Wireless Specifications

Integrated Wi-Fi/Picocell Platform Specification

WR-SP-IWP-I01-120724

ISSUED

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Key to Document Status Codes

Work in Progress	An incomplete document, designed to guide discussion and generate feedback that may include several alternative requirements for consideration.
Draft	A document in specification format considered largely complete, but lacking review by Members and vendors. Drafts are susceptible to substantial change during the review process.
Issued	A stable document, which has undergone rigorous member and vendor review and is suitable for product design and development, cross-vendor interoperability, and for certification testing.
Closed	A static document, reviewed, tested, validated, and closed to further engineering change requests to the specification through CableLabs.

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1 SCOPE

1.1 Introduction and Purpose

The wireless industry is experiencing a tremendous amount of growth in new technology (such as 3GPP Long Term Evolution (LTE), new mobile operator entrants, mobile users, and data usage on wireless networks). As this growth continues, the need for a heterogeneous wireless environment is paramount to provide the quality of service, coverage and bandwidth end users demand in order for mobile operators to compete for market share. This tremendous growth is driving the emergence of small cells to provide macro network offload, and surgically fill coverage holes. Small cells may be used for speed to market, as the ability to build macro cells in many areas become more difficult due to zoning, permitting restrictions, and communities not willing to have macro sites in their backyard. MSO assets are well positioned to bring unique value to mobile operators seeking to deploy, fill coverage, or data offload with the development of a small cell offer. While data traffic growth is the primary driver for the deployment of small cells, voice services continue to require support as well. Two wireless technologies are widely used to provide services for users – Wi-Fi and Cellular.

This specification defines a new small cell platform, the Integrated Wi-Fi/Picocell (IWP). The IWP hosts both Wi-Fi and cellular Picocell radios in a modular chassis which is designed for use in Cable Operator networks. The IWP allows Cable Operators to offer Cable Operator managed Wi-Fi and MNO-managed cellular Picocell services from a single platform.

The IWP will offer flexible backhaul interface options including interfaces to DOCSIS®, fiber, and wireless networks. Deployment scenarios include various mounting options such as, but not limited to, ceiling, and wall, for-the-indoor units, and strand, vault, pole, wall, and other outdoor mounting options for the outdoor units.

1.2 Requirements

Throughout this document, the words that are used to define the significance of particular requirements are capitalized. These words are:

"MUST"	This word means that the item is an absolute requirement of this specification.
"MUST NOT"	This phrase means that the item is an absolute prohibition of this specification.
"SHOULD"	This word means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.
"SHOULD NOT"	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
"MAY"	This word means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

2 REFERENCES

2.1 Normative References

In order to claim compliance with this specification, it is necessary to conform to the following standards and other works as indicated, in addition to the other requirements of this specification. Notwithstanding, intellectual property rights may be required to use or implement such normative references.

All references are subject to revision, and parties to agreement based on this specification are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

[DPoE MULPI] DOCSIS Provisioning of EPON Specifications, DPoE MAC and Upper Layer Protocol Interface Specification, DPoE-SP-MULPIv1.0-I02-120607, June 7, 2012, Cable Television Laboratories, Inc.

[IEC 60529] ANSI/IEC 60529 Degrees of protection provided by enclosures (IP Code), AS 60529-2004.

[IEEE 802.16] IEEE Std. 802.16™-2009 IEEE Standard for Local and metropolitan area networks - Part 16: Air Interface for Broadband Wireless Access Systems, May 2009.

[IEEE 802.1AB] IEEE Std. 802.1AB™-2009 - IEEE Standard for Local and Metropolitan Area Networks-- Station and Media Access Control Connectivity Discovery.

[IEEE 802.1ad] IEEE Std. 802.1ad™-2005, IEEE Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks Amendment 4: Provider Bridges, May 2006.

[IEEE 802.1ag] IEEE Std. 802.1ag™-2007, IEEE Standard for Local and Metropolitan Area Networks Virtual Bridged Local Area Networks Amendment 5: Connectivity Fault Management, October 2007.

[IEEE 802.1Q] IEEE Std. 802.1Q™-2011 - IEEE Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks, August 2011.

[IEEE 802.3ah] IEEE Std. 802.3™-2008 IEEE Standard for Information technology-Specific requirements - Part 3: Carrier sense multiple access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, December 2008.

[L2VPN] Data-Over-Cable Service Interface Specifications, Business Services over DOCSIS, Layer 2 Virtual Private Networks, CM-SP-L2VPN-I09-100611, June 11, 2010, Cable Television Laboratories, Inc.

[MULPI] Data-Over-Cable Service Interface Specifications, DOCSIS 3.0 MAC and Upper Layer Protocols Interface Specification, CM-SP-MULPIv3.0-I18-120329, March 29, 2012, Cable Television Laboratories, Inc.

[OSHA 1910.269] OSHA 1910.269 Electric Power Generation, Transmission, and Distribution - General Industry Standard, Occupational Safety & Health Administration.

[OSHA 1910.333] OSHA 1910.333 Selection and use of work practices, Occupational Safety and Health Administration.

[OSSI3.0] Data-Over-Cable Service Interface Specifications, DOCSIS 3.0 Operations Support System Interface Specification, CM-SP-OSSIv3.0-I18-120329, March 29, 2012, Cable Television Laboratories, Inc.

[PHY3.0] Data-Over-Cable Service Interface Specifications, DOCSIS 3.0 Physical Layer Specification, CM-SP-PHYv3.0-I10-111117, November 17, 2011, Cable Television Laboratories, Inc.

[RFC 1492] IETF RFC 1492, Terminal Access Controller Access-Control System, Internet Engineering Task Force, July 1993.

[RFC 2865] IETF RFC 2865, Remote Authentication Dial In User Service (RADIUS), Internet Engineering Task Force, June 2000.

[RFC 6540] IETF RFC 6540, IPv6 Support Required for All IP-Capable Nodes, Internet Engineering Task Force, April 2012.

[TR-069 1-3] TR-069, CPE WAN Management Protocol v1.1, Issue 1 Amendment 3, November 2010, Broadband Forum Technical Report.

[Wi-Fi MGMT] Wi-Fi Management Interface Requirements, WR-SP-Wi-Fi-MGMT-I03-120216, February 16, 2012, Cable Television Laboratories, Inc.

[Wi-Fi-GW] Wi-Fi Requirements for Cable Modem Gateways, WR-SP-Wi-Fi-GW-I02-120216, February 16, 2012, Cable Television Laboratories, Inc.

[Y.1731] ITU-T Recommendation Y.1731, OAM functions and mechanisms for Ethernet based networks.

2.2 Informative References

This specification uses the following informative references.

[PCMM] PacketCable Specifications, Multimedia Specification, PKT-SP-MM-I06-110629, June 29, 2011, Cable Television Laboratories, Inc.

[TR-181 2-2] TR-181 Device Data Model for TR-069, Issue 2 Amendment 2, February 2011, Broadband Forum Technical Report.

[Wi-Fi-ROAM] Wi-Fi Roaming Architecture and Interfaces Specification, WR-SP-Wi-Fi-ROAM-I02-120216, February 16, 2012, Cable Television Laboratories, Inc.

2.3 Reference Acquisition

- The Broadband Forum, 48377 Fremont Blvd., #117, Fremont, CA 94538; Phone: +1-510-492-4020, http://www.broadband-forum.org/technical/trlist.php.
- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027 USA; Phone +1-303-661-9100; Fax +1-303-661-9199; http://www.cablelabs.com
- Institute of Electrical and Electronics Engineers, 3 Park Avenue, 17th Floor, New York, NY 10016-5997 USA; Phone: +1 212 419 7900, Fax: +1 212 752 4929; http://www.ieee.org
- Internet Engineering Task Force (IETF) Secretariat, 48377 Fremont Blvd., Suite 117, Fremont, California 94538, USA, Phone: +1-510-492-4080, Fax: +1-510-492-4001, http://www.ietf.org
- International Telecommunication Union (ITU), Place des Nations, 1211 Geneva 20, Switzerland; Phone: +41 22 730 5111; Fax: +41 22 733 7256; http://www.itu.int
- U.S. Department of Labor, Occupational Safety & Health Administration, 200 Constitution Ave., NW, Washington, DC 20210; Phone: 800-321-OSHA (6742); http://www.osha.gov

3 TERMS AND DEFINITIONS

This specification uses the following terms:

Picocell	A small cellular base station that improves coverage and data throughput for mobile users and increases capacity in the mobile network.
Service Location	An authorized service location where the IWP can opened and internal modular components can be inserted, removed, or replaced.
TR-069	Term used to refer to the CPE WAN management protocol suite defined in [TR-069 1-3].

4 ABBREVIATIONS AND ACRONYMS

This specification uses the following abbreviations:

2G voice	Second-Generation Wireless Telephone Technology
3GPP	Third Generation Partner Project
AC	Alternating Current
CM	Cable Modem
CMTS	Cable Modem Termination System
CPU	Central Processing Unit
CSFB	Circuit Switched Fallback
CWMP	Customer Premise Wide Area Network Management Protocol
DHCP	Dynamic Host Configuration Protocol
EMS	Element Management System
eNB	Enhanced Node B
EPC	3GPP Evolved Packet Core
EVDO	Evolution-Data Optimized
GRE	Generic routing encapsulation
GTP-U	GPRS Tunneling Protocol, User plane protocol
HFC	Hybrid Fibre-Coaxial
HSPA	High Speed Packet Access
IWP	Integrated Wi-Fi / Picocell
LLDP	Link Layer Discovery Protocol
LTE	3GPP Long Term Evolution
MME	EPC Mobility Management Entity
MNO	Mobile Network Operator
MSO	Multiple (cable) Systems Operator
NAS	Non-Access Stratum
NMS	Network Management System
NSI	Network Side Interface of the CMTS
ONU	Optical Network Unit
PoE	Power over Ethernet
RAN	Radio Access Network for mobile networks
RF	Radio Frequency
S1-AP	LTE S1 interface Application Protocol
SFP	Small Form-factor Pluggable
S-GW	EPC Serving Gateway
SNMP	Simple Network Management Protocol

UE	User Equipment
UGS	DOCSIS Unsolicited Grant Service
VLAN ID	Virtual Local Area Network Identification
WAN	Wide Area Network
WiMAX	Worldwide Interoperability for Microwave Access
X2-AP	LTE X2 interface Application Protocol

5 IWP CONCEPTUAL BLOCK DIAGRAM

The IWP is an outdoor and indoor unit with integrated wireless access and backhaul interfaces. It has support for integrated Picocell radio module(s) and Wi-Fi access point(s). It offers flexible backhaul interface options including coaxial, fiber or wireless for transporting the Picocell and Wi-Fi traffic. The unit is powered by the AC power available either on the HFC (Hybrid Fibre-Coaxial) plant or the power utility line.

A conceptual IWP block diagram depicting the main functional modules is shown in Figure 1.

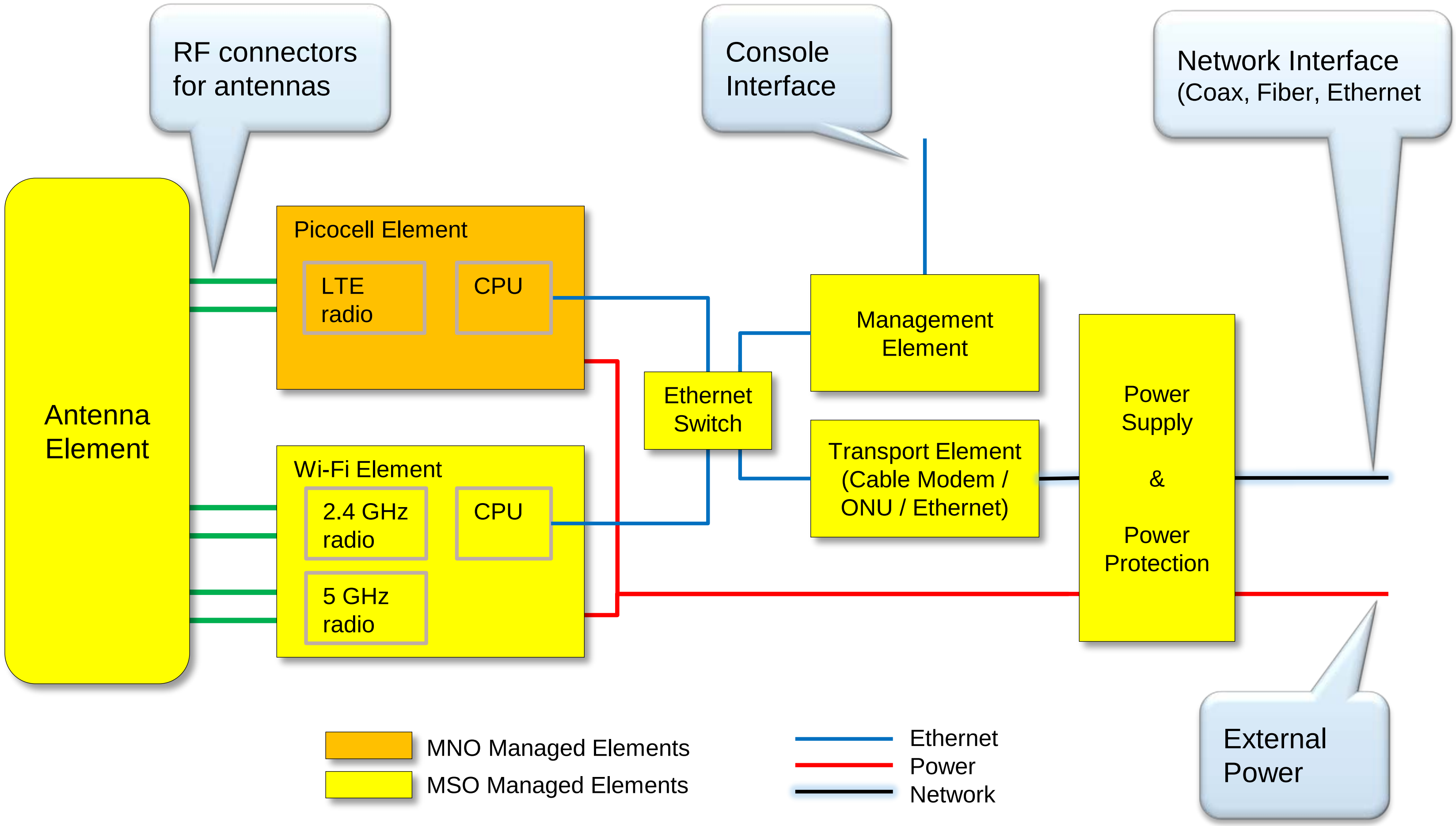

Figure 1: IWP Conceptual Block Diagram

Power Supply & Power Protection Element converts the cable plant or utility line AC power to the power format required and supplies power to the rest of the modules requiring power. It also acts as a protective barrier between the IWP and cable plant, minimizing any harmful effect to each other.

Transport Element converts the signal to/from the physical backhaul medium to provide data connection for the IWP unit. The product supports various backhaul interfaces (DOCSIS 3.0, fiber, or wireless).

Ethernet Element acts as the traffic aggregator/arbitrator for all Wi-Fi and Picocell related traffic. It connects to the backhaul module and needs to interface with all planned backhaul modules.

Management Element is a management agent for the IWP. It monitors and reports IWP environmental alarms. It can also execute operational tasks such as remote power recycling.

Wi-Fi Element is a standard-compliant Wi-Fi access point and is utilized for MSO's public Wi-Fi services.

Picocell Element is a compact cellular radio access network ("RAN"), consisting of baseband and transceiver. It is intended that this module be easily accessible and upgradeable to various RAN technologies (e.g., 2G voice, HSPA, EVDO, WiMAX, LTE, etc.).

Antenna Element radiates the Wi-Fi and Picocell RF signal and can be either internally (preferred) or externally integrated.

The philosophy behind the platform is to modularize the major functional blocks with industry-standard interfaces so that these modules can easily be changed and upgraded as needed.

6 GENERAL

6.1 Application

The requirements contained in this specification assume that the IWP will be deployed in North America. These requirements are numbered preceded by the letter "R" (i.e., R1.)

6.2 Packaging

Two packaging options are envisaged for the IWP:

1. Single modular enclosure containing all of the IWP elements shown in the reference architecture.
2. Dual modular enclosures with the Picocell element contained in a secondary enclosure, and all of the other elements contained in the primary enclosure. In this configuration, the Antenna element would be split with separate antennas for the Picocell element, and the Wi-Fi element enclosed by or connected to their separate enclosures.

These enclosures are modular chassis' which house the functional components. The enclosure packages are standardized to accept appropriate radios of any type and support a variety of mounting options.

R1. The IWP MUST provide single and dual enclosure packaging options.

6.3 Availability

IWP availability is a tradeoff between capital expense and operational expense. IWPs deployed in outdoor applications may not be easily accessible which will impact the Mean Time To Repair (MTTR).

R2. The IWP (including all installed elements) MUST have an MTBF of at least 200,000 hours

7 EXTERNAL INTERFACE SPECIFICATIONS

The IWPs will have a number of external physical interfaces:

- Network
- Power
- Antenna
- Console
- Dual Enclosure Ethernet Interconnect

7.1 Network Interfaces

The IWPs will support a number of different network interfaces:

1. DOCSIS 3.0 Coax
2. Ethernet
3. EPON

R3. Only one interface SHOULD be active at a time.

R4. The network interface to the IWP MUST support IPv4 and IPv6.

R5. The IWP MUST be capable of operating in a pure IPv6 environment with no IPv4 usage for management or customer traffic [RFC 6540].

R6. The IWP MAY support dual stack IPv4 and IPv6 operation.

R7. The network interface MUST allow the MSO to provision the backhaul in cost-effective manners (e.g., dynamic IP over static IP).

7.1.1 DOCSIS 3.0 Coax

R8. The IWP MUST provide a Standard Female F Connector.

7.1.2 Ethernet

R9. The IWP MUST provide an SFP Cage supporting a variety of Gigabit Ethernet SFP modules that will be specified by the Cable Operator:

a. RJ45

b. Optical Ethernet - (e.g., 1000 BaseSX)

R10. SFP modules meeting the environmental requirements for outdoor applications are required.

7.1.3 EPON

R11. The IWP MUST provide an SFP Cage supporting user accessible and obtained EPON ONU SFP modules capable of full rate 1G EPON.

R12. SFP modules meeting the environmental requirements for outdoor applications are required.

7.2 Electrical Power

Power is provided by Power over the DOCSIS 3.0 Coax interface or by a separate power connector.

R13. The IWP MUST support a standard locking power connector socket such as a NEMA L5.

7.3 Antenna

The IWP will need to support a number of different radios and antenna design combinations for Wi-Fi and Picocell modules. As a result the Antenna / Diplexer is probably best implemented as a modular component that can be changed to meet the specific deployment and operator requirements.

Depending on the frequency bands and output power required in specific deployment applications, RF interference needs to be considered in the Antenna / Diplexer and RF amplifier designs.

R14. The IWP SHOULD support internal antennas for both LTE and Wi-Fi.

R15. The IWP SHOULD minimize the number antennas by leveraging duplexers where possible.

R16. The IWP MUST support at least 2 antennas.

R17. The IWP SHOULD support at least 4 antennas.

R18. The IWP MUST support 2x2 MIMO antenna configurations for LTE.

R19. The IWP SHOULD support 4x4 MIMO antenna configurations for LTE.

R20. The IWP antennas in a MIMO configuration SHOULD be separated at a distance equal to an even multiple of the Lambda.

R21. If the antennas are external, the connectors MUST be standard N type.

Support for multiple sectors is expected to vary based on the deployment scenario. Strand mount IWPs will typically be single sector while other options such as pole top may require multiple sectors.

R22. The IWP and Picocell MUST support 1 sector for RAN.

R23. The IWP and Picocell SHOULD support 3 sectors for RAN.

7.4 Console

R24. The IWP MUST provide an externally accessible RJ45 interface for local console access.

7.5 Dual Enclosure Ethernet Interconnect

R25. The IWP MUST provide an externally accessible Ethernet RJ45 interface on both the Primary and Secondary enclosures to support connection when the Dual Enclosure package is used.

R26. The IWP Primary Enclosure MUST support PoE as an option for the Ethernet Interconnect link where PoE provides sufficient power to supply the secondary enclosure.

8 IWP ELEMENTS

The IWP has a number of internal elements:

- Backhaul transport element
- Ethernet switch
- Picocell element
- Wi-Fi AP

8.1 Transport

8.1.1 Cable Modem Requirements

The [MULPI] specification has significantly improved the cable modem data rate in the downstream and upstream directions compared to previous versions, through the means of channel bonding. By bonding a minimum of four channels in each direction, DOCSIS 3.0 compliant. CMs can achieve a minimum Physical (PHY) rate of 160 Mbps on the downstream and 120 Mbps on the upstream. This still may not match the instantaneous rate on the Picocell. Rate mismatch may occur in case of access network congestion. This specification assumes that the rate mismatch is resolved at the upper layer by flow control protocol at the UE or the Serving Gateway (S-GW) and consequently does not require specific rate limiting protocol on the CM-Picocell interface.

R27. The DOCSIS backhaul module (CM) MUST be compliant with CableLabs DOCSIS 3.0 suite of specifications, which includes [MULPI], [PHY3.0], and [OSSI3.0].

In addition, in order for the IWP to function with an embedded LTE Picocell element, the following are additional requirements placed on the DOCSIS 3.0 CM.

R28. The DOCSIS 3.0 CM MUST support 8 bonded downstream channels and 4 bonded upstream channels.

R29. The DOCSIS 3.0 CM MUST support at least 16 service flows in each direction.

R30. The DOCSIS 3.0 CM SHOULD support at least 32 service flows in each direction.

R31. The DOCSIS 3.0 CM MUST support at least 16 classifiers in each direction.

R32. The DOCSIS 3.0 CM SHOULD support at least 32 classifiers in each direction.

R33. The DOCSIS 3.0 CM MUST support [L2VPN].

R34. The DOCSIS 3.0 CM MUST support a 1 Gb/s Ethernet interface.

8.1.2 EPON

R35. The IWP MUST support EPON as a backhaul element.

R36. The EPON interface MUST be compliant with the CableLabs DPOE suite of specifications, which includes [DPoE MULPI].

R37. The EPON interface MUST be compliant with [IEEE 802.3ah] (1GEPON).

R38. The EPON interface MUST support EPON SFP modules with a reach of at least 20 km (12.5 mi).

8.1.3 Wireless

Wireless backhaul is a requirement in deployments where it is not feasible to provide a wired connection. For IWPs deployed with a Picocell module, Non Line of Sight, 100 Mb/s+ licensed radio systems are required. In the foreseeable future, Picocell wireless backhaul will probably be supported via an external system which connects to the IWP via Ethernet.

5 GHz unlicensed wireless backhaul would be acceptable for Wi-Fi wireless backhaul.

R39. The IWP MUST support an external wireless backhaul solution. Typically this will interface to the IWP via the Ethernet interface.

R40. The IWP SHOULD support an internal wireless backhaul solution.

8.2 Resource Provisioning and Traffic Priority and Separation

The principal mechanism for providing QoS is to classify packets traversing the backhaul network segment into DOCSIS service flows and then to schedule these service flows according to a set of QoS parameters. DOCSIS service flows provide a means to separate traffic, enabling prioritization and shaping, and can be statically configured at system initialization. The DOCSIS 3.0 and DPoE technologies provide a number of tools to enable Quality of Service guarantees.

To facilitate traffic forwarding and differentiation on the NSI interface of the headend equipment[1] when DOCSIS or EPON transport elements are used, this specification utilizes [L2VPN]. The configuration and forwarding in the transport network is out of the scope of this specification and is determined by the MSOs. The L2VPN specification allows the modular Picocell or Wi-Fi traffic classified by the transport element[2] and put into unique service flows to be encapsulated in tunnels such as on the NSI port of the headend equipment. There are a number of enhancements[3] being considered for L2VPN at the publication time of this specification, and as such, this specification may be updated based on a revised L2VPN specification.

To service upstream service flows, the DOCSIS and DPoE specifications define a set of scheduling services with configurable QoS parameters. Each scheduling service is tailored towards a specific type of traffic with their distinct QoS constraints. Typically in DOCSIS networks, data traffic is serviced with best effort scheduling service, and voice traffic UGS or UGS-AD.

This specification defines the requirements on the modular Picocell and Wi-Fi elements in order to enable the QoS toolset. The exact methods for how these capabilities are implemented to provide service to the MNOs will be determined by the MSOs.

8.2.1 Tunneling

Tunneling is an alternative method that can be used by the IWP for traffic differentiation and QoS provisioning on the NSI interface. For example GRE, CAPWAP, or PMIPv6 tunnels can be set up between the Wi-Fi and/or Picocell element in the IWP, and a tunnel aggregator on the NSI side of the headend equipment. The exact configuration and usage of tunnels are outside the scope of this specification and will be determined by the MSOs.

8.2.1.1 Picocell and Wi-Fi Traffic

For traffic engineering such as prioritization and shaping, as well as settlement purposes, the IWP separates the upstream Wi-Fi traffic from the Picocell traffic. On the backhaul network segment, the transport element separates the Wi-Fi and Picocell traffic by using separate Service Flows. When DOCSIS or EPON transport elements are used, the traffic is then encapsulated into separate L2VPN tunnels by the headend equipment on its NSI port. In order to classify upstream traffic on to separate tunnels, the transport element uses either the destination IP address or VLAN tagging embedded in the upstream Ethernet frame. When tagging is used as a classification method, the upstream traffic coming into the transport element has already been pre-tagged by both the Picocell and the Wi-Fi element.

Among the VLAN tagging methods, [IEEE 802.1Q] and [IEEE 802.1ad] are acceptable. Support for 802.1ad dual tagging provides MSOs and MNOs with flexibility and scalability as they design solutions for traffic forwarding from the IWP. While the exact tagging implementation is out of the scope of this specification, it is envisioned that

[1] In DOCSIS, headend equipment refers to the CMTS. In DPoE, headend equipment refers to DPoE System.
[2] In DOCSIS, transport element refers to the CM. In DPoE, transport element refers to D-ONU. For more information see [DPoE MULPI].
[3] An example is while DOCSIS service flows can be dynamically configured such as triggered by an addition of an LTE dedicated bearer, currently, [L2VPN] only allows for static configuration of the tunnels.

as an example, a unique outer tag can be used for each IWP, and inner tags for structuring traffic separation around the applications within the IWP.

8.2.1.2 Wi-Fi

R41. The Wi-Fi element MUST be able to tag the upstream traffic with a pre-configured VLAN ID.

8.2.2 Signaling and User Plane Picocell Traffic

The IWP transports Picocell signaling traffic at a higher priority than the Picocell bearer traffic. On the backhaul network segment, the transport element separates the signaling and bearer traffic by using separate Service Flows. When DOCSIS or EPON transport elements are used, the traffic is then encapsulated into separate L2VPN tunnels by the headend equipment on its NSI port.

The signaling traffic to be tunneled includes X2-AP traffic, the signaling traffic on the interfaces between the Picocell and neighboring Picocells and/or eNBs, as well as S1-AP and NAS traffic, the signaling traffic between the Picocell/UE and the MME. The minimum number of tunnels required to transport signaling traffic is one.

This specification does not require traffic engineering on a per UE basis. As such, the minimum number of tunnels required to transport bearer GTP-U traffic is one.

R42. The Picocell element MUST be able to tag the upstream signaling and bearer traffic with separate, pre-configured VLAN IDs.

8.2.3 Voice and Data Traffic

As the QoS requirements for voice and data traffic are different, MSOs may be interested in further differentiation of the upstream bearer traffic. Because all bearer traffic is forwarded to S-GW in the MNO network, the same tunnel can be used to carry voice and data traffic from a Picocell on the backhaul network segment. To provide differentiated QoS, the transport element separates voice and data traffic by classifying them into different upstream service flows. The 3GPP RAN interface specifications mandate DSCP markings that are mapped to bearer plane QoS on the IP transport. Therefore, the transport element uses the DSCP markings on the packets to classify upstream voice and data traffic into separate service flows. For CSFB voice traffic, the requirement is placed on the Picocell element to mark the voice packet with pre-configured DSCP markings.

R43. The Picocell element MUST be able to mark upstream packets with pre-configured DSCP.

8.3 Performance Requirements

Network transport requirements for mobile backhaul are typically defined by agreements between the MNO and the MSO in a Master Service Agreement (MSA). Typically, the MSA specifies profiles on throughput, frame delay, frame delay variation, and frame loss. These profiles vary by the MSO service offerings, MSO network configurations, and the RAN technology being used. Therefore the definition of the profiles, as well as the configuration and provisioning of the IWP elements are out of the scope of this specification.

8.4 Ethernet Switch

R44. The Ethernet Switch MUST have sufficient number of ports to support all of the separate elements inside the IWP.

R45. The Ethernet Switch MUST be remotely configurable and manageable.

R46. The Ethernet Switch MUST support [IEEE 802.1Q] and [IEEE 802.1ad] VLAN tagging.

R47. Each Ethernet switch port MUST support 1 Gb/s throughput except for the console port if it is connected through the Ethernet switch.

R48. The Ethernet Switch MUST support Power over Ethernet (PoE) as an option for the ports which connect to the Wi-Fi and Picocell elements.

8.5 Picocell Element

R49. The Picocell element MUST support LTE.

R50. The Picocell element SHOULD support LTE Advanced.

R51. The Picocell element SHOULD support the following 3GPP, 3GPP2, and WiMAX RAN technologies: GSM, GPRS, EDGE, HSPA, CDMA, 1xRTT, EV-DO, and WiMAX.

R52. The Picocell Elements supporting the 3GPP standard (GSM, UMTS, HSPA+, LTE) MUST be compliant through the 3GPP Release 9 series of specifications.

R53. The Picocell Elements supporting the 3GPP standard (GSM, UMTS, HSPA+, LTE) SHOULD be compliant through the 3GPP Release 10 series of specifications.

R54. The Picocell Elements supporting the 3GPP standard (GSM, UMTS, HSPA+) MUST be based on Flat RAN architecture, i.e., "BTS collapsed RNC" as defined by 3GPP Rel-8 HSPA Evolution.

R55. The Picocell Elements supporting the 3GPP2 standard (CDMA) MUST be compliant through the 3GPP2 1xRTT and EVDO revB series of standards.

R56. The Picocell Elements supporting the WiMAX standard MUST be compliant through [IEEE 802.16].

R57. The Picocell elements SHOULD support multiple modular RAN radios.

R58. The Picocell elements SHOULD support multiband radios for at least two frequency bands.

R59. The Picocell Elements SHOULD support software defined multiple technologies: WCDMA (HSPA+), WiMAX or LTE with no change in hardware required.

R60. The Picocell elements MUST support any operating band in the North America.

R61. The Picocell elements SHOULD support any operating band requested by MSOs providing services for MNOs located in other areas of the world.

R62. Pole mount licensed radio SHOULD provide a minimum of 4W RF output power.

R63. Strand mount licensed radio SHOULD provide a minimum of 1W RF output power.

R64. The Picocell Elements MAY support the use of a Picocell Gateway.

R65. The IWP and Picocell Elements MUST support 1 sector.

R66. The IWP and Picocell Elements SHOULD support 3 sectors.

8.6 Wi-Fi AP

R67. The Wi-Fi element of the IWP MUST conform to the non-residential requirements of [Wi-Fi-GW] and [Wi-Fi MGMT].

8.7 Air Interface Performance

R68. Picocell and Wi-Fi radios MUST be able to co-exist without degrading each other's performance.

8.8 Synchronization

The Picocell elements will require a clock synchronization source. This clock source may be embedded with the Picocell element itself or may be implemented as a common source provided by the IWP. The common source will be useful where the IWP supports more than one Picocell element.

R69. The IWP SHOULD support a common source clock synchronization options including Synchronous Ethernet, IEEE 1588v2, and GPS.

9 OAM SPECIFICATIONS

The IWP provides separate and distinct management domains:

- MNO Management Domain
    - Picocell Element
- MSO Management Domains
    - IWP Network Element
    - Network Backhaul Transport Element
    - Wi-Fi element

Figure 2 shows an example using a cable modem for transport:

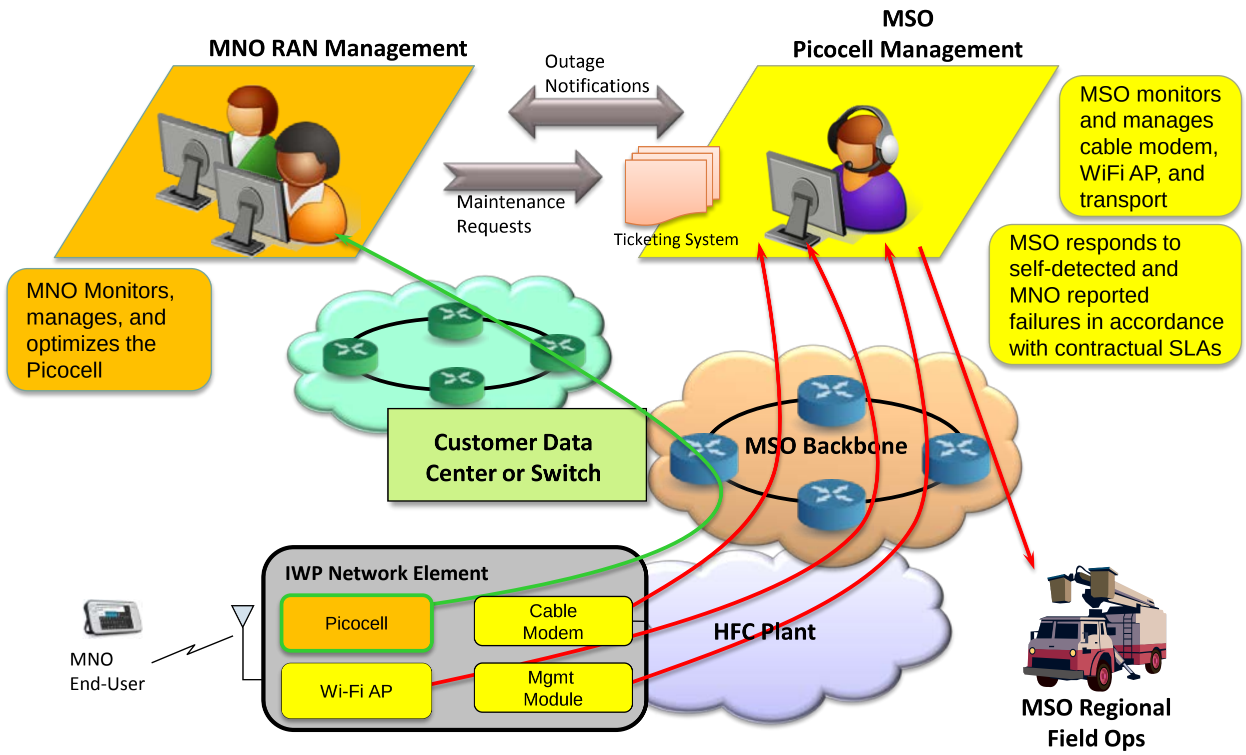

Figure 2: IWP Management Domains Example

R70. IWP MUST offer an option for each main functional module (e.g., CM, Wi-Fi, Picocell) to be managed by a separate management platform.

R71. IWP MUST offer remote SW/HW diagnostic and troubleshooting capabilities in order to minimize truck rolls.

R72. IWP installation, provisioning, commissioning and management procedures MUST support large scale deployments.

R73. All IWP elements with updatable firmware MUST support dual firmware image capability to support in service upgrade to a new firmware image or fallback to the previously installed firmware.

R74. Each IWP Element MUST be capable of logging performance data at 15 minute intervals.

R75. The IWP Element itself SHOULD be capable of storing performance data for at least 8 hours.

R76. The IWP elements MUST support a mechanism to receive and install firmware and software updates from the NMS.

The requirement for IPv6 only operation noted in Section 7.1, applies not only to customer payload traffic, but to ALL management functions as well.

9.1 MNO Management Domain

R77. The Picocell Element MUST provide an EMS interface to the MNO. The Picocell Element will be managed by a separate management platform hosted by MNOs. The MNO is responsible for the Picocell Element NMS. The Picocell element MUST be able to be remotely operated and managed by MNOs.

R78. Each Picocell element in the IWP MUST support a separate interface to a Picocell Element Management System (EMS) provided by the Picocell vendor.

R79. The Picocell EMS interface MUST implement a secure IP link between the Picocell element and the Picocell EMS over the transport network.

R80. The Picocell element MUST provide remote reset capability for the Picocell element.

R81. The Picocell element MUST provide the capability to turn off the RF transmitter power.

R82. The IWP management interface MUST allow Remote power on / off or Remote power cycling to be performed by the MNO when access to this function is authorized by the MSO.

9.2 MSO Management Domain

R83. The installer MUST have the ability to view status information about the device via the console interface.

R84. The console interface MUST provide device component status, network link status, connected device status and application status.

R85. All information available via the console interface MUST also be available to CSRs and technicians troubleshooting the device remotely.

R86. The IWP and all of its elements MUST recover automatically from a complete loss of all power sources without any external intervention.

R87. The IWP and all of its elements MUST recover automatically from a complete loss of all backhaul connectivity without any external intervention.

R88. The IWP and all of its elements MUST support remote firmware upgrade and firmware rollback.

9.2.1 Discovery

R89. The IWP and all its elements MUST perform self-discovery with the appropriate EMS when the IWP is first powered ups and connected to the network. In addition each IWP component MUST support auto-discovery among each other component.

Discovery among IWP components is performed by the use of LLDP as defined in [IEEE 802.1AB].

R90. The IWP MUST support LLDP as defined in [IEEE 802.1AB].

R91. The components attached (e.g., not integrated into the IWP system) MUST support LLDP [IEEE 802.1AB] in order to be recognized by the IWP.

Among the LLDP functionality supported by the [IEEE 802.1AB] LLDP services are:

- Device Information and capabilities of connected components.
- Topology configuration of the discovered component in the IWP.
- Geo Location information if available.
- Status information of components.

9.2.2 IWP Network Element

R92. IWP Network Element MUST support an EMS management interface.

R93. The IWP MUST support secure local and remote access for configuration and management.

The following interfaces are required for management.

R94. All available configuration items MUST be configurable via these interfaces.

R95. There MUST NOT be configuration settings which cannot be accessed via these interfaces.

R96. Management interfaces MUST be fully documented with available commands, allowed arguments, and expected responses:

- http/SSL with possibility of disabling http.
- Telnet/SSH with possibility of disabling Telnet.
- SNMP v2c/v3 - supply full MIB data and any available supporting documentation for SNMP interface(s).
- Support for [TR-069 1-3].

Regardless of whether the IWP is implemented as a single enclosure or dual enclosure, the following requirements apply.

R97. IWP MUST store basic system identification/status information and make it accessible remotely and via a local maintenance port.

R98. The IWP MUST provide basic alarms and heart beat for each element within the IWP: Picocell Element, Network Transport Element, and Wi-Fi element.

R99. IWP alarms and heart beat MUST be implemented in SNMP v.3 and sent over the Network Interface to the MSO EMS using a configured IP address.

R100. The IWP MUST support reset (i.e., reboot) of all elements of the IWP, individually, and collectively via management interface.

R101. The IWP MUST support Remote power on/off capability for each of IWP modules via management interface.

R102. The IWP MUST support Remote power cycling for each of IWP modules via management interface.

R103. The IWP MUST support RESTORE Factory default settings of the Wi-Fi air interface via management interface.

R104. The IWP MUST support RESTORE Factory default settings of the cable modem via management interface.

R105. The IWP MUST provide the installer the ability to view status information about the device, including the air interface, from a diagnostic page in the web UI. This IWP diagnostic page MUST show device component status, network link status, and connected device status.

R106. The IWP SHOULD generate an alarm when the antenna module is not properly connected or functioning.

9.2.3 Transport Element

R107. Transport Elements MUST support an EMS management interface. The EMS interface will be appropriate to the transport technology used.

R108. The Transport Element MUST provide Ethernet performance monitoring such as [Y.1731].

R109. The Transport Element MUST provide Backhaul performance monitoring.

9.2.4 Wi-Fi Element

R110. The Wi-Fi Element MUST provide an EMS interface to the MSO.

R111. The Wi-Fi Element MUST support [TR-069 1-3].

9.2.5 Fault Management

R112. The IWP MUST support detection and recovery from the loss of backhaul connectivity.

R113. The IWP MUST provide reports for status, configuration information, alarms, statistics, and error logs to the EMS including uptime and temperature.

R114. The IWP elements MUST support resetting a set of statistics on command from the EMS.

R115. The IWP MUST be able to report its geographic location to the EMS.

R116. The IWP and its elements MUST support self-detection and reporting of critical alarms or faults including change in the physical location, and failure of subsystems.

R117. The IWP MUST report alarm to the EMS for power outage related incidents at the time of power restoration including the duration of the outage.

R118. The IWP MUST report an alarm to the EMS regarding Picocell element failure.

R119. The IWP MUST support [IEEE 802.1ag].

9.2.6 Alarm Requirements

R120. All relevant alarms and alerts MUST be configurable to perform notification via SNMP trap.

R121. Alarm notification and severity SHOULD be configurable on a per alert type basis.

R122. The system SHOULD be able to specify custom alarm message in the SNMP trap.

R123. The system MUST support a minimum of 3 alarm destinations for alarm notifications.

R124. The system MUST monitor IWP ambient temperature and generate high/low temperature alarms.

R125. The system MUST monitor IWP inline AC power and generate high/low voltage alarms.

R126. The system MUST monitor antenna connection and generate VSWR alarms.

R127. The system MUST monitor overall IWP health status and generate IWP fault alarms.

R128. The system MUST monitor IWP outgoing queue(s) and generate backhaul congestion alarms.

R129. The system MUST proactively monitor for other service-impacting faults/events and generate respective alarms.

9.3 Configuration Management

9.3.1 General Configuration Requirements

R130. The IWP and its elements MUST support a fully documented mechanism to receive and execute configuration change commands from the EMS.

R131. Where applicable, an IWP management interface (e.g., CLI) MUST support secure local and remote access for configuration and management via [RFC 1492] or [RFC 2865].

R132. IWP and its elements SHOULD use an encrypted channel for all remote management and configuration.

R133. The IWP MUST support DHCP configuration and static IP addressing of its WAN interface.

R134. IWP and its elements configuration MUST be managed using a standards based interface such as CWMP or SNMP.

R135. IWP and its elements MUST be capable of obtaining configuration on boot up.

R136. IWP and its elements MUST operate with its last known good configuration in the event that it cannot contact the configuration management system upon reset or reboot.

R137. IWP and its elements MUST provide a method to apply runtime configuration changes without a device reset.

R138. IWP and its elements SHOULD NOT require the use of vendor's proprietary application for configuration management.

R139. IWP and its elements' firmware MUST be managed firmware management mechanism and capabilities.

10 MECHANICAL AND POWER SPECIFICATIONS

10.1 General

The IWP is to be installable by a single cable technician.

R140. The IWP MUST have field service tap points for attaching RF level instruments.

R141. The IWP MUST have health check and service LEDs visible from ground level.

R142. The IWP MUST use passive cooling and MUST NOT require a fan for cooling.

R143. The IWP MUST have FCC emission compliance.

R144. The Enclosure MUST accommodate a 5/8-24 threaded feed-through connector typically used in conjunction with the stub cable for the fiber backhaul configuration.

R145. The IWP MUST have fiber management facilities capable of handling a pre-connectorized stub cable in the fiber backhaul configuration.

The IWP energy efficiency is a significant concern for the cable operators. Given the large numbers of IWPs that may be deployed, the overall power consumption must be optimized.

10.2 Modularity

The IWP design must support replaceable units for key internal modules. The modular mechanism is beyond the scope of this specification but the use of a standardized interface connector is highly desirable. The complexity of the module replacement procedure should be minimized.

R146. The IWP MUST support a modular architecture for flexible configuration of key internal modules.

R147. The IWP MUST support a replaceable Picocell Module.

R148. The IWP SHOULD support a replaceable Wi-Fi Module.

R149. The IWP MUST support a replaceable Antenna Module.

R150. The IWP MUST support a replaceable Power module

R151. The IWP MUST support a transport Module which can easily configured for DOCSIS, EPON or Ethernet transport.

R152. The Enclosure SHOULD support a compartmentalized internal structure to easily support various IWP and backhaul configurations.

R153. The Transport, Picocell and Wi-Fi elements MUST be optional elements which can be installed, removed or replaced at a service location.

R154. The Transport, Picocell and Wi-Fi elements SHOULD be optional elements which can be installed, removed or replaced in the field.

R155. The Enclosure MUST be designed to support different antenna types/configurations (frequency band, MIMO and etc.).

10.3 Mounting Options

R156. The IWP MUST be designed to minimize the time to install or replace the unit.

10.3.1 Outdoor

R157. The IWP MUST meet Salt Spray Exposure ratings.

Using ASTM B117-09, the IWP is required to be tested for 600 hours with a rating of 6 or better using ASTM D1654-05, Procedure A, Method 2.

R158. The IWP MUST be able to run in ambient temperatures of -40°C to at least +55°C ambient, and repeatedly cold start at -40°C.

R159. Solar loading MUST be managed to maintain IWP at ambient temperature.

R160. Enclosure SHOULD be watertight with an [IEC 60529] IP 67 rating.

All external seals and access ports MUST be properly sealed and pressure-tested against 15 psi.

R161. The IWP SHOULD be able to operate within the safe working distance of high voltage lines and transformer yards as defined in [OSHA 1910.269] and [OSHA 1910.333].

10.3.1.1 Strand

R162. The Picocell element module components MUST NOT exceed 23.25 mm (.93") in height from centerline of PCB.

R163. The Picocell element module MUST NOT be larger than 135.5 sq. cm (21 sq. in).

R164. The Picocell element module PCB length or width MUST NOT exceed 25 cm (10").

The Power consumption of the IWP must be minimized since the power available on the strand is constrained

R165. The Picocell element MUST NOT consume more than 50 watts of power.

R166. IWP including antennas MUST fit in the 30 cm (12") telecom space, i.e., does not exceed 30 cm (12”) below the messenger cable to which it is mounted.

R167. IWP including antennas SHOULD fit in 20 cm (8") telecom space, i.e., does not exceed 20 cm (8”) inches below the messenger cable to which it is mounted per NESC Rule 235H2.

R168. The IWP MUST NOT extend more than 5 cm (2") above the cable strand.

R169. The IWP MUST NOT weigh more than 50 lbs.

R170. The IWP SHOULD be certified gunshot proof. See Section I.1.

10.3.1.2 Pole / Wall

R171. The IWP SHOULD be certified gunshot proof. See Section I.1.

10.3.1.3 Roof

R172. The IWP SHOULD support the separation of the antenna(s) from the IWP enclosure to allow the mounting of the antenna(s) on a roof-top parapet.

10.3.2 Indoor

R173. The IWP MUST be able to run in ambient temperatures of 0°C to at least 55°C.

R174. The IWP MUST be wall mountable.

R175. The IWP MUST be ceiling mountable.

10.4 Antenna

R176. The antenna module(s) SHOULD be covered over the Enclosure with minimum visible protrusion for aesthetics.

R177. All antenna jumper cables SHOULD be routed internally in the Enclosure without external exposure.

10.5 Power Supply Requirements

10.5.1 General

R178. Two types of rectifier power module options MUST be provided, 120V line power and CATV Plant Power. A combined module may alternately be provided as long as it can be set up for (and shipped with) 90 Volt class coaxial powering by default.

R179. A backup battery MUST NOT be required for operation of the IWP.

R180. Battery backup MAY be provided.

R181. Technician-accessible fuses MUST NOT be used.

R182. Sacrificial surge protection devices MUST NOT be equipped (e.g., gas tubes or MOVs) on the coaxial input port when coaxial powering is used.

R183. The IWP switch-mode noise at ~20MHz MUST NOT sum on the upstream and compromise DOCSIS return.

10.5.2 CATV Plant Powered

R184. Coaxial cable power interface module MUST be usable in both 60 VAC and 90 VAC nominal quasi-square-wave systems.

R185. 60 VAC and 90 VAC MUST be selected by a jumper setting (switch not allowed).

Jumper default is the 90 Volt position.

R186. The technology MUST be switched-mode rectifier; and may incorporate optional power factor correction (PFC).

R187. Total Power Consumption SHOULD be less than 100W.

R188. The Operating Voltage range MUST be 40 to 100 VAC quasi- square wave.

R189. The Continuous Minimum Input Voltage MUST be 36 or 58, depending on system (60 V or 90 V).

R190. The Low Voltage Cutoff MUST be 33 +/-3 VAC for 60 volt class systems, 55+/-3 for 90 volt class systems, jumper selectable. Unit MUST NOT draw significant power below selection.

R191. The Minimum Restart Voltage MUST be 33 +/-3 VAC.

R192. The Cold Start Delay MUST be >500ms <1 sec, variable according to startup RMS voltage ramp time; locations where voltage comes up quickly MUST start sooner than locations where input voltage comes up more slowly.

R193. The Operating Frequencies MUST be 47 to 63 Hz.

R194. IEEE C62.41, Category B3 (high system exposure) 1.5/50uS & 8/20uS, 6kV, 3kA combination wave MUST be provided.

10.5.3 Commercial Line Power

R195. The Operating Voltage range MUST be 90 VAC to 305 VAC (277 VAC + 10% margin) sinusoidal (utility line power).

R196. The utility line power interface module MUST be usable over a 60 Hz, sinusoidal, AC voltage range of 90 VAC to 305 VAC.

10.6 Protection circuits

R197. The IWP MUST have temperature or overheating Protection.

R198. The IWP MUST provide proper antenna in-line surge protection.

R199. The IWP MUST provide Lightning Protection: RF surge suppression to accommodate a maximum 20 kA pulse per the standard IEEE 8/20 microsecond waveform.

Appendix I Testing the Device

I.1 Gunshot Test

- Shoot at the device center of mass of the enclosure with a 12 gauge shotgun at a range of 40 feet.
- Ensure the pellets do not penetrate and the device remains functional.
- Wear protective facemask and clothing to protect from pellet bounce-backs.

Appendix II Acknowledgements

CableLabs would like to thank the cable operator members of CableLabs for their support in guiding the requirements defined in this specification, as well as the vendors who helped in the review of these requirements:

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