Mobility Support for IEEE 802.16d Wireless Networks

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Outline

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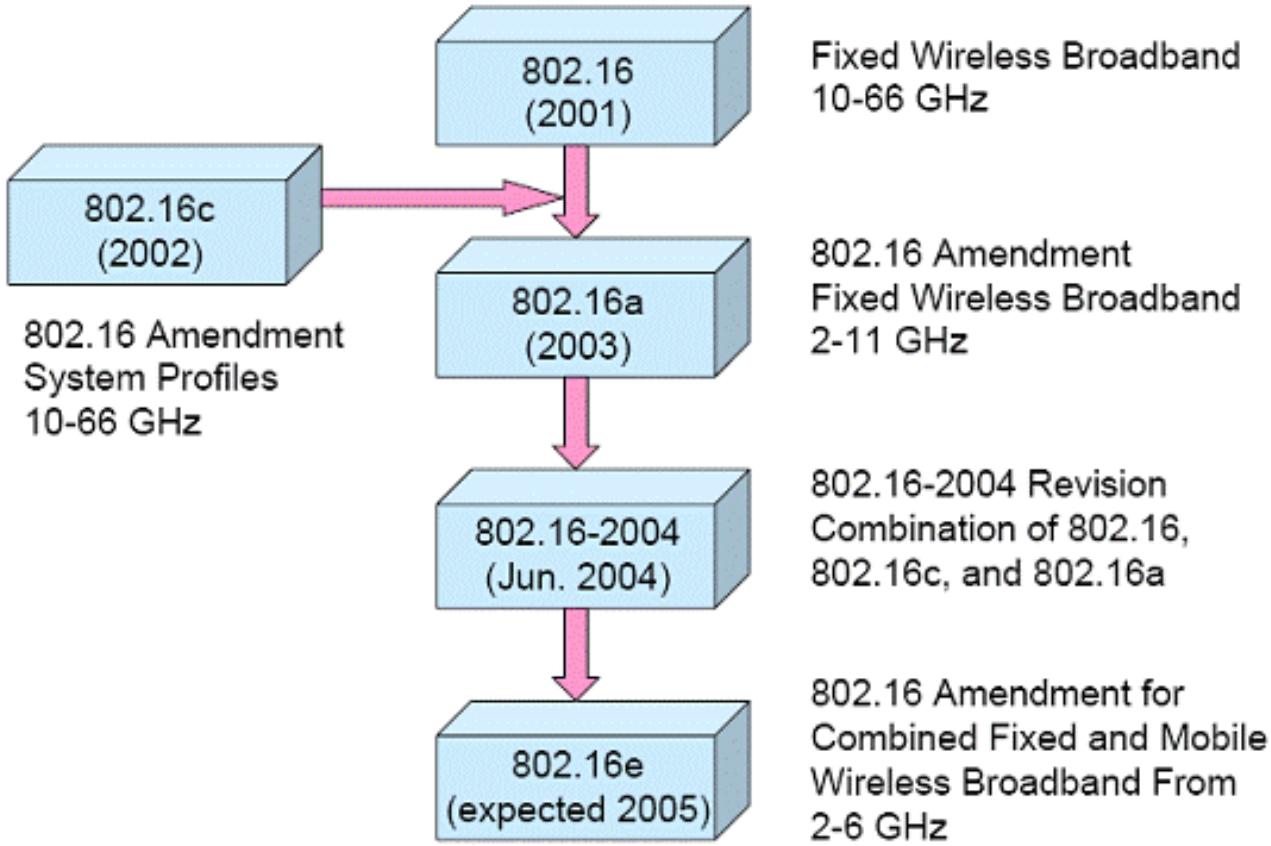
WiMAX Brief

- 802.16-2004 has been proposed to provide last-mile connectivity to fixed locations by radio links
- Commercial usage
  - Fixed access (eg. Cable modem and xDSL)
  - MAN (eg. Big hot spots)
  - Wireless mobile system (Inter-cell hand-offs)
- Provides the rate up to 75Mb/s
- Expectation
  - Integrate portability into Notebook in 2006
  - Integrate mobility into handset in 2007

802.16 Standard Evolution



Introduction

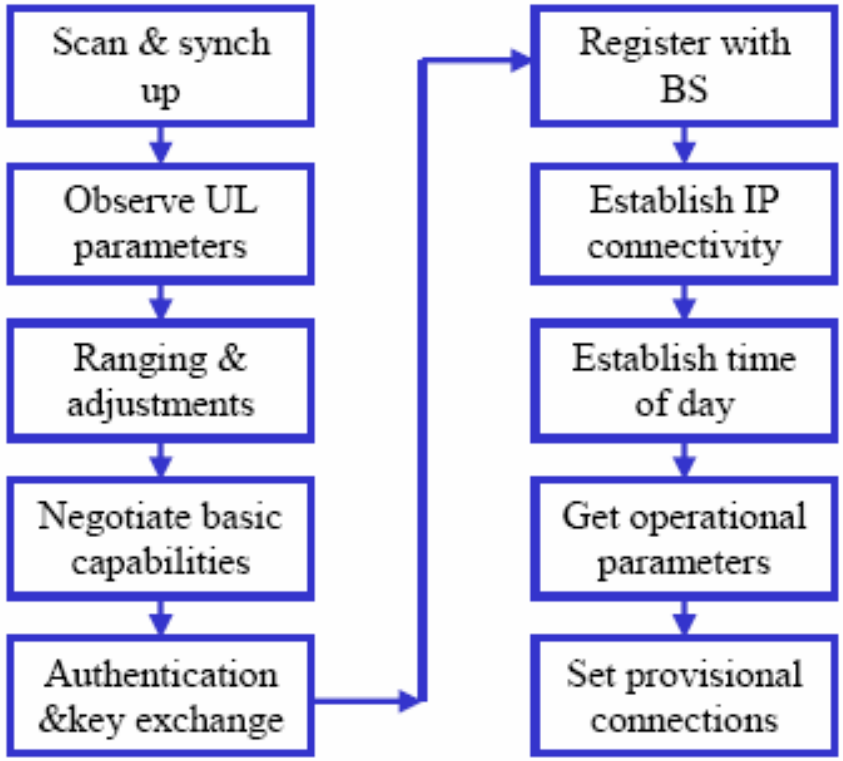
- Target
  - Provides the mobility supported by the 802.16d network without any change in the specification
- Motivation
  - 802.16d devices will be widely deployed in the field before the 802.16e standard is finalized
- Mobility capability issues
  - Connection handoff
  - Correct reception for moving terminals

Introduction

- Seamless connection handoff in the 802.16d standard by

  - Applying some of the existing functionalities defined for the terminal initialization process
  - Devising a set of protocols for message exchanges for handoff
  - Forwarding some of the operational parameters from the current base station to a new one via the backhaul network, instead of over the radio link

Initialization Process for 802.16d



Functionalities for Connection Handoff

- Eliminate unnecessary steps in the initialization process to obtain the functionalities required by connection handoff

  - Assumed that the current BS and the new BS involved in the handoff have identical capabilities ~~(step4)~~

  - User re-authentication and encryption keys can be achieved by exchange of control messages in the backhaul network (~~step5~~)

Functionalities for Connection Handoff

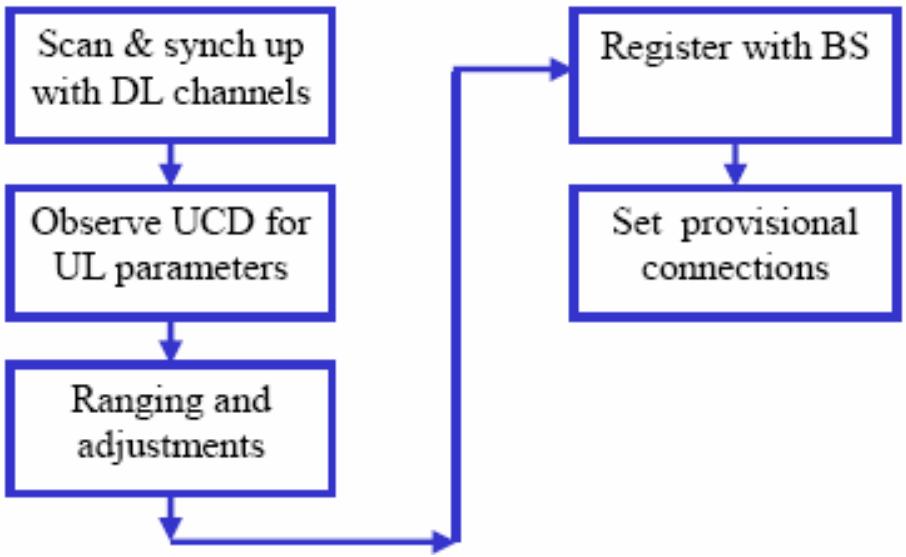
- The same IP connectivity is maintained by use of HMIP in spite of handoff, one can avoid the need for reestablishing a new IP connection ~~(step7)~~

- As the existing IP connection remains unchanged, there is no need for the SS to receive new operational parameters ~~(step9)~~

- Assume that BSs are synchronized, it is unnecessary for the SS to re-establish time of day as part of the handoff process ~~(step8)~~

Functionalities for Connection Handoff

- The handoff procedure actually represents a “short” initialization process



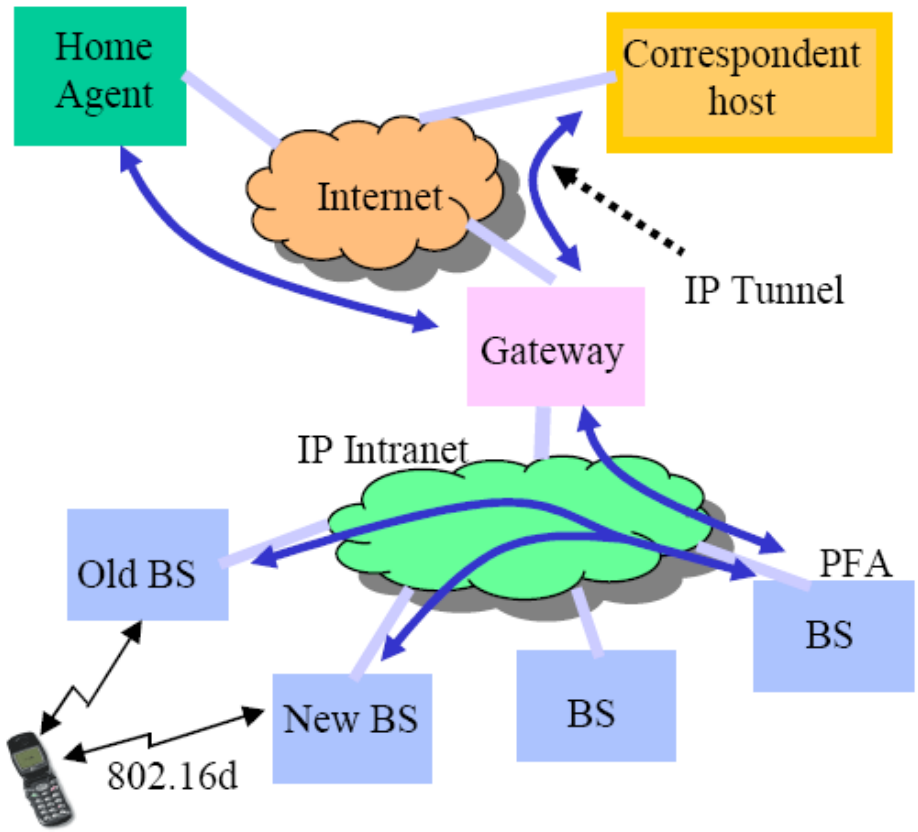
Latency for the Handoff Procedure

- Assume
  1) 7 msec per frame (which is a medium frame length)

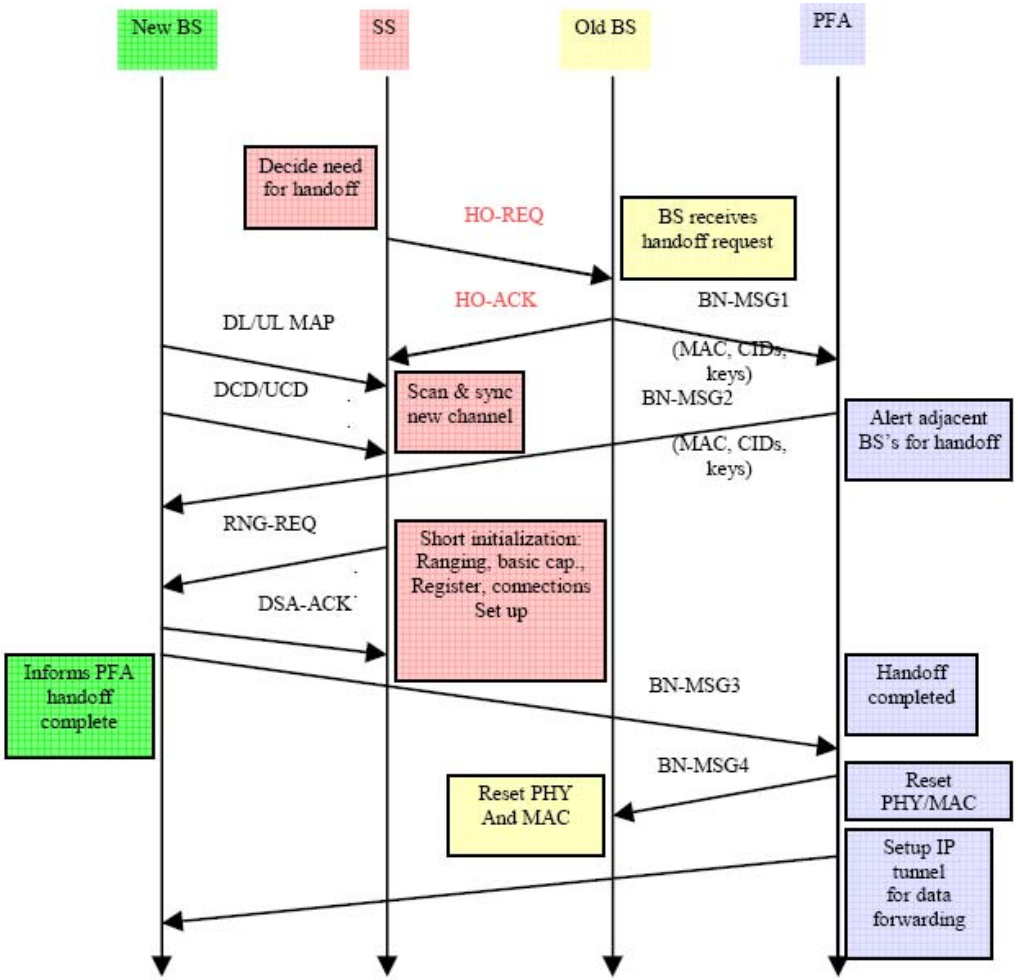
  2) Messages can be processed and responding messages can be sent in the next frame

Functions	Message exchanged		Delay (for 7 ms/frame)	
	SS	BS	Number of frames	msec
Synch up with DL channels	-	-	5	35
Observe UL parameters	-	-	5	35
Ranging & adjustment	2x RNG-REQ	2x RNG-RSP	4	28
Registration	REG-REQ	REQ-RSP	2	14
Establish connections	DSA-RSP	DSA-REQ, DSA-ACK	3	21
Total handoff latency			19	133

Hierarchical Mobile IP for 802.16d Network



Handoff Protocol and Message Exchanges



Use of Existing Message to Request and ACK Handoff

- Reuse an existing message, the De-registration Command (DREG-CMD) with action code of 03, to serve the place of the HO-REQ and HO-ACK messages.
- Why?
  - DREG-CMD message:

    Shall be transmitted by the BS to force the SS to change its access state

    If the action code is 03, the SS shall return to normal operation and may transmit on any of its active connections

Use of Existing Message to Request and ACK Handoff

- Advantages for choosing DREG-CMD (code=03) message:
  - No adverse effects
  - Supported by mixed SSs and BSs with or without the new handoff capability

Handoff Latency Requirement

- The frequency of handoff depends upon the speed of the SS
- Assume that the terminal must complete handoff in overlapping area, then the connection is dropped
- Assume that the cell radius is 1 km and that there is a 5% overlapping area of two adjacent cells, and distance d km between the bases

$$\frac{2}{\pi}\left[\cos^{-1}\left(\frac{d}{2}\right)-\left(\frac{d}{2}\right)\sqrt{1-\left(\frac{d}{2}\right)^2}\right]$$

Handoff Latency Requirement

=> d=1.75 km

The maximum total distance over which the handoff must be completed is 250 m.

- For the maximum supported mobile speed of 40 km/h (with a BER of 0.002% or less and QPSK modulation) we see that the handoff must be completed within 22.5 sec
- Thus, such a requirement can be easily met

Conclusions

- The 802.16d standard can intrinsically support terminal mobility without any change in the specification, although its original intent is to provide the last-mile connectivity to fixed locations.
- As the 802.16d devices will be widely available in the near future, our proposed techniques can be applied to enable mobility capabilities for the ‘legacy’ devices, regardless of the final acceptance of the new 802.16e standard

References

- A. Campbell, et. al., “Design, implementation, and evaluation of Cellular IP,” *IEEE Personal Communications Magazine*, August 2002, pp 42-49.
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- I. Koffman and V. Roman, “Broadband Wireless Access Solutions Based on OFDM Access in IEEE 802.16,” *IEEE Commun. Mag.*, April 2002, pp. 96-103.