CLEAR and 4G WiMAX

Overview for IEEE ComSoc SCV

February 10, 2010

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Agenda

• Introduction and Network
• Developer Enablement
  – Open Devices
  – Location
  – Session Information
  – Video/Media
  – QoS
• Developer Resources
  – Innovation Network
  – Developer Workshop
  – Developer Website
• Panel/Q&A
Agenda

- Introduction and Network
- Developer Enablement
- Developer Resources
- Panel/Q&A
Clearwire Introduction

• A growing nationwide wireless broadband 4G network
  – 25 markets and 30 million people in coverage by end of 2009
  – 80 markets and 120 million people covered by end of 2010
• One 4G network, many brands
  – Clear, Sprint, Comcast, Time Warner, and Bright House
• Nationwide 2.5GHz spectrum holding with an average
  of 150 MHz spectrum per market
• Multiple rounds of billion dollar funding
  – $3.2 billion in funding and resources in 2008 from Sprint,
    Comcast, Intel, Time Warner, Google, and Bright House
  – $1.5 billion more from Sprint, Comcast, Time Warner, Intel,
    Bright House, and Eagle River
  – $920 million just announced in additional debt financing
CLEAR Across America

120 Million POPs across 80 Markets in 2010

Market

<table>
<thead>
<tr>
<th>Market</th>
<th>POPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>2</td>
</tr>
<tr>
<td>Chicago</td>
<td>3</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>4</td>
</tr>
<tr>
<td>Washington D.C.</td>
<td>5</td>
</tr>
<tr>
<td>Houston</td>
<td>6</td>
</tr>
<tr>
<td>Atlanta</td>
<td>7</td>
</tr>
<tr>
<td>Dallas/Ft. Worth</td>
<td>8</td>
</tr>
<tr>
<td>Boston</td>
<td>10</td>
</tr>
<tr>
<td>San Francisco Bay Area</td>
<td>12</td>
</tr>
<tr>
<td>Baltimore</td>
<td>18</td>
</tr>
<tr>
<td>Seattle</td>
<td>19</td>
</tr>
<tr>
<td>Portland</td>
<td>28</td>
</tr>
<tr>
<td>Las Vegas</td>
<td>40</td>
</tr>
<tr>
<td>Charlotte</td>
<td>43</td>
</tr>
<tr>
<td>Honolulu</td>
<td>68</td>
</tr>
</tbody>
</table>

Clearwire Commercial Roll Out

- Blue: Launched 2009
- Green: Launching 2010

Clearwire Spectrum Holdings
# A Next Generation Network

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>True broadband speeds with mobility and metro coverage</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>Spectrum capacity to deliver true mobile broadband experiences</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Next gen standards based on OFDM technology, designed to deliver multi-megabit speeds to the end user device</td>
</tr>
<tr>
<td><strong>Network</strong></td>
<td>All-IP network, low cost, simple, low latency – superior mobile performance</td>
</tr>
</tbody>
</table>
**A Next Generation Network**

<table>
<thead>
<tr>
<th></th>
<th>CLWR 802.16e</th>
<th>Carrier #1 EVDO - A</th>
<th>Carrier #2 EVDO - A</th>
<th>Carrier #3 HSPA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak Rates</strong></td>
<td>19 Mbps</td>
<td>2.4 Mbps</td>
<td>2.5 Mbps</td>
<td>1.9 Mbps</td>
</tr>
<tr>
<td><strong>Mean Rate</strong></td>
<td>6.5 Mbps</td>
<td>0.7 Mbps</td>
<td>0.9 Mbps</td>
<td>0.9 Mbps</td>
</tr>
<tr>
<td><strong>Mean Latency</strong></td>
<td>83 ms</td>
<td>168 ms</td>
<td>201 ms</td>
<td>354 ms</td>
</tr>
</tbody>
</table>

Note: Drive tests were conducted at off-peak hours to minimize loading effects.

Location: Portland, OR  
Drive route: 17 miles  
Drive time: 30 min  
Average Speed: 35 mph  
Max Speed: 55 mph

*1* [Clearwire Mobile WiMAX](#)

150 MHz *(2.5 GHz)*  
4G WiMAX  
85 MHz *(1)*  
3G  
60 MHz *(1)*  
700 MHz
Agenda

• Introduction and Network

• Developer Enablement
  – Goals
  – Open Devices
  – Location
  – Session Information
  – Video/Media
  – QoS

• Developer Resources
• Panel/Q&A
Developer Enablement Goals

- Clear’s vision is a network that provides for customers the next generation of mobile, broadband services that leverage Clear’s speed and capacity.

- Our model is based on an open network that will attract innovative developers and OEMs:
  - Open to all kinds of services
  - Open to all kinds of devices (WiFi-like certification model)

- We are also working to open the network itself, giving applications and services the ability to interact and work with the network to optimize the customer experience.

- Today I am going through some of the network services we are providing and some we are working to provide. But we are also very interested in your feedback on what you want from the network as well.
Open Network for Open Devices

- WiMAX is an open network standard like WiFi
  - Any device can be certified through the WiMAX Forum
  - Devices don’t have to come from the carriers
- WiMAX handsets should start arriving in 2010
  - More devices to come in 2011
- So our APIs need to work across all kinds of devices
Location

• Our goal is to ensure that location is easily accessible on all WiMAX devices and that application/web developers are taking advantage of this ubiquitous access

• We are approaching this goal in several ways
  – Client/server service that can be used by an applications on any WiMAX device to determine “where am I”
  – Server/server service that supports “where are they” for more advanced use cases like geo-fencing and tracking
  – Enabling location in the browser (Chrome, Firefox, IE)
  – Working with existing location providers to also use WiMAX for their location results
Location on WiMAX

- Location is calculated based on the device’s cell sector
- Works for any device (no GPS or client hardware needed)
- Response is a lat/long for the sector centroid (400-800 meters accuracy)
  - Plan to improve accuracy through “multilateration” (150-200 meters)
- Sub-second response time
- Excellent battery performance
- Being offered under a free business model
Location - Client/Server API

• Lightweight JSON/HTTP service that allows client applications on devices to query their location (“Where am I?”)
  – Implementation matches the Google Geolocation API Network Protocol
• Response includes the Lat/Long and can include the address if requested
• Usage is free subject to terms of service

• Browser Support
  – Currently can be accessed through Google Gears
    • Requires adding Clear Location Provider to provider’s list using JavaScript fragment
  – Working on adding direct support for Gears, Firefox, and other browsers as well

```javascript
g�oolocation.getCurrentPosition(successCallback, errorCallback, {
gerarsLocationProviderUrls:
  ["http://testlocation.clearwire-wmx.net:8000/json/"
  ,"http://www.google.com/loc/json"]
});```
Location - Server/Server API

• Allows a server to query and track a device’s location using its IP address or MAC address (“Where are they?”)
  – Follows ETSI standard Parlay X 9 specification (SOAP/HTTP)
• Response includes the lat/long
• Web servers can query location based on the IP address of the client (regardless of the browser or client type)

• Authentication/Access
  – Utilizes secure mutual certificate authentication
  – Usage is free subject to terms of service
  – Terms of service include requirement for user opt-in
Our goal is to expose knowledge about the network to applications and services so they can better optimize their usage of the network and improve the end-customer experience.

Example Use Cases
- **Device and Connection Management (Apps and OS integration)**
- **Location Information**
  - Use BSID to determine location (neighboring BSID increases accuracy through multilateration).
- **Network Adapting Applications**
  - Video and other applications can preemptively adjust their network usage based on RF information (RSSI, CINR)
- **Diagnostics Collection and Reporting**
Session Information – Fields and Uses

These is some of the session information we are working to expose:

- Sector ID (BSID)
- Signal strength (RSSI)
- Signal quality (CINR)
- Transmit power (txPWR)
- Connection Management

We are approaching this goal in several ways:

- Standardizing and promoting a common API (CAPI) across chipsets and OSs for accessing the session information
- Connection Manager reference implementation
  - Open source running on several chipsets and OSs
- Longer term we are thinking of ways to expose session information at the server level
Session Information - Common API (CAPI)

• Provides a documented API for accessing session information
  – Connection Managers can use “read write” mode to control the chipset
  – Other applications can concurrently use “read only” mode to access session information
Session Information – CAPI Current State

- CAPI 1.2.1 has been implemented by a variety of chipset and CM vendors
  - Intel embedded laptops already ship with CAPI are available for development today
  - We are working with our vendors to ship CAPI with the majority of our aircards (and will push as a software update)

- International carriers are also working on making CAPI available for their devices

- Standardization process is also underway for CAPI “2.0” which adds additional functionality including:
  - Neighboring sector information
  - Applications requesting QoS
  - Sector handoff notification
Video/Media Support

• Our goal is to have truly differentiated video quality (and quantity) on our network

• We have several efforts underway on Video/Media support
  – Performing network testing using standard video tests and end-consumer experience to ensure network is optimal for video
  – Providing session information awareness to video clients and servers so they can optimize their delivery
  – Performing in-network video optimization (based on network state)

• We also are discussing with video service providers different ways we can further optimize their services and our network (e.g. faster buffering, video layering - H.264/SVC)
Quality of Service

• Quality of Service (QoS) refers to the ability of the network to provide a desired service level for selected traffic on the network.
  – Service levels are specified in terms of throughput, latency (delay), jitter (delay variation) and packet errors or loss.
  – Different service levels are specified for different types or streams of traffic.
  – To provide QoS, the network identifies or “classifies” different types or streams of traffic and processes these traffic classes differently to achieve (or attempt to achieve) the desired service level for each traffic class.

• Our goals for QoS are:
  1. To provide customers with a high quality experience by managing network traffic to minimize the impacts of congestion
  2. To support different types of services with different service level requirements on a single shared network
QoS Current Status

• Clearwire has implemented QoS in the current network
  – Clearwire RAN vendors have implemented IEEE 802.16 specification for QoS
  – Clearwire is currently exercising QoS for fixed and mobile VoIP

• Currently adding dynamically triggered QoS
  – Can be triggered from either device or the server (including 3rd party servers)
  – Targeting an early 2011 launch

• Finalizing the policy for offering QoS
  – Currently in a dialog with the FCC and partners to determine the proper model for when QoS should be enabled (part of the FCC’s Open Internet NPRM)
  – In the meantime we are doing testing and creating network management guidelines on how QoS affects services and overall network performance
  – Clearwire will finalize how our QoS model (including 3rd party support) based on the results of our dialog with the FCC. Multiple sources estimate the FCC will set Open Internet guidelines in the Q3-10 timeframe.
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What is it?
- Pre-commercial application testing network in Silicon Valley
- Benefit: Free service for developers until network goes commercial
- 4G mobile application focus
- Target Audience: Application and Content Developers

What it is not
- Hardware and device testing ground
- Focused on embedded device enablement
- Standards effort or initiative
- Targeted for end users
4G WiMAX Developer Workshop

When: Tuesday, March 2, 2010
1:00 PM – 7:00 PM
Where: Santa Clara Convention Center, Santa Clara, CA

Who: Innovation Network Members and Tonight’s attendees

What: Hot 4G technical and business topics:
• CLEAR’s 4G WiMAX API’s - How to integrate 4G tools into your software
• 4G WiMAX 101 for developers
• 4G WiMAX device and chipset architectures
• WiMAX business opportunities and trends from leading industry reps
• Networking reception with staff from CLEAR and sponsors

You are Invited!
See Allen after the event for Free pass
More Info at Developer.Clear.com/Innovation

Visit us at the CLEAR 4G WiMAX Developer Workshop
3/2 Santa Clara Convention Center
Developer Website and Contact Info

- We are looking for ideas on how we can further optimize and share our network for next generation services
- Get more info and participate in forums at Clear Developer Site
  - [http://developer.clear.com](http://developer.clear.com)
- Signup for Innovation Network
  - [http://developer.clear.com/innovation](http://developer.clear.com/innovation)
- Also feel free to contact us directly
  - allen.flanagan@clearwire.com - Innovation Network
  - david.rees@clearwire.com – Developer Enablement
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