Designing a Novel Unlicensed Nomadic Access Relay Station in IEEE 802.16-based Wireless Access Networks

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Introduction

- Broadband wireless access network (BWAN) technologies provide mobile high-speed services in recent years
  - WiMAX – IEEE 802.16
  - WiBro – IEEE 802.16 based

- BWAN service providers expect WiBro provide service with much **lower cost** and **higher data rate** than 3G

- However, BWAN is not likely to totally replace the existing wireless technology, such as WiFi
  - Due to lower cost and high-speed in LAN
Introduction

• WiFi mesh (802.11s) is developed to build a wireless mesh network using WiFi
  – Extends the service coverage of Wi-Fi network
  – Backhaul links is still an issue

• Some of studies lately goal to build a wireless mesh network using WiFi for user access link and WiMAX for backhaul link
  – Satisfy user in terms of data rate and cost
Motivation

• BWAN and WLAN Coexistence
  – WLAN and BWAN are developed for different service usage models
    • Alternative wireless solution to Ethernet cables and xDSL/cable modems
  – Compared with 3GPP Unlicensed Mobile Access (UMA) technology, BWAN coexisted with WLAN can provide lower cost service
    • Single mode vs dual mode
    • Service provider-oriented vs user-oriented
Motivation

- A novel **service provides-oriented** unlicensed nomadic access (UNA) relay station is proposed in WiBro access network
  - Individual unlicensed user can be visible and managed at the core network side
    - For QoS, access control, and billing
  - The relay station connects unlicensed band user terminal and core network using connection ID (CID)
    - CID is defined to manage each of service (traffic) flow within WiBro system
- WiNERS
  - **WiBro unlicensed Nomadic access Relay Station**
Motivation
Related Works

• Connection sharing using NAPT
  – NAPT is a popular technique to avoid the lack of public IP address
  – In WLAN-BWAN coexisted network, service flows form individual users are not manageable for access control, QoS, and billing
  – The network system should be modified to recognize each of the WiFi user at core network side
    • The NAPT basically is not designed to distinguish each of users at external network side
Related Works

NAPT-based WiFi user Traffic Forwarding Concept

Issues:
1. NAPT-based access router needs to report the internal address associated with each of user’s service flow – **signaling overhead**
2. Core network needs to setup a table of identification given by NAPT router dynamically – **maintenance overhead**
3. Every incoming and outgoing packet will be inspected to find out where it belongs – **processing overhead**
Related Works

WiBro Dynamic Service Addition Flow Sequence

a) MS-Initiated
CID : Connection Identification
SFID : Service Flow Identification
DSA : Dynamic Service Addition

b) ACR-Initiated
RAS : Radio Access System
ACR : Access Control Router
Description of WiNNERS

- **Concept**
  - Design and implement a service provider-oriented relay station
  - Equipped with at least two radio interfaces
Description of WiNNERS

WiNNERS constructs a virtual tunnel from ACR at the core network side to individual user terminal.
Description of WiNNERS

WiBro Connection Manager (WCM)

CID-UNA Mapper (CM)

WiBro-UNAConn. Initiation Manager (WCIM)

QoS Control

UNA Connection Manager (UCM)

Ethernet

WiNNERS Functional Block Diagram
Description of WiNNERS

- **UNA Connection Manager (UCM)**
  - Serves as an WiFi AP and WiBro connection initiation requester
  - Takes care DHCP

- **WiBro-UNA Connection Initiation Manager (WCIM)**
  - Relays WiBro connection request to WCM
  - Asks for CID reply

- **WiBro Connection Manager (WCM)**
  - Takes care WiBro connection setup process
  - Passes requested CID to WCIM

- **CID-UNA Mapper (CM)**
  - Maintains 1-to-1 mapping table of CID and each WiFi user terminal
Description of WiNNERS

• In WiNNERS, each WiFi user can be registered as a new WiBro network subscriber
  – QoS level can be offered based on service level agreement
Inter-connection Setup Flow in WiNNERS
Description of WiNNERS

- CID-to-ID Mapping for the use of Private IP Address
  - Unlike the NAPT-based router, port translation is done on the ACR side
  - XOR operation
    - $x \oplus y = y' \rightarrow x \oplus y' = y$
  - Proposed operation
    - $CID_j \oplus sp_i = xsp_i \rightarrow CID_j \oplus xsp_i = sp_i$
      Where $sp_i$ is source port $i$ given to a service flow at user side and $xsp_i$ is a new port number generated for $sp_i$ by XOR port translation
Service Flow Management in WiNNERS (in case of Private IPv4)

- ACR maintains an xspi-to-CIDi mapping table without including the original port number.
- ACR uses xspi as a key to find out which CID to be used.
Discussion for Proposed Relay System

- Samsung are currently developing WiFi wireless mesh network gateway with a WiBro backhaul link and WiFi user access link
Discussion for Proposed Relay System

• Mobility
  – When MS moves to an adjacent cell, the system transfer all transport CIDs belonging to the MS to the adjacent cell
    • MS does not have to reinitiate network entry process

• Multicast
  – Multicast service is also based on CID management in WiBro and can be also applied
Conclusions

• A service provider-oriented relay system is developed
  – Called WiBro unlicensed nomadic access relay station (WiNNERS)
  – Goals to provide the service providers with the capability to directly manage individual unlicensed band users
  – Makes WiFi business model more lucrative
  – Realize WiBro-WiFi interworking with minimum modifications