Project	**IEEE 802.16 Broadband Wireless Access Working Group - TG3 <http://ieee802.org/16>**
Title	**802.16.3 Air Interface : Proposed System Characteristics - Relative Deployment Costs**
Date Submitted	**2000-09-07**
Source(s)	David Trinkwon Transcomm Inc 6521 Arlington Blvd Falls Church, VA, 22042, USA Voice: 972 345 5226 Fax: 602 532 7013 mailto:trinkwon@compuserve.com
Re:	**802.16.3 Invitation to Contribute: Document Number: IEEE 802.16.3-00/09** URL: <http://ieee802.org/16/sub11/docs/802163-00_09.pdf> **Request for Key Systems Characteristics and Evaluation Criteria**
Abstract	This contribution proposes four deployment cost factors as Key System Characteristics to be used in the evaluation of alternative technology proposals for the 802.16.3 air interface. A number of components are identified, together with the associated system and/or air interface properties that affect them. This includes the combined effects and/or trade-offs between various individual properties that will enable the optimization necessary to support various service provider business plan and deployment objectives in the real world.
Purpose	To define some Key System Characteristics and their component parts which will assist with a comparative evaluation of alternative technology proposals.
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate text contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures (Version 1.0) <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, if there is technical justification in the opinion of the standards-developing committee and provided the IEEE receives assurance from the patent holder that it will license applicants under reasonable terms and conditions for the purpose of implementing the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:r.b.marks@ieee.org> as early as possible, in written or electronic form, of any patents (granted or under application) that may cover technology that is under consideration by or has been approved by IEEE 802.16. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

Proposed System Characteristics - Relative Deployment Costs

David Trinkwon
Transcomm Inc

Introduction

Apart from spectrum availability and licensing, the major factor affecting the viability of a facility-based service provider's business plan (and its ability to also satisfy Regulatory expectations which might be embodied in its spectrum licensing obligations) are the various costs of acquiring, deploying and operating a Fixed Wireless Access (FWA) system under "real world" service, revenue and profitability objectives.

The 802.16.3 Functional Requirements Document (FRD) [Section 1.2 Target Markets] states :

> " … The critical parameters for serving these markets … is the combination of coverage / capacity factors that affects access cost per user, the deployability, maintainability and product costs associated with the customer premise installation, and the spectrum efficiency / reuse for economically serving the required number of customer locations with a minimum number of base station locations and backhaul routes.
>
> The target markets to be addressed by the 802.16.3 protocols in BWA networks are single family residential, SOHO, small businesses and multi-tenant dwellings. "

To the extent that the air interface enables or restricts certain capabilities and costs of the overall FWA system, it is important to understand these impacts as part of the evaluation process for various combinations and trade-offs within or between MAC and PHY proposals. This contribution proposes ways that the relative cost impacts can be factored into the 802.6.3 evaluation process.

1. Initial Coverage Costs

In essence, this translates into the quantity (and associated costs) of base stations needed to meet the initial coverage objectives, given certain assumptions about antenna heights, customer demographics / density and link availability objectives for each class of customer / service. Ideally, a single base station per geographic area is the cheapest solution, with omni-directional, shaped or dynamic (adaptive) antenna patterns as appropriate. In addition to the basestation equipment and antenna costs, the initial coverage costs include base station structure and site costs, backhaul / feeder costs to each basestation (and between basestations) and the associated survey, planning, installation and commissioning costs.

The significance of the Initial Coverage Cost is that it determines the "time to market" for simultaneously deploying FWA throughout one or more geographic markets. It can also be the major component of the deployed cost per customer for the first M customers in each market, as illustrated in the table below.

The main parameter that can be affected by the air interface is the quantity of base-stations needed to provide initial geographic coverage and the minimum (i.e. cheapest) configuration of the initial basestation equipment to meet the day one service and capacity objectives.

Table 1 : Initial Coverage Cost per Customer

Initial	Initial Coverage Cost per Customer ($) for M =				
Cost ($)	100	1000	2500	5000	10000
50,000	500	50	20	10	5
100,000	1,000	100	40	20	10
150,000	1,500	150	60	30	15
200,000	2,000	200	80	40	20
250,000	2,500	250	100	50	25
300,000	3,000	300	120	60	30
350,000	3,500	350	140	70	35
400,000	4,000	400	160	80	40
450,000	4,500	450	180	90	45
500,000	5,000	500	200	100	50
600,000	6,000	600	240	120	60
700,000	7,000	700	280	140	70
800,000	8,000	800	320	160	80
900,000	9,000	900	360	180	90
1,000,000	10,000	1,000	400	200	100

Air interface proposals should therefore be compared on the basis of their overall link budgets for the frequency bands and spectrum utilization in question, less the margins that need to be deducted in practice to maintain the desired link predictability and availability in the presence of fading, different levels of multipath, foliage, climatic and other impairments.

Where a proposal includes the possibility to mount the customer premises antenna (e) indoors, and/or for the customer (or his unskilled / semi-skilled agent) to carry out the CPE installation, this will usually require additional loss margins to be allowed. Typical values should be identified / discussed, based on the air interface characteristics proposed.

The practical coverage can then be assessed using standard radio planning tools on model deployment scenarios for typical urban, suburban and rural applications in target developed and developing countries.

A secondary air interface property that can often affect the Initial Coverage Cost is the possibility that the air interface can simultaneously support the backhaul link, or at least enable an alternative radio system to share the same licensed spectrum band for backhaul purposes.

Proposers should explain how their technology minimizes the number of base stations needed to provide initial coverage, how it can minimize backhaul costs and how it can minimize the initial configuration costs for the basestation equipment.

2. Incremental Capacity and Spectrum Costs

This increases the number of basestations and/or the total bandwidth and basestation equipment required to meet the projected and actual user traffic / usage needs over the life of the FWA system (typically 10 - 15 years). The Initial Coverage Costs provided the initial basestations and minimum capacity configurations to establish footprint and service offering capability. Incremental Capacity and Spectrum costs include :

a) **Additional Bandwidth and Equipment** - for the initial (coverage) basestations in order to meet the service growth until the available bandwidth is exhausted. This might include re-sectorization of the basestations, additional radio sub-systems / modules, technology upgrades etc, and must include any associated re-programming, re-pointing or upgrading of existing customer premises equipment if necessary.

b) **Additional Basestations -** either at day one, or subsequently, to continue to meet the traffic / usage needs of the existing and newly connected customers. Where the additional basestations cause reductions in the range or capacity of existing basestations, then the associated costs of re-programming, re-pointing or upgrading affected existing customer premises equipment must be

allowed for. Unless full frequency reuse (N=1) is possible in the adjacent cells / sectors, the penalty of the additional / "wasted" licensed bandwidth must be taken into account.

The 802.16.3 Functional Requirements document (FRD) [Section 5.7 Capacity] states :

> " … The delivered base station capacity … SHALL be calculated as the aggregate capacity of all sectors supported by a base station. Sector capacity is defined as the product of two factors: the "modulation factor" and the "sector-bandwidth factor" based on quality of service guarantees. The "modulation factor" is defined as the sector's aggregate bit rate divided by the bandwidth. The "sector-bandwidth factor" is defined as the total frequency band available for the BWA service, adjusted by the appropriate frequency re-use factors. This reflects mainly the factor of frequency reallocation and the ability to optimize frequency usage… "

The air interface is the primary enabler and constraint on system capacity for any given spectrum assumptions. Given the projected / required traffic / usage models, the PHY and MAC protocols must minimize the overheads involved in order to maximize the payload throughput (which itself already includes other overheads associated with TCP/IP and similar protocols).

802.16.3 proposals should state the maximum payload throughput per "band" for single cell and multi-cell deployments, taking into account any power limitations and emission mask / interference restrictions imposed by the licensing rules or their technology. These statements could be made in a format similar to Table 2 below, for each candidate frequency band, eg:

- US MDS (n x 6MHz), FCC / Breckenridge Rules
- Canada MCS (n x 6MHz), Industry Canada Rules
- CITEL MMDS and country specific Rules
- Canada 3.5GHz (1 or 2 x 25MHz) (Rural, Urban)
- CITEL 3.5GHz (2 x 25MHz) and country specific Rules
- ETSI 3.5GHz, (2 x 3.5 / 7 / 14 /28MHz) and country specific Rules
- UK 3.5GHz (2 x 17.5MHz)
- UK 3.9GHz (2 x 84MHz)
- US WCS (1 or 2 x 5MHz, 2 x 10MHz)
- US PCS (2 x 5 / 10 / 15MHz)
- US GWCS, 3650-3700, other (TBD)
- CITEL Other (TBD)
- ETSI Other (TBD)
- Other Countries / Bands (TBD)

Table 2 : Net Payload Capacity (Mb/s)

	Bandwidth (MHz)		Single Cell (Mb/s)		Multi Cell (Mb/s)			
Band	BS to CPE	CPE to BS	BS to CPE	CPE to BS	BS to CPE	CPE to BS	Multipath Environment	Frequency Reuse (N)
							Low	
							Moderate	
							High	
							Low	
							Moderate	
							High	
							Low	
							Moderate	
							High	

3. Customer Premises Costs

This is the cost of adding each customer to the core network via the FWA system, and includes the following components :

a) **Predictability** - the extent to which service quality can be predicted / assured for each customer before dispatching an installer, surveyor or equipment for customer self-installation. Some of this can be accommodated in the link margins specified under (1) above, but significant additional installation or marketing costs (typically $100 - $1,000 per customer) can be incurred if additional effort is needed, or customers have to be refused service. Air interface characteristics play a major role in determining the (low cost) predictability of coverage and link availability.

b) **Installability** - the costs incurred by the service provider and/or the customer installing and commissioning the equipment located at the customer premises, including (where applicable) indoor and outdoor units, power units and batteries, internal wiring, router / phone system setup etc.

Also to be included are the costs of any repeat or follow-up visits and activity to correct errors, measure or confirm satisfactory performance, address variations or fluctuations over time (e.g. due to foliage growth, new clutter / obstructions, or equipment upgrades/retrofits to remain compatible with network evolution and upgrades).

Typical installation costs can vary between $100 and $3,000 per customer depending on the activities involved, skill levels needed, safety regulations/practices and local labor rates etc. Any assumptions on reducing these costs (especially in non-Line of Sight (NLOS) situations) which include an increase in coverage margins from the case in Section (1) needs to be stated, and factored back into the initial coverage costs since it probably reduces the cell size / range and increases the number of basestations needed (over and above capacity limitations).

c) **Equipment -** This includes the indoor / outdoor units, optional power supply/ battery backup items, internal wiring and interface ports / cards / modules unique to the FWA solution. Current costs are typically greater than $300 per residential or SME customer, supporting single or multiple ports and services.

d) **Expansion and Upgrade Items -** This includes hardware, software and other options to be added or varied after the initial installation in order to bring more or different ports or services into use for the customer, maintain compatibility with (mandatory) basestation or access network upgrades. Additional costs can be incurred if this also involves visits to the customer location, re-installation or re-alignment of (different) indoor / outdoor modules or if the access network has to be suspended in order for software downloads to be completed to all customer units before basestation upgrades can be brought into service.

Proposers should explain how their technology minimizes the customer premises costs, including any impact on the link budget / margin assumptions used to determine coverage.

4. Incremental Coverage Costs

The 802.16.3 Functional Requirements document (FRD) [Section 2.2] includes an optional Repeater Function. This provides the ability to extend coverage to shadowed locations or remote / small customer clusters without incurring the full costs of an additional basestation / site. This can be very significant for developing countries, rural or isolated communities, or specific telecommuter / SOHO or service overlays. The ability of the 802.16.3 system / air interface to support simple / cheap repeater, relay or remote antenna configurations from a "central" basestation or controller site can be a very important capability. Proposers should describe such capability in an appropriate way, together with any impacts on coverage, capacity or cost of the main cell(s).

Conclusions

Proposers should present information on how their air interface properties impact the various life cycle costs described in sections 1 thru 4 above for a deployed system and the associated business plans.

802.16 members (especially service providers and business plan or deployment consultants) should be asked to submit contributions on typical deployment scenarios, objective evaluation criteria and relative weightings which can be used to model the coverage, capacity and customer premises costs, insofar as they can be improved or otherwise impacted by the air interface properties.