality and characteristics in internetworking networks.

\[
C_{icc} = C_s + C_p
\]

Correspondingly, transmission cost \( C_i \) for Intra-cell, Intra-RNC, and Inter-RNC communication is defined as \( C_{i,acc} \), \( C_{i,irs} \), and \( C_{i,rr} \) respectively. Similarly, the processing cost \( C_p \) for each type can be also expressed as \( C_{p,acc} \), \( C_{p,irs} \), and \( C_{p,rr} \) respectively. Similar to [7], those transmission costs (one way) per unit time can be expressed as following:

\[
C_{i,acc} = 3 \cdot \lambda \cdot \bar{K} \cdot \phi
\]

\[
C_{i,irs} = 2 \cdot \lambda \cdot \bar{K} \cdot \phi + \lambda \cdot \bar{K} \cdot \phi \cdot F_{RNC-BS}
\]

\[
C_{i,rr} = 2 \cdot \lambda \cdot \bar{K} \cdot \phi + \lambda \cdot \bar{K} \cdot \phi \cdot F_{WLAN-RNC} + F_{WLAN-UMTS} + F_{WLAN-UMTS}
\]

Where \( \lambda \) denotes the session arrival rate, which is assumed proportional to the density of MNs in a WLAN, \( \bar{K} \) denotes the average session size in the unit of packet, and \( \phi \) and \( \bar{K} \) are the transmission costs in a wireless and a wired link, respectively. \( F_{RNC-BS} \), \( F_{WLAN-RNC,UMTS} \), \( F_{WLAN,UMTS} \), and \( F_{WLAN,inter} \) denote the hop distance between a BS and corresponding RNC, Core UMTS network and RNC, Internet and Core UMTS network, and WLAN and Internet, respectively.

To derive total transmission cost in HCRAS, we further introduce the probability of each type of communication, as \( P_{acc} \), \( P_{irs} \), and \( P_{rr} \), respectively. The relationship of these probabilities goes as follows:

\[
P_{acc} + P_{irs} + P_{rr} = 1
\]

So the mean of total transmission cost \( C_{il} \) of HCRAS can be expressed as,

\[
E(C_{il}) = P_{acc}C_{i,acc} + P_{irs}C_{i,irs} + P_{rr}C_{i,rr}
\]

The one-way data packets route in Tight Coupling is: MN→WLAN→Core UMTS→RNC→BS→CN. Note that the route in Loose Coupling is the same as the route of Inter-RNC communication in HCRAS. Thus, the total transmission cost of Tight Coupling, \( C_{iT} \), and for Loose Coupling, \( C_{iL} \) can be expressed as,

\[
C_{iT} = \lambda \cdot \bar{K} \cdot (2\phi + \phi \cdot (F_{WLAN-UMTS} + F_{UMTS-RNC} + F_{RNC-BS}))
\]

\[
C_{iL} = 2 \cdot \lambda \cdot \bar{K} \cdot \phi + \lambda \cdot \bar{K} \cdot \phi \cdot (F_{WLAN-UMTS} + F_{UMTS-RNC} + F_{RNC-BS})
\]

where \( F_{WLAN-UMTS} \) represents the hop distance between Core UMTS network and WLAN.

Similar to [8], processing cost \( C_p \) in each type of communication includes de-capsulation of the IP packets from other nodes, checking its visitor list in local database to see
whether it has an entry for the destination MN, re-encapsulation of the IP packets, and management of routing packets. The load on Core UMTS network for routing packets depends on the number of MN in each cell, the number of BS, and the number of RNC. The cost of checking visitor list is proportional to the size of data table that is proportional to the number of MNs located in a certain service area. The routing cost is proportional to the logarithm of the number of lower level nodes. For instance, the routing cost for a RNC is proportional to the logarithm of all BSs located in its management area. For each infrastructure entity in internetworking network, we further define the cost of de-encapsulation of the IP packets from other nodes and re-encapsulation of the IP packets as self-processing cost, which is proportional to the session arrival rate.

We assume that the number of RNC in each Core UMTS network is \( N_{RNC} \), each RNC manages \( N_{BS} \) BSs, and the number of MN in each cell is \( N_{MN} \). Specifically, in fluid-flow model, \( N_{MN} \) can be express as follows:

\[
N_{MN} = \rho \cdot A_{BS}
\]

\[
A_{BS} = \frac{\sqrt{3}}{24} \cdot L_{BS}^2
\]

where \( \rho \) is the user density in a BS, \( A_{BS} \) is the area of a BS, and \( L_{BS} \) is the perimeter of cell coverage area (hexagonal shape). So for HCRAS, the processing cost can be calculated for intra-cell communications \( (C_{p-ar}) \), intra-RNC communications \( (C_{p-r}) \), and inter-RNC communications \( (C_{p-rr}) \) as follows:

\[
C_{p-ar} = \zeta_{WLAN} + \zeta_{BS}
\]

\[
C_{p-r} = \zeta_{WLAN} + \zeta_{BS} + \zeta_{CUMTS} + \zeta_{RNC} + \zeta_{BS}
\]

where \( \zeta_{WLAN} \), \( \zeta_{BS} \), \( \zeta_{CUMTS} \), \( \zeta_{RNC} \), and \( \zeta_{BS} \) represent the processing cost of WLAN, Internet, Core UMTS, RNC, and BS, respectively. Those processing costs can be further expressed as follows:

\[
\zeta_{WLAN} = \lambda \cdot \eta_{WLAN}
\]

\[
\zeta_{BS} = \lambda \cdot \eta_{BS}
\]

\[
\zeta_{CUMTS} = \lambda \cdot \eta_{CUMTS}
\]

\[
\zeta_{RNC} = \lambda \cdot \eta_{RNC}
\]

\[
\zeta_{int} = \lambda \cdot \eta_{int}
\]

\[
\zeta_{int} = \lambda \cdot \eta_{int}
\]

\[
\zeta_{int} = \lambda \cdot \eta_{int}
\]

Similarly, we can get the processing cost functions of Tight Coupling \( (C_{pT}) \), and Loose Coupling \( (C_{pL}) \):

\[
C_{pT} = \zeta_{WLAN} + \zeta_{CUMTS} + \zeta_{RNC} + \zeta_{BS}
\]

\[
C_{pL} = \zeta_{WLAN} + \zeta_{int} + \zeta_{CUMTS} + \zeta_{RNC} + \zeta_{BS}
\]

IV. Vertical handoff management in HCRAS

In contrast to Loose Coupling and Tight Coupling that use Mobile IP in handoff process, HCRAS adopts Fast Handoff and wireless access to achieve more efficient handoff with less latency and packet loss rate. Fast handoff uses L2 trigger to optimize the MN movements by anticipating incoming handover in advance. We assume that MN can detect nearby broadcasting signals from UMTS and WLAN networks before it initializes vertical handoff. Specifically, we use an improved Tunnel Based Handover algorithm [5] to achieve seamless vertical handoff between WLAN and UMTS networks. At the beginning of the handoff process in HCRAS, an MN continues to use its old CoA to communicate with its CN(s). A bidirectional wireless tunnel is created between BS and WCDC in WLAN. Therefore, incoming data packets intended for the MN can be forwarded from old network to new network via that wireless link between BS and WCDC, and then new network transfers them to the MN. Outgoing packets from the MN take the reverse path from new network to old network and then finally to CN(s). At the same time, the MN also uses same route to register its new CoA with its home agent (HA) to finish binding process. So in this way, MN can keep undisrupted communications with its CNs while doing binding process with its home agent and CN(s). Figure 4 gives the steps involved in handoff from WLAN to UMTS networks.

![Figure 4. Handoff from WLAN to UMTS networks](image)

The vertical handoff cost in integrated networks is mainly determined by handoff latency, which results from the new prefix discovery on the new subnet, the new care-of address establishment, and the time needed to notify the correspondents and home agent about the new locality of a MN (binding process). The handoff cost may consist of binding update cost \( C_B \), which is approximately equal to 1.5 round trip times between MN and its CN [7], and Signaling Processing Cost \( C_{P} \). In contrast to Loose Coupling and Tight
Coupling whose handoff latency is mainly due to delay for the binding process ($C_{BL}$ for Loose Coupling, and $C_{BT}$ for Tight Coupling), for HCRAS, there only exists $C'_{\rho}$, because MNs use wireless routing and Tunnel Based Handoff algorithm to realize vertical handoff causing no delay during binding process of Mobile IP.

We denote the average round trip time between MN and CN as $S_0$, and assume CN is located in UMTS network. Thus, $C_0$ equals to 1.5 times $S_0$. The vertical handoff can be classified into two situations according to MN’s mobility: a. MN moves from WLAN into UMTS core networks; b. MN moves from UMTS core networks into WLAN. For both Loose Coupling and Tight Coupling, the round trip cost of situation b is more than that of situation a, because the routing in situation b involves more intermediate nodes. Here we only consider the situation b, the worse case. In this case, the round trip cost of Tight Coupling ($S_T$) and Loose Coupling ($S_L$) can be calculated as follows:

$$S_T = 2 \cdot (2 \cdot \rho + \phi \cdot (F_{WLAN-CUMTS} + F_{SUMPS-CUMTS} + F_{SUMPS-RNC} + F_{BL}))$$

$$S_L = 2 \cdot (2 \cdot \rho + \phi \cdot (F_{WLAN-CUMTS} + F_{BL}))$$

The cost of handoff for HCRAS can be expressed as follows:

$$C'_{\rho} = P_{WLAN} + P_{BS}$$

where $P_{WLAN}$ and $P_{BS}$ are the average processing cost for fast handoff at WLAN and BS, respectively. We use Fluid-Flow Model to analyze MN’s mobility characteristics in and out of WLAN. We assume the coverage areas of a WLAN and a cell are both hexagonal as shown in Figure 2. We further assume the direction of an MN’s movement in a cell (including WLAN Area) is distributed uniformly in the range of $(0, 2\pi)$. Let $v$ be the average velocity of an MN. So the WLAN crossing rate can be calculated as follows:

$$R_w = \rho \cdot v \cdot L_{WLAN}$$

where $\rho$ is the user density in a WLAN, and $L_{WLAN}$ is the perimeter of a WLAN coverage area. Therefore, the handoff cost per MN can then be calculated for HCRAS ($C_{BL}$), Tight Coupling ($C_{BT}$), and Loose Coupling ($C_{BL}$), respectively, as follows:

$$C_{BT} = \frac{R_{WLAN} \cdot C_{BL}}{\rho \cdot A_{WLAN}} = \frac{R_{WLAN} \cdot 1.5 \cdot S_T}{\rho \cdot A_{WLAN}}$$

$$C_{BL} = \frac{R_{WLAN} \cdot C_{BL}}{\rho \cdot A_{WLAN}} = \frac{R_{WLAN} \cdot 1.5 \cdot S_L}{\rho \cdot A_{WLAN}}$$

$$C_{BL} = \frac{R_{WLAN} \cdot C_{BL}}{\rho \cdot A_{WLAN}} = \frac{R_{WLAN} \cdot 1.5 \cdot S_L}{\rho \cdot A_{WLAN}}$$

where $A_{WLAN}$ is the area of WLAN. For the hexagonal cell model, the $A_{WLAN}$ can then be calculated as follows [7]:

$$A_{WLAN} = \frac{\sqrt{3}}{24} \cdot L_{WLAN}^2$$

V. Numerical Results

In this section, we present various analysis results to evaluate the proposed architecture. Referenced from [7-8], the parameter values are shown in Table 1.

Table 1 System parameters for numerical analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\eta_{\text{BL}}$</td>
<td>10</td>
</tr>
<tr>
<td>$\eta_R$</td>
<td>10</td>
</tr>
<tr>
<td>$\eta_{\text{RNC}}$</td>
<td>10</td>
</tr>
<tr>
<td>$\eta_{\text{UMTS}}$</td>
<td>20</td>
</tr>
<tr>
<td>$\eta_{\text{int}}$</td>
<td>20</td>
</tr>
<tr>
<td>$P_{\text{BL}}$</td>
<td>4</td>
</tr>
<tr>
<td>$P_{\text{BS}}$</td>
<td>4</td>
</tr>
</tbody>
</table>

From (26), the handoff rate is sensitive to the user density in a WLAN. In addition, the data packets transmission cost is also prone to the variance of user density in a WLAN area. In Figure 6, the relationship between intersystem communication cost $C_{int}$ and user density $\rho$ is investigated. Here, $\lambda$, $\kappa$, $P_{\text{acc}}$, $P_{aw}$ are set as 0.1, 10, 0.1, 0.4, respectively. $C_{int}$ increases linearly as $\rho$ increases for all the schemes, HCRAS, Loose Coupling and Tight Coupling. Similar to Figure 5, the cost of HCRAS is less than that of both Tight Coupling and Loose Coupling. This result also verifies that HCRAS can reduce the signaling cost in both UMTS core network and Internet through dynamically optimizing signaling and traffic routing. Specifically, there is no signaling processing cost for HCRAS in Core UMTS networks or Internet in intra-cell, intra-RNC communication and vertical handoff.

As another component of performance metric, the total system cost $C_{tot}$ of each coupling scheme is defined as sum of intersystem communication cost $C_{int}$ and vertical handoff cost $C_{h}$:

$$C_{tot} = C_{int} + C_{h}$$

In order to analyze the total cost of all coupling schemes, a performance factor called the session-to-mobility ratio (SMR) [7,8] is introduced. The SMR expresses the relative ratio of the session arrival rate to the user mobility. In our fluid-flow model, the SMR equals to $\lambda / R_{WLAN}$. Figure 7 shows the impact of SMR on total cost. The user density is 0.001. We
keep $\lambda$ unchanged and increase SMR by decreasing MN’s average velocity $v$ in WLAN. When SMR is less than 1, all coupling schemes have larger total cost. This is because the handoff cost becomes dominant factor when mobility rate higher than the session arrival rate. So it is more important to reduce the handoff cost than to reduce the intersystem communication cost when average velocity of MN is higher. It is also shown that the cost of HCRAS is much smaller than two other existing coupling schemes. Thus, it is better for us to deploy HCRAS that can dynamically adapt to the change of internetworking context by distributing traffic in lower level of networks without incurring system cost in binding process.

In terms of traffic routing, it is necessary to investigate the distribution of intersystem communication traffic. The impact of probability of intra-cell communication on the HCRAS intersystem communication cost is investigated. $\lambda$, $K$, $v$, and density are defined as 0.1, 10, 2m/s, and 0.0005, respectively. Figure 8 shows that the intersystem communication cost of HCRAS decreases when the probability of intra-cell communications increases. It is also shown that intersystem communication cost decreases when the probability of intra-RNC ($P_2$ in Figure 8) increases. This is because the more intra-cell or intra-RNC communications take place, the less data traffic and signaling are forwarded to core networks. Again, this figure demonstrates that HCRAS wireless routing can not only improve the efficiency of signaling and data transmission, but also dynamically adjust the burden of core UMTS networks according to calling types.

In former discussions, all results are based on fixed area of WLAN ($L_{WLAN} = 50m$) and the area of a cell in UMTS networks is much larger than that of a WLAN. In figure 9, we investigate the characteristics of HCRAS under the effect of changing perimeter of WLAN. Here, the HCRAS system costs include total cost, total handoff cost, and total intersystem communication cost. We examine those costs as a function of different MNs. To characterize an MN’s mobility, different average velocities are used. In the case of fluid-flow mobility model, the average velocities of the static MNs (2m/s) and dynamic MNs (30m/s) are used in Figure 9 (a) and Figure 9 (b), respectively. The total cost of HCRAS in both cases increase when the service area of WLAN, which is proportional to square of WLAN perimeter, increases. For more dynamic MN ($v=30m/s$), the total cost is dominated by total handoff cost because of high handoff rate, as shown in figure 9 (b). The total cost function is approximately linear like the total handoff cost function. However, for static situation ($v=2m/s$), the total intersystem communication cost dominates total cost of HCRAS, as shown in Figure 9 (a). This is because vertical handoff becomes less frequent when MNs stay in WLAN instead of fast roaming. Therefore, the total cost function shows the nonlinear characteristic following intersystem communication cost function.

VI. Conclusion

In this paper, we propose a novel hybrid internetworking architecture, HCRAS, for internetworking between WLAN and UMTS cellular networks. HCRAS utilizes IEEE 802.16 standard to achieve direct communication between base stations in UMTS cellular networks and WLAN. Therefore, both Intra-cell and Intra-RNC communications can use the wireless link to establish direct communication without routing the singling and data traffic to the core networks. HCRAS presents a more efficient, robust and reliable solution for integration of WLAN and the UMTS cellular networks through wireless link. In addition, we also propose two new algorithms for intersystem communication and vertical handoff between WLAN and UMTS networks, based on Fast Handoff and IPv6 technology. The analysis and numerical results show that our internetworking scheme outperforms the tight-coupling and loose-coupling for various scenarios in terms of system routing efficiency, signaling cost, and handoff cost.

References