ONDAS NETWORKS

802.16e SOFTWARE PLATFORM

General Software Features

Feature	Description
Architecture	
Operation system	Embedded Linux
Application software and firmware components	1. MAC layer application running on ARM processor 2. PHY layer application running on DSP 3. FPGA code (digital filtering) 4. AD9364/AD9361 configuration
Standard Compliance	
IEEE802.16e standard with extensions	
Waveform characteristics	
Multicarrier waveform	OFDMA with 512/1024 subcarriers
Sub-channelization	• PUSC: orthogonal sub-channels in both uplink and downlink
Sub-channel configuration	In 512 Subcarriers (5 MHz wide channel) : 15 Subchannels in DL and 17 in UL. In 1024 Subcarriers: (8 & 10 MHz wide channels): 30 Subchannels in DL and 35 in UL
Modulation	QPSK, 16QAM, 64QAM
Forward Error Correction	Convolutional Turbo Coding (CTC) rates ½, ⅔, ¾, ⅚
Repetitions	Code words are repeated if needed to improve receiver sensitivity.
Adaptive Modulation and Coding	The Modulation and coding scheme (out of the schemes above), is determined automatically for each remote and in each direction every configurable CINR evaluation period.
Adaptive Repetitions	The number of Code-word repetitions is determined automatically for each remote and in each direction every configurable CINR evaluation period.
TDD Frame Structure	
Configurable Frame duration	5 ms (for 5 MHz & 10 MHz), 6.25 ms (for 8 MHz)
Configurable DL:UL Ratio	The number of OFDMA symbols in the uplink sub-frame is configurable between 8:1 and 1:8 ratios to support symmetrical, asymmetrical and reverse asymmetrical traffic scenarios.
Configurable RTG and TTG gaps	The transmit to receive and receive to transmit gaps are configurable as needed to support the maximum base station to remote station distance. A distance of > 100 km can be supported.
Time Ranging	
Closed loop time ranging	The base station adjusts automatically the ranging parameters at the remote stations based on the timing it receives CDMA codes from the remote.
Spectral Efficiency	
Raw Data efficiency	64 QAM – 6 bits/sec/Hz 16 QAM – 4 bits/sec/Hz QPSK – 2 bits/sec/Hz
End user data efficiency measured with IPERF UDP tool	Up to 3 bits/sec/Hz @ 64QAM ⅚.
RF Characteristics	
Frequency range	50 MHz to 6 GHz. The frequency range supported by a radio is determined by the RFM used in the radio
Center frequency resolution	1 Hz
Channel bandwidth	5MHz, 8 MHz, 10 MHz. The channel bandwidth supported by a radio is determined by the RFM used in the radio

Duplexing method	• TDD, Half Duplex FDD • FDD can be made available The duplexing method for a radio is determined by the RFM used in the radio
Maximum Transmit Power	This is determined by the hardware platform maximum transmit power and by the maximum transmit power configuration.
Closed loop power control	The transmit power of the remote station is adjusted in a closed loop process such that the receive power at the base station will be as close as possible to a configured target power level.
Minimum required CINR (dB)	QPSK with CTC Rate ½: 3 QPSK with CTC Rate ¾: 6 16QAM with CTC Rate ½: 8 16QAM with CTC Rate ¾: 12 64QAM with CTC Rate ⅔: 15 64QAM with CTC Rate ¾: 17 64QAM with CTC Rate ⅚: 22
Receiver Sensitivity (dBm) vs Channel Bandwidth, number of sub-channels and Modulation and Coding Scheme	-174 + 10 * log (BW in Hz) + Minimum Required CINR in dB + 3 dB implementation loss. BW = Effective Channel bandwidth * # of sub-channels/Max # of sub-channels
MAC Layer Characteristics	
Centralized deterministic Point to Multipoint MAC layer	
On demand bandwidth allocations taking into account QOS parameter configuration	
Up to 1024 endpoints supported by a single base station	
Quality of Service	
Classification	Traffic is classified in the uplink and in the Downlink direction into multiple one way (downlink or uplink) service flows. Classification is based on layer 2 and layer 3 header fields.
Classification Rule priority	Traffic is classified in the uplink and in the downlink, direction based on the classification rule priority.
Traffic Priority	Each QOS service type can take priority level 1 to 7
Minimum and Maximum Sustained Rates	Each service flow can be configured with a minimum and maximum sustained rate
Packing/Fragmentation reassembly of packets	Based on the availability of radio over the air resources, packets may be fragmented (if a complete packet does not fit into an allocation) or multiple packets are packed to reduce overhead. For example, packing of multiple 64 byte packets into a single over the air Protocol Data Unit (PDU) is more efficient than using distinct PDUs to transmit each 64 byte packets.
Advanced Packet Header Suppression (PHS)	Fields in the header and the data portion of the packet can be suppressed on an individual service flow basis. The values of the fields are learned automatically. Multiple values can be stored for each field.
Security	
Encryption	1. Supports AES128 2. Supports encryption key generation and distribution process as defined in IEEE802.16
Authentication	Supports EAP-TLS for remote radio authentication as per IEEE802.16
Comply with all applicable FERC/NERC CIP requirements	
Password protected access	
Operation	
System Configuration	XML based configuration.
Inbuilt CLI	Command line interface to show/configure the radio measurement parameters, system configuration. Separate CLI agent is available to run CLI independently.
Logging utility	Logging utility to view/capture the system logs. System logs can be captured to file.
System Monitoring	Detects any unexpected system misbehavior and does auto recovery
SNMP v3 support	Reports MIB values on demand and generates traps for system alarms. Can communicate with FullMAX NMS or with any third party NMS employing SNMP v3.
Two file systems in Radio	One file system is used to maintain the current loads and configuration while the second file system is used to perform software & configuration upgrade/modification. The radio can switch back to the previous loads and configuration if the upgrade is not successful.
Out band interference measurement	A configurable out-band interference utility can be used to scan the adjacent bands.

Networking	
Layer 2 forwarding	Received Ethernet frames are transported transparently end to end. Any layer 3 protocol (including non-routable protocol packet) are transported.
All major TCP/IP protocols are supported	
Has an IP host used for radio management. The IP address can be configured statically or dynamically through DHCP.	
Ingress Data rate throttling through switch configuration	

Base Station Specific Software Features

Feature	Description
Power control	
Configurable Transmit Power	Configurable up to the maximum power allowed for the band and subject to the platform limitations.
Synchronization	
TDD Frame synchronization	Aligned with a GPS derived 1 PPS signal.
Frequency synchronization	Derived from < 1 ppm accuracy internal TCXO. Serves as the source for frequency synchronization in the sector.
Configurable Sampling clock	Derived from < 1 ppm accuracy internal TCXO. Serves as the source for sampling clock synchronization in the sector
Preamble	The base station transmits a preamble at the first symbol of the TDD frame. This can be used by the remotes for TDD frame, frequency and sampling clock synchronization.
MIMO	
Maximal ratio Combining	
Primary Scheduler at the base station	
Function	Schedules downlink and uplink bursts with QOS considerations. Allocations are done in bulk at all service flows in a remote station.
Scheduling mode	Best Effort (BE), Real time polling service (rtPS), Unsolicited Grant Service (UGS)
Fairness	Service flows subject to the same QOS parameters receive the same bandwidth allocation in an overcapacity traffic scenario.
Uplink & Downlink QoS	Each Class of Service is a set of QoS parameter values (e.g., scheduling type, Traffic priority, Latency parameter.). A Class of Service is configured for each uplink and downlink service flow
Latency	- The latency determined by the TDD frame duration and the primary scheduling mode. - One-way latency can be as low as 3x frame duration (e.g., 15ms for 5ms frame).
BS initiated Service flow change	For automatic PHS
Unicast and Multicast Service	Each service flow can be unicast (i.e., intended for a specific remote) or multicast (i.e., intended for all remotes).
Packet Loop Back	Capable to loop back uplink received packets to all connected MSs. (Inbuild switch capability). This allows peer to peer MS communication.
Service flow configuration	Capable of configuring different Service flow using XML configuration
Service Class configuration	Capable of configuring different Service class using XML configuration
Table of connected entities	Maintains list of all connected entities for packet forwarding in Downlink
LCD	Displays different states of BS and how many MS are connected to BS
Mobility	
Optimized parameter configuration for Mobile Stations	"The Base Stations learns if a Remote Station is Mobile or Fixed and applies distinct power control and link adaptation procedures for Mobile and Fixed Remote Stations. **Examples:** a. CINR thresholds per MCS are lower for Mobile Stations compared to Fixed Stations. b. Power and time ranging for Mobile Stations is done on an open loop basis.

Fixed and Mobile Specific Software Fearutes

Feature	Description
Secondary scheduler at the remote station	
Functions	- Cooperates with the primary scheduler at the base station to support the QOS configuration. - Distributes the base station allocations to the service flows in the remote stations.
Scheduling mode	Best Effort (BE), Real time polling service (rtPS), Unsolicited Grant Service (UGS)
Uplink QoS	Each Class of Service is a set of QoS parameter values (e.g., scheduling type, Traffic priority, Latency parameter.). A Class of Service is configured for each uplink service flow
Uplink Latency	One-way latency 3x Frame Size. 15ms for 5ms frame
Synchronization	
TDD Frame synchronization	Derived from received preamble
Frequency synchronization	Derived from received preamble
Sampling clock synchronization	Derived from received preamble
Channel acquisition	
Automatic acquisition of the band	Upto 8 bands (BS) can be configured in MS and MS selects best band (BS) based on measured DL RSSI and DL CINR.
Automatic Gain Control (AGC)	
AGC on/off	AGC can be tuned off, i.e., the gain is determined manually to optimized the gain in fixed installations.
Other features	
Over the air software download	
LCD	Displays different states of MS along with DL link measurement
Mobility	
Fast AGC per symbol power tracking:	Fixed Remote Stations employ the preamble signal to compute the AGC gain. This allows once per frame AGC gain adjustment. Given the fast received power fluctuations in a mobility scenario, Mobile Stations are able to make an AGC gain adjustment once per OFDMA symbol.
Open loop power control:	Fixed Remote Stations adjusts their transmit power based on a commands from the base station as part of a closed loop power control process. This is typically not fast enough for Mobile Stations. Mobile Stations employ reciprocity along with acquiring the Base Station EIRP to determine the transmit power in an open loop process.