Desarrollo de una red telemática para proveer acceso a Internet en el municipio de Arafo.

Mario González-Nuevo Artime

I.T.T. Telemática

Consultor: Miquel Font Rosselló

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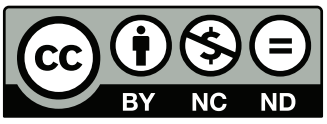
A mi mujer, Cris, a quien le agradezo su paciencia por tantos fines de semana sin salir de casa.

Nunca podré recompensarte. Te quiero.



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1. Introducción

1.1. Justificación del TFC y contexto en el cual se desarrolla: punto de partida y aportación del TFC.

Este proyecto tiene lugar como trabajo de fin de carrera de la titulación *Ingeniería Técnica de Telecomunicación, especialidad en Telemática*, de la Universitat Oberta de Catalunya.

El proyecto se denomina "Desarrollo de una red telemática para proveer acceso a Internet en el municipio de Arafo", pertenece al área de integración de redes telemáticas, y parte del supuesto en el que el Ayuntamiento de Arafo desea ofrecer conectividad a Internet gratuita en los límites de su municipio.

Básicamente, se trata de diseñar un sistema que lleve Internet a las calles, parques y plazas del término municipal de Arafo, en la isla de Tenerife.

Estará financiado por el ayuntamiento local, y será un valor añadido a los servicios que presta dicho ayuntamiento. De este modo el proveedor del servicio es el propio ayuntamiento, y los usuarios finales son los vecinos de dicho ayuntamiento.

Tras realizar un análisis de población objetivo, analizar requerimientos y adaptar el proyecto requerido por dicho ayuntamiento a la legislación aplicable de la CMT, que es bastante restrictiva en cuanto a proveer acceso a Internet de manera gratuita, se realizarán estudios de cobertura, y se hará un análisis del ancho de banda requerido, determinando al mismo tiempo que tecnologías inalámbricas de transporte de datos son las óptimas para el proyecto.

Del mismo modo, será necesario proveer a la red de las medidas de seguridad necesarias para proteger tanto la propia infraestructura, como a los usuarios finales de la misma.

1.2. Objetivos del TFC.

Los objetivos principales de este Trabajo de Fin de Carrera son:

- Proveer acceso a Internet a los vecinos del municipio de Arafo, como parte de los servicios que el ayuntamiento presta a la población.
- Hacerlo de manera segura, tanto para los usuarios finales, como para la integridad del propio servicio.
- El desarrollo deberá realizarse con el menor coste posible, siempre y cuando el ahorro de costes no suponga una merma del resto de objetivos del proyecto, dado que no disponemos de concurso y bases al que ajustar el mismo.

- Se realizará un estudio de cobertura para determinar los equipos necesarios para que la señal se reciba con la calidad suficiente, garantizando una velocidad de conexión mínima establecida, en las zonas del casco principal de Arafo.

- Se estudiará el tipo de tráfico que se quiere ofrecer en la red, dimensionando la misma para evitar estados de saturación y cuellos de botella, y de modo que pueda adaptarse fácilmente a un aumento de los usuarios en el futuro.

Las tareas de mantenimiento, soporte, garantía, gestión remota de la red y monitorización serán gestionadas por el Servicio de Informática del Ayuntamiento de Arafo.

En una segunda fase, no contemplada en este proyecto, pero si tenida en cuenta a efectos de crecimiento en el futuro:

- Se realizará un estudio de cobertura para determinar los equipos necesarios para que la señal se reciba con la calidad suficiente, garantizando una velocidad de conexión mínima establecida, en el núcleo conocido como la Hidalga, algo más alejado del casco principal, pero dentro de los límites del municipio.

Podemos observar los límites del municipio de Arafo en el mapa de la figura 1. En él observamos el núcleo poblacional de Arafo donde daremos cobertura, y el núcleo secundario de la Hidalga, más hacia la costa, donde se dará cobertura en una futura segunda fase.

1.3. Alcance del proyecto.

Este proyecto abarca todas aquellas tareas relacionadas con la ingeniería, diseño y desarrollo de la red, de modo que se apliquen todos aquellos conocimientos adquiridos en la carrera de Telecomunicaciones.

Queda fuera del estudio del mismo la instalación eléctrica necesaria para los equipos, así como la implantación real de todo el sistema.

1.4. Planificación del proyecto.

Una primera planificación de tareas a llevar a cabo en este proyecto es la que se observa en la figura 2. Esta contempla las tareas necesarias para acometer este TFC, no del proceso de instalación de la red.

Además se temporizan dichas tareas con el diagrama de Gantt de la figura 3.

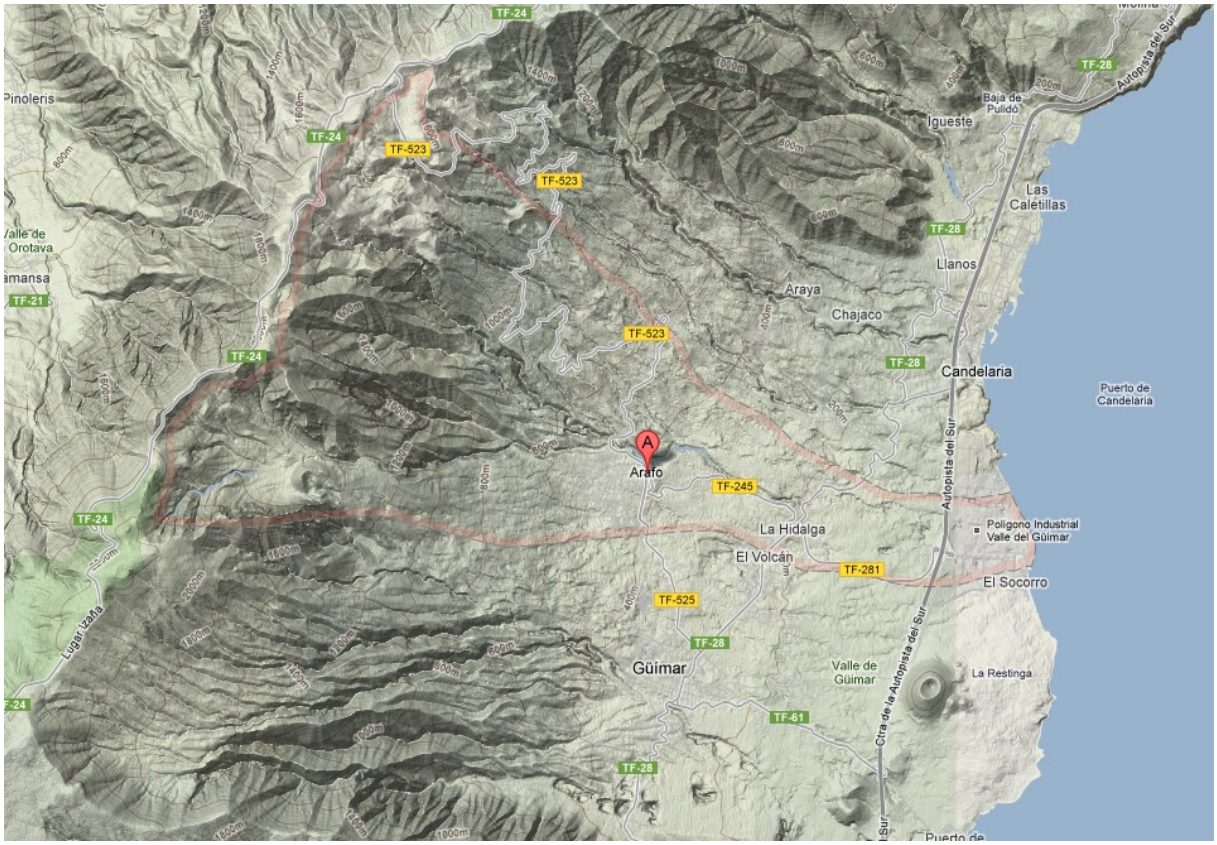

Figura 1: Perímetro del municipio de Arafo (Isla de Tenerife)

Título	Esfuerzo
1) Decisión de proyecto	**2s 7h**
• 1.1) Eleccción de proyecto	1s 1d 0,5h
◆ 1.2) Comunicación de decisión de proyecto	
• 1.3) Definición de objetivos	2d 4,5h
• 1.4) Elaboración del plan de trabajo	2d 2h
◆ 1.5) Entrega de la planificación	
2) Análisis preliminares	**6s 3d 5,5h**
• 2.1) Análisis de la legislación de la CMT	1s
• 2.2) Decisión y adaptación del proyecto a normativa aplicable	1s
• 2.3) Análisis de población objetivo y tráfico necesario	1s
• 2.4) Estudio de equipamiento necesario y requerimientos técnicos	1s
• 2.5) Estudio preliminar de cobertura	2s 3d 5,5h
◆ 2.6) Primera entrega del trabajo	
3) Diseño de red	**4s**
• 3.1) Diseño de red	2s
• 3.2) Verificación de cobertura	2s
◆ 3.3) Segunda entrega del trabajo	
4) Presupuesto y memoria	**17s 2d 5,5h**
• 4.1) Elaboración de presupuesto	1s 4d
• 4.2) Maquetación de la memoria	15s 3d 5,5h
◆ 4.3) Entrega de la memoria final	
5) Presentación	**1s 1,25h**
• 5.1) Elaboración de la presentación	1s 1,25h
◆ 5.2) Entrega de la presentación	

Figura 2: Tabla de tareas del TFC

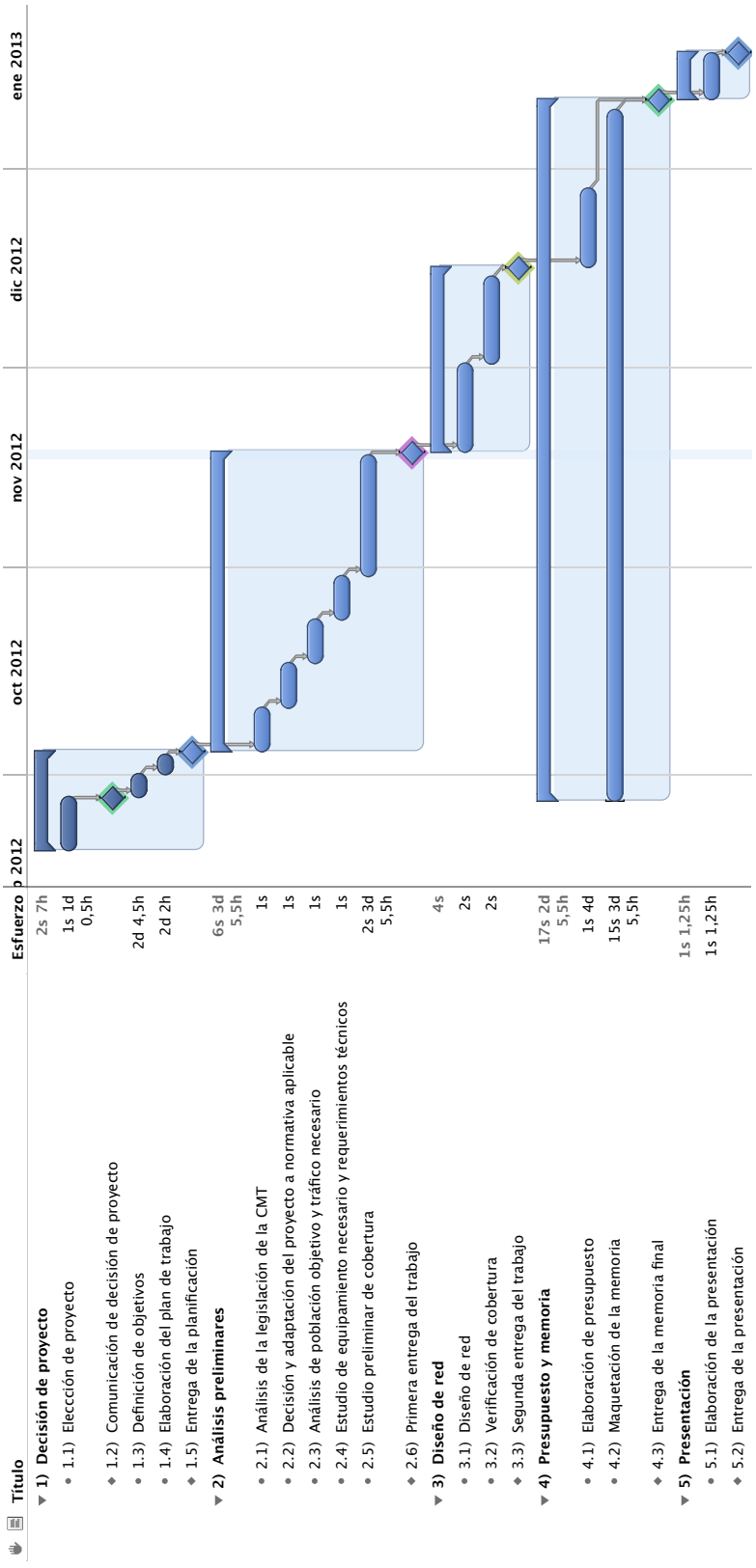

Figura 3: Diagrama de Gantt del TFC

2. Análisis preliminares

2.1. Análisis de la legislación de la CMT.

Como se ha esbozado superficialmente en la introducción, uno de los aspectos clave del proyecto es la legislación de la Comisión del Mercado de las Telecomunicaciones (en adelante, CMT).

La CMT es la Autoridad Nacional de Regulación (ANR) del sector de las telecomunicaciones en España[1], y tiene como funciones principales establecer y supervisar las obligaciones que han de cumplir los operadores del mercado de las telecomunicaciones, fomentar la competencia en el mercado de los servicios audiovisuales y la resolución de conflictos entre operadores, entre otras.

La CMT es bastante restrictiva en cuanto a prestar servicios de acceso Internet de forma gratuita, que es el objetivo de este TFC. De la circular 1/2010 de la CMT[2], se puede extraer a modo de resumen que un ayuntamiento puede prestar un servicio de acceso a Internet bajo una de las siguientes condiciones:

- Que dicho ayuntamiento se registre como operador de servicios de comunicaciones, además de establecer un modelo de negocio viable desde el punto de vista económico, con contabilidad independiente a la del propio ayuntamiento, y en las que obviamente, no se pueden usar fondos públicos.

- Que el servicio de acceso público a Internet se preste en zonas públicas, excluyendo expresamente edificios de viviendas o mixtos, de manera que no se pueda disfrutar desde los domicilios, y limitando la velocidad de acceso a 256 Kbps.

Constituir un modelo de negocio y darse de alta como operador de comunicaciones no es el objetivo de este proyecto, por lo que las características técnicas de el mismo se ajustarán de modo que el servicio prestado cumpla con la segunda de las condiciones que acabamos de exponer.

Por otro lado, dado que se registrarán datos personales de los usuarios con fines legales, para el hipotético caso de que se cometan delitos usando nuestra infraestructura, y cumplir con la LOPD[3] y la LSSI[4], el Servicio de Informática del Ayuntamiento de Arafo se hará cargo de

[1] http://es.wikipedia.org/wiki/Comisión_del_Mercado_de_las_Telecomunicaciones_de_España
[2] http://www.cmt.es/c/document_library/get_file?uuid=f26dcedb-3cfc-429e-8629-303fc2c6de81&groupId=10138
[3] http://www.agpd.es/portalwebAGPD/canaldocumentacion/legislacion/estatal/common/pdfs/Ley-15_99.pdf
[4] http://www.boe.es/boe/dias/2002/07/12/pdfs/A25388-25403.pdf

recabar los registros, así como de su custodia y almancenamiento.

2.2. Decisión y adaptación del proyecto a normativa aplicable.

Por lo tanto, este PFC comprende el desarrollo y despliegue de la infraestructura necesaria para dar cobertura final mediante Wi-Fi en la banda de 2.4 GHz a las zonas públicas del municipio de Arafo donde exista una mayor densidad de usuarios potenciales.

A estas zonas se les dará conectividad a Internet, mediante una primera red de distribución, basada en enlaces PtMP, y a través de una segunda red de acceso, que usa puntos de acceso WiFi para dar conectividad a los usuarios finales.

Estas zonas, en concreto, serán:

- La Plaza del Ayuntamiento.
- El Auditorio Juan Carlos I.
- El Centro de ocio artesanal.
- El campo de fútbol y lucha.

Además el nodo central estará en el propio ayuntamiento, donde se ubicarán las estaciones base y el resto de equipamiento de red que sea necesario.

Para cumplir con todos los requisitos de la CMT, los *HotSpots* limitarán la velocidad por usuario a 256 Kbps, y se ajustará la posición y potencia de cada punto de acceso para que la señal WiFi no llegue al interior de las viviendas.

El acceso a Internet, será, en consecuencia, gratuito para los usuarios.

2.3. Análisis de población objetivo y tráfico necesario.

Según los datos facilitados por el Instituto Nacional de Estadística[5], en el año 2011, había un total de 5536 habitantes registrados en el municipio de Arafo.

Pese a que los últimos datos del instituto de la mujer reflejan aún cierta diferencia en el uso de las tecnologías de la información entre hombres y mujeres[6], en favor de los primeros, para este proyecto vamos a asumir un uso equitativo en cuanto a sexos, por lo que no tendremos en cuenta las diferencias de población por sexos. Además esa diferencia de uso de las TI muestra una tendencia a igualarse, con lo que en un plazo presumiblemente corto, será despreciable.

[5] http://www.ine.es/inebmenu/mnu_padron.htm

[6] http://www.inmujer.gob.es/estadisticas/consulta.do?area=4

Del total de 5536 habitantes mencionado, en la franja de edad que comprende desde los 15 hasta los 75 años, se encuentran 4193 habitantes. Se ha elegido dicha franja según los datos publicados por el Ministerio de Industria, Energía y Comercio[7], que revelan un mayor uso de Internet entre los más jóvenes, uso que disminuye a medida que avanzamos en la edad analizada.

La red, compuesta por cuatro *HotSpots*, dará soporte para al acceso simultáneo a 400 usuarios, que supone aproximadamente la décima parte del total de los usuarios potenciales. Haciendo hincapié en que hablamos de acceso simultáneo, se trata de una cifra bastante razonable.

De este modo, si queremos que cada *HotSpot* de servicio a 100 usuarios concurrentes, utilizaremos un punto de acceso que cumpla este requisito, o tantos puntos de acceso como sean necesarios, sumando su capacidad.

Dado que los puntos de acceso seleccionados soportan más de 100 conexiones concurrentes, cada *HotSpot* estará compuesto por un único punto de acceso, pues es suficiente en términos de capacidad y cobertura.

Se limitará, mediante el software integrado en los propios puntos de acceso, que el número de usuarios simultáneos activos en un mismo punto de acceso no sea mayor de 100. En una segunda fase, cuando se instalen puntos de acceso adicionales en la zona de la Hidalga, la capacidad global de la red se verá incrementada. Los enlaces de la red distribución, soportan 150 Mbps por cada estación base, por lo que no es un factor limitante, siempre y cuando se contrate con el ISP un caudal suficiente.

Teniendo en cuenta el dimensionado de la primera fase de la red, y para garantizar 256 Kbps a 400 usuarios, es necesario contratar al ISP un servicio de 100 Mbps.

En la tabla 1 se resumen las capacidades y requerimientos de ancho de banda para los elementos de la red críticos.

[7] http://www.ontsi.red.es/ontsi/es/estudios-informes/informe-anual-2011-edicion-2012

elemento	nº usuarios	B/W por usuario	B/W total
HotSpot	100	256 Kbps	25 Mbps
Base Station	200	256 Kbps	50 Mbps
Router	400	256 Kbps	100 Mbps

enlace	medio	B/W disponible	B/W requerido
AP - CPE	100Base-TX	100 Mbps	25 Mbps
CPE - BS	AirMAX@	150 Mbps	50 Mbps
BS - *Router*	1000Base-T	1 Gbps	100 Mbps

Tabla 1: Tabla de capacidades y requerimientos de ancho de banda.

2.4. Requerimientos de cobertura.

Como ya hemos detallado anteriormente, las zonas a cubrir mediante la señal Wi-Fi son:

- La Plaza del Ayuntamiento.
- El Auditorio Juan Carlos I.
- El Centro de ocio artesanal.
- El campo de fútbol y lucha.

Si añadimos a esta lista, el edificio del propio ayuntamiento, ya tenemos la lista completa de ubicaciones donde tendremos que instalar nuestros equipos de RF.

Podemos ver dichas ubicaciones en el mapa de la figura 4. Las zonas WiFi están sombreadas en verde, mientras la ubicación del Ayuntamiento aparece sombreada en rojo.

Siendo el nodo central, y lugar donde se ubicarán las estaciones base, el Ayuntamiento, se puede observar que el peor caso en cuanto a distancia de enlace AirMAX será el que une el propio Ayuntamiento con el campo de fútbol. En concreto sobre el mapa se han medido 680 metros. Esta distancia no supone impedimento para que los enlaces AirMAX consigan negociar al máximo de la velocidad, como se verá en el estudio de cobertura.

Figura 4: Ubicación del os equipos de RF y zonas de cobertura WiFi.

3. Infraestructura necesaria

3.1. Conceptos técnicos utilizados

3.1.1. *HotSpots*

Un *HotSpot*[8] es una zona donde se ofrece acceso a Internet de forma inalámbrica. Tienen una zona de cobertura que está delimitada según la potencia de transmisión, las antenas utilizadas, o los obstáculos que puedan existir en la zona. Podemos ver una ilustración de la zona de cobertura de un *HotSpot* en la figura 5.

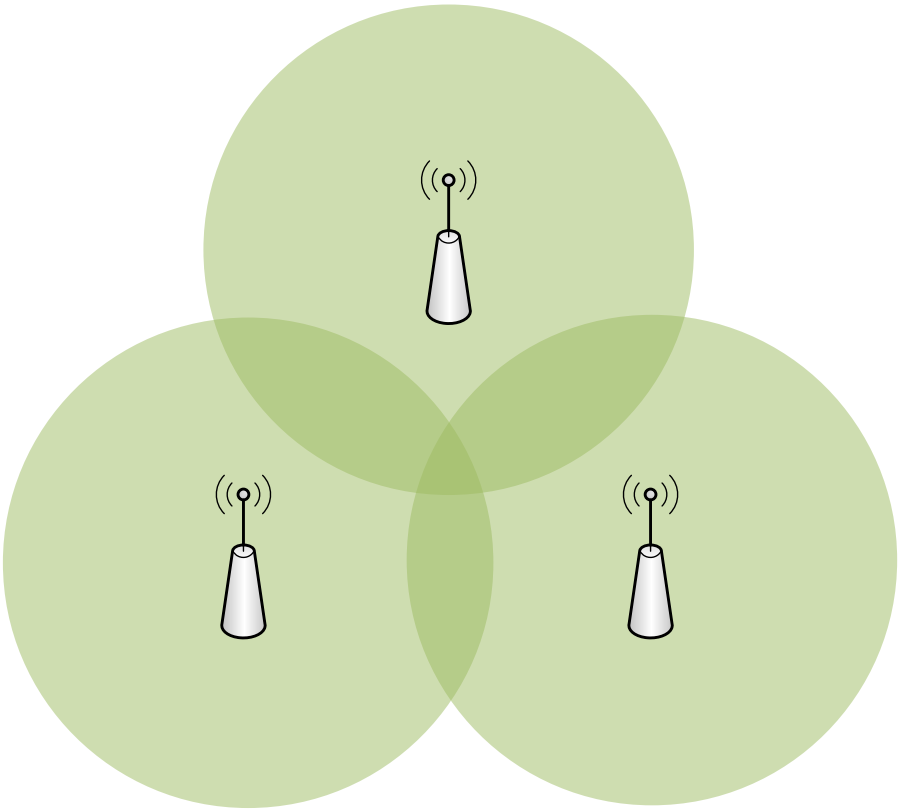

Figura 5: Zona de cobertura de un *HotSpot* formado por tres antenas.

El servicio se presta mediante WiFi, usando el estándar 802.11, y puede trabajar en la banda de 2.4 GHz (la más común) o en la de 5 GHz.

[8] http://es.wikipedia.org/wiki/Hotspot_(telecomunicaciones)

protocol	date	freq.	bandwidth	max. speed	MIMO	modulation	range
802.11	1997	2.4 GHz	20 MHz	2 Mbits	1x	DSSS, FHSS	100 m.
802.11a	1999	5 GHz	20 MHz	54 Mbits	1x	OFDM	120 m.
802.11b	1999	2.4 GHz	20 MHz	11 Mbits	1x	DSSS	140 m.
802.11g	2003	2.4 GHz	20 MHz	54 Mbits	1x	OFDM, DSSS	140 m.
802.11n	2009	2.4/5 GHz	20/40 MHz	150 Mbits	4x	OFDM	250 m.

Tabla 2: Comparativa de los distintos protocolos y sus características principales.

3.1.2. WiFi (IEEE 802.11)

802.11 son un conjunto de estándares que definen el uso de los dos niveles inferiores de la capa OSI (capa física y capa de enlace) en redes locales inalámbricas, trabajando en la banda de 2,4 y 5 GHz. La primera versión data de 1997, y ha ido evolucionando hasta la fecha actual añadiendo prestaciones[9].

Figura 6: Logotipo de WiFi

Podemos ver una tabla comparativa de los distintos protocolos y sus características principales en la tabla 2.

Wi-Fi se usa para la conexión de dispositivos electrónicos de forma inalámbrica. Los dispositivos habilitados con Wi-Fi, ordenadores, consolas, o teléfonos inteligentes, pueden conectarse a Internet a través de un punto de acceso de red inalámbrica.

[9] http://en.wikipedia.org/wiki/IEEE_802.11

3.1.3. MIMO

MIMO[10] son las siglas de *Multiple Input Multiple Output*. En radiofrecuencia, se refiere al uso de múltiples antenas tanto en el transmisor como en el receptor de una comunicación.

En la comunicaciones sin hilos, ofrece un aumento significativo de la velocidad de transmisión, así como en el alcance, sin aumentar el ancho de banda ni la potencia de transmisión.

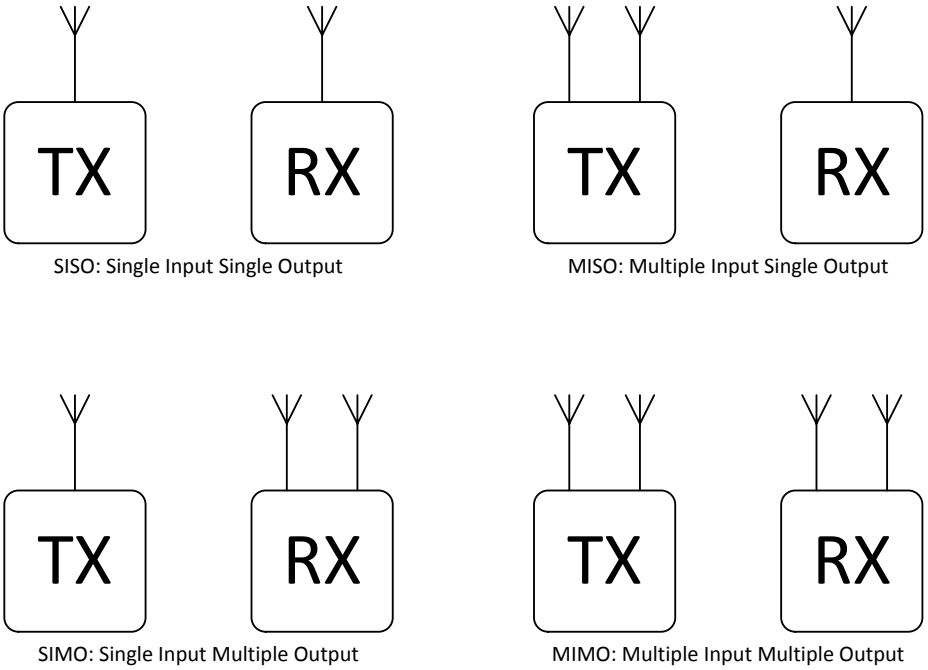

Figura 7: Distintas formas de MIMO.

Lo que hace es repartir la potencia transmitida entre las distintas antenas para conseguir, o bien una mayor eficiencia espectral, o bien mayor fiabilidad en la conexión.

3.1.4. Tipos de antenas

Las antenas se pueden clasificar en tres clases, según su directividad:

- **Directivas o direccionales.** Son aquellas que concentran su mayor densidad de energía de radiación y ganancia de recepción en torno a un azimut concreto. Este se conoce como haz principal.
- **Omnidireccionales.** Son que aquellas que presentan un diagrama de radiación casi constante en los 360º de azimut. No necesitan orientación, pero tienen una ganancia menor

[10] http://en.wikipedia.org/wiki/MIMO

que las directivas. Sin embargo son convenientes para transmitir a varios receptores, o para cuando los receptores son móviles.

- **Sectoriales.** Son un caso particular de las directivas, donde el haz principal es más ancho que en estas, con valores de apertura de 90 a 120 grados, típicamente. En este rango de azimuts, presentan un valor de ganancia casi constante. Tienen menos ganancia que las directivas, pero más que las omnidireccinales.

3.1.5. Conexiones de red: Punto a punto (*PtP*) y punto a multipunto (*PtMP*)

En redes, existen dos tipos de conexiones según su tipología:

- Conexión **punto a punto**. Es aquella que conecta únicamente dos puntos distantes.
- Conexión **punto a multipunto**. Es aquella que discurre desde una única ubicación, hacia múltiples ubicaciones, compartiendo el acceso al medio. Un *HotSpot* en un ejemplo de este tipo de conexión, siendo un extremo el punto de acceso WiFi, y el otro extremo los distintos usuarios de la red.

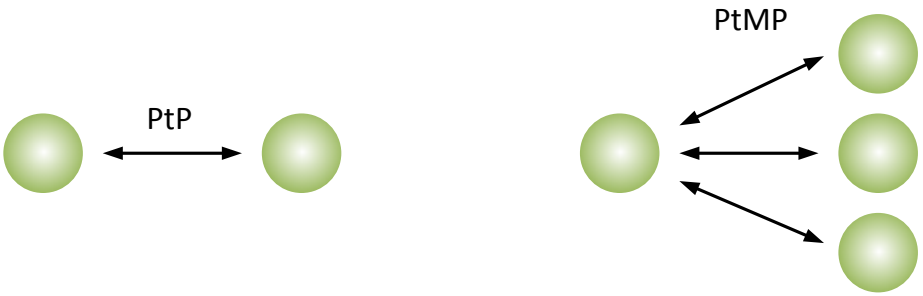

Figura 8: Topología PtP y PtMP

Una conexión entre dispositivos AirMAX consta de dos equipamientos de comunicaciones: En un extremo, una estación base o **BS** (*Base Station*) en el lado del proveedor, y en el otro, un equipo local de cliente o **CPE** (*Customer Premises Equipment*), conectado en el lado del usuario final.

Una estación base se puede comunicar con un CPE en modo PtP, o con varios CPE en modo PtMP.

3.1.6. Protocolo AirMAX TDMA

AirMAX es un protocolo propietario de transmisión de datos, basado en TDMA y MIMO, derivado del estándar 802.11, que utiliza las ondas de radio en las frecuencias de 900, 2.4, 3 y 5.8 GHz. Este desarrollo proporciona velocidades reales de hasta 150 Mbps en distancias de 50 kilómetros, según el fabricante.

Para poder estudiar la mejora que introduce AirMAX, veamos primero en que consiste una colisión entre nodos no visibles (*hidden node collision*[11]).

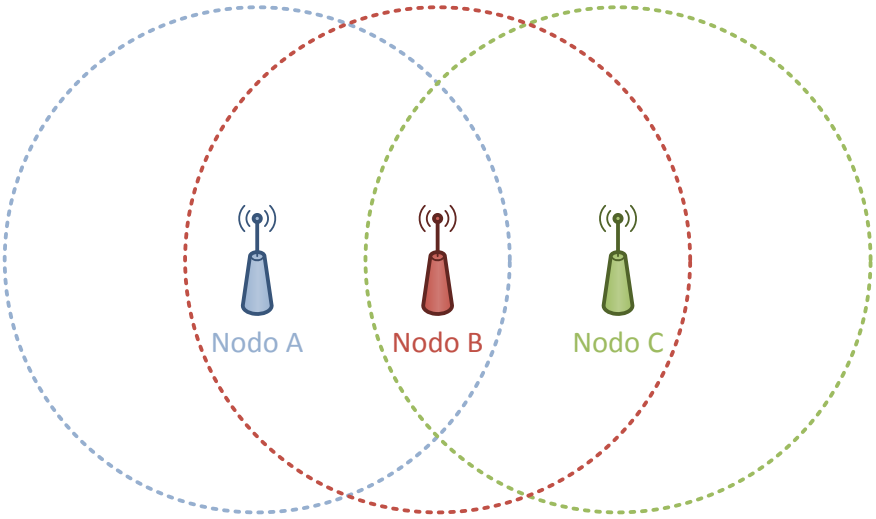

Figura 9: Gráfico explicativo sobre el fenómeno conocido como *hidden node collision*: El nodo A y el nodo C están al alcance del nodo B, pero entre ellos no tienen comunicación.

El estándar 802.11, con el fin de de compartir el medio de transmisión, usa CSMA/CA, o *Carrier Sense Multiple Access with Collision Avoidance*. En la práctica, esta técnica "escucha" el medio y la estación transmisora no envía un paquete hasta que detecta que el medio compartido está libre. Sin embargo, si una estación que quiere transmitir, tiene fuera de su alcance a otra estación que se encuentra transmitiendo en el mismo segmento de red (ver figura 9), no puede evitar iniciar la transmisión, y causa una colisión. Como los datos se corrompen, hay que volver a transmir los paquetes perdidos, con la consecuente merma en la velocidad de transmisión. Este problema además es muy frecuente en comunicaciones PtMP, que son las que nos ocupan.

AirMAX TDMA mejora el estándar 802.11 haciendo uso de TDMA (*Time Division Multiple Ac-*

[11] http://en.wikipedia.org/wiki/Hidden_node_problem

cess) en sustitución de CSMA/CA. Establece unos *Time Slots* preasignados y coordinados por la estación base, para cada extremo (en este caso CPE) del enlace PtMP. De este modo, no se producen colisiones porque cada equipo dispone de un intervalo de tiempo para transmitir, y esto hace posible el aumento de velocidad de transferencia respecto al estándar 802.11.

3.2. Topología de red

En la figura 10 podemos observar la conexión entre los dispositivos de red. Como se aprecia en la leyenda, la conexión entre el ISP, *router*, *firewall*, *switch* y los servidores es Gigabit Ethernet mediante cableado estructurado, por lo que no tendremos problemas en cuanto a cuellos de botella por la interconexión de estos dispositivos.

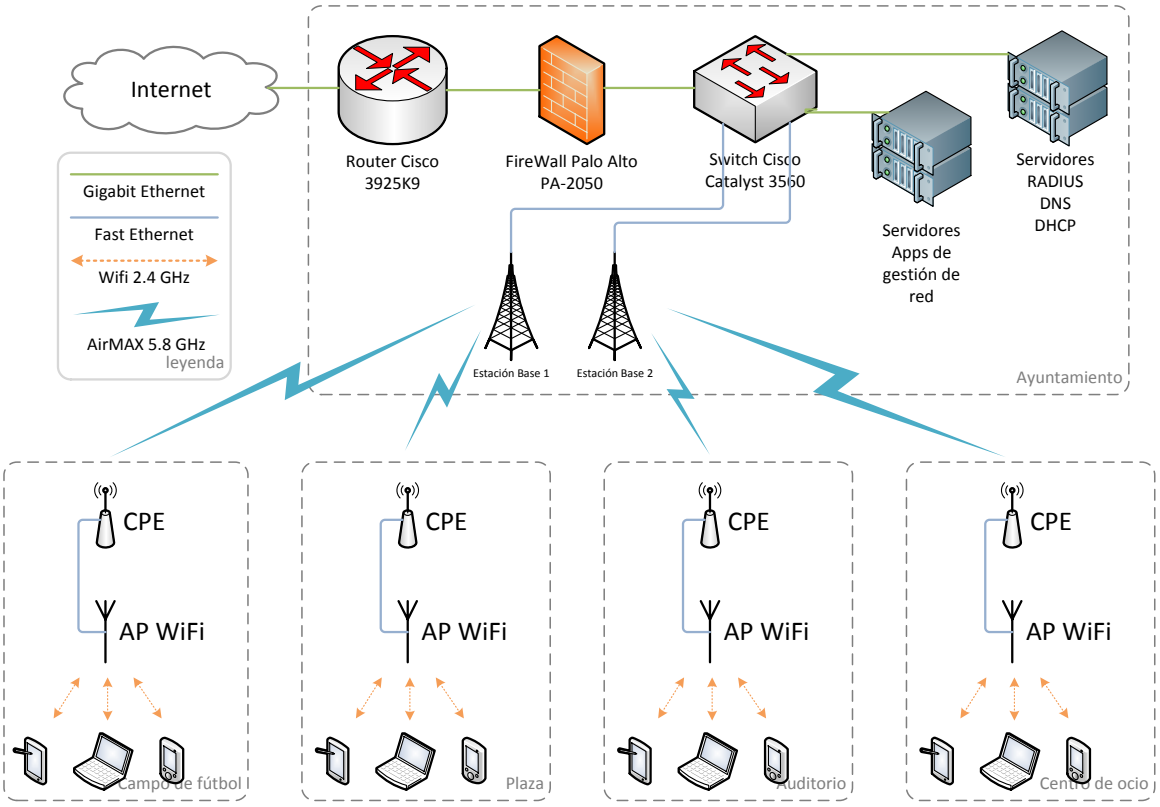

Figura 10: Topología general de los equipos de red.

El resto de equipamiento, tanto los equipos inalámbricos AirMAX como los WiFi, poseen conexiones FastEthernet, que tampoco serán un factor limitante, teniendo en cuenta que hemos dimensionado para dar acceso simultáneo a 100 usuarios por punto de acceso. Esto supone 25 Mbps en cada punto de acceso, o 50 Mbps por cada estación base, la mitad del caudal que

soporta FastEthernet (ver tabla 1).

Es importante detallar como cada *HotSpot* está compuesto de una unidad CPE, que recibe los datos en la banda de 5.8 GHz desde las estaciones base del ayuntamiento, y por un punto de acceso en la banda de 2.4 GHz, ambas unidades conectadas entre si mediante cableado estructurado y FastEthernet.

3.3. Estudio de equipamiento necesario y requerimientos técnicos.

3.3.1. Tecnologías empleadas y jerarquía de conexiones.

Nivel 1 (distribución). Para la comunicación de datos desde el nodo central del ayuntamiento a las distintos *HotSpots*, se utilizarán enlaces AirMAX privados basados en 802.11, en modo PtMP.

Usaremos la banda libre de 5.8 GHz, que posibilita operar sin licencia. La potencia máxima de transmisión de estos dispositivos es de 27 dBm, o 500 mW, que se ajusta a la legislación española, la cual especifica un máximo para esta frecuencia de 33 dBm o 2W (UN-143).

Nivel 2 (acceso). Para dar la cobertura final a los usuarios en las zonas de cobertura o *HotSpots*, se usará Wi-Fi. En concreto se usará el estándar 802.11 b/g/n, en la banda de 2.4 GHz, de modo que sea compatible con el mayor número de usuarios posibles.

Nuestra frecuencia de trabajo en Wi-Fi será 2.4 GHz y se ajustará la potencia de salida a 20 dBm o 100 mW (UN-85) o menor, según la cobertura necesaria, que es el máximo que establece la normativa española.

Esta normativa se refiere al cuadro nacional de atribución de frecuencias[12] (CNAF), y en concreto a las notas de utilización nacional (UN)[13]

3.3.2. Fabricantes seleccionados.

En lo referente a los equipos de RF, el fabricante elegido es Ubiquiti Networks[14]. Se ha barajado también a la conocida firma Alvarion, fabricante con amplia experiencia en equipamiento WiMAX, pero la mejor relación precio/prestaciones de los equipos de Ubiquiti Networks nos hace decantar por este último. Una de las razones de la diferencia de en el precio de ambos

[12] http://www.minetur.gob.es/telecomunicaciones/Espectro/Paginas/CNAF.aspx
[13] http://www.minetur.gob.es/telecomunicaciones/Espectro/CNAF/notasUN2010.pdf
[14] http://www.ubnt.com

Figura 11: Estación base AirMAX Rocket M GPS, modelo RM5-GPS

fabricantes es que para usar el estándar WiMAX hay que pagar la licencia correspondiente, al contrario que ocurre con AirMAX.

Ubiquiti Networks dispone de equipos sólidos, con una fiabilidad avalada por instaladores que así lo reflejan en los foros especializados, con unos precios muy competitivos, que ayudarán a reducir tanto la inversión inicial en adquisición de equipos, como el coste por propiedad, debido al mantenimiento de los mismos.

En cuanto a la electrónica de red, se recurre a equipamiento de Cisco, tanto para el *Router*, como para el *Switch*, y de un cortafuegos e IPS/IDS del fabricante Palo Alto Networks.

3.3.3. Estaciones base.

Las estaciones base estarán compuestas de una unidad AirMAX Rocket M GPS, modelo RM5-GPS (ver figura 11), más una antena AirMAX Sector (ver figura 12), modelo 5G-16-120.

Se adjuntan como anexos las características técnicas de ambas unidades, al final de la memoria, aunque podemos destacar como principales, respecto a la estación base, que dispone de una parte radio 2x2 MIMO, con alcance de hasta 50 kms., y una velocidad real TCP/IP de 150 Mbps. Además este modelo GPS, usa unos receptores GPS para sincronización respecto a otra estación base con la que comparta ubicación, con lo que se eliminan las interferencias por ubicación común o *co-location interference*. Respecto a la antena, se trata de una unidad sectorial, con apertura de 120º, y una ganancia de 16 dBi. Existen otros modelos de mayor tamaño y

Figura 12: Antena sectorial AirMAX Sector, modelo 5G-16-120

ganancia, pero dadas las distancias a cubrir, con la unidad elegida es más que suficiente, y así se contiene el coste.

3.3.4. Unidades CPE.

Las unidades elegidas como Equipo Local de Cliente o CPE, son las AirMAX Nanostation M, modelo NSM5 (ver figura 13), y las AirMAX Nanostation loco M (ver figura 14), modelo LOCOM5. Se trata de unidades CPE para intemperie, con parte radio 2x2 MIMO, alcance hasta 50 kms, y velocidad TCP/IP real de 150 Mbps. Estas unidades tienen la antena integrada junto con la radio. La diferencia de la NSM5 y la LOCOM5 es que la primera tiene 2 interfaces de red Ethernet 10/100 BASE-TX, por uno de la LOCOM5. Además la antena de la NSM5 tiene 16 dBi, por 13 dBi de la LOCOM5. Más adelante, en la sección "posibles ampliaciones" veremos el por qué de estas unidades con dos interfaces de red.

Se adjuntan también anexos con las características técnicas de ambas unidades, en la sección correspondiente.

3.3.5. Puntos de acceso Wi-Fi.

Para dar cobertura a los *HotSpots*, utilizaremos la serie UniFi, modelo para exteriores, UAP-Outdoor (ver figura 15). Negocia velocidades de hasta 300 Mbps e incluyen dos antenas omnidireccionales, y tienen un puerto secundario Ethernet para futuras ampliaciones. Importante hacer notar que se gestionan remotamente, incluyendo la actualización del firmware, y sobre todo que incluyen portal cautivo para usuarios invitados y soporte para portales externos. También permiten gestionar la velocidad de los usuarios, punto importante para nosotros, donde

Figura 13: Unidad CPE AirMAX Nanostation M, modelo NSM5

Figura 14: Unidad CPE AirMAX Nanostation loco M, modelo LOCOM5

Figura 15: Punto de acceso UniFi Wi-Fi UAP-Outdoor (la foto corresponde al modelo de 5GHz.)

aplicaremos el límite de 256 Kbps.

Se adjunta anexo de características técnicas.

3.3.6. Electrónica de red Cisco.

El *Router* es un Cisco 3925/K9 (ver figura 16), que dispone entre otros de fuente de alimentación doble o redundante, y una capacidad de proceso de 350 Mbps en servicios concurrentes, adecuado a nuestras necesidades y a entornos WAN de alta velocidad. Dispone además de 4 puertos Gigabit Ethernet para futuras ampliaciones.

En cuanto al *Switch*, se trata de un Cisco WS-C3560G-24TS-S (ver figura 17), y cuenta con 24 puertos Ethernet 10/1000/1000, además de 4 puertos SFP Gigabit Ethernet. No se ha optado por el modelo con PoE, puesto que las estaciones base cuentan son su propia fuente de alimentación PoE.

3.3.7. Electrónica de red Palo Alto Networks.

El *firewall* de Palo Alto Networks PA-2050 (ver figura 18) va más allá de los cortafuegos tradicionales. Este IDS/IPS, es capaz de realizar identificación de aplicaciones (App-ID), de manera que permite categorizar, bloquear y clasificar dichas aplicaciones, particularmente en entornos HTTP y HTTPS. Es por lo tanto, un *firewall* de nivel 7. Este modelo en concreto es capaz de identificar aplicaciones en un tráfico de hasta 1 Gbps. Los detalles se pueden consultar en las hojas

Figura 16: *Router* Cisco 3925/K9.

Figura 17: *Switch* Cisco WS-C3560G-24TS-S.

Figura 18: *Firewall* Palo Alto Networks PA-2050

de especificaciones adjuntas a esta memoria.

3.3.8. Servidores.

Se incluyen cuatro servidores en formato de 19 pulgadas para *rack*, Dell PowerEdge R410, al que se le instalará el SO Ubuntu Server 12.04 LTS. Esta versión se trata de una versión *Long Term Support*, ideal para nuestro proyecto, y que ofrece una gran eficiencia, seguridad y robustez comparado con otros sistemas.

Estos cuatro servidores funcionan en grupos de dos, de manera redundante:

- En el primer grupo, correrá todo el software de gestión de los equipos AirMAX y WiFi.
- En el segundo grupo, correrán servicios de autenticación RADIUS, DNS y DHCP.

3.3.9. Equipamiento vario necesario.

Además se incluye en el proyecto, el suministro de un ordenador portátil con todo el software de gestión necesario para administrar tanto la electrónica de red, como para la configuración y gestión del equipamiento de radio.

Se suministra también un bastidor o *rack* de 19 pulgadas, que alojará la electrónica de red, y que irá ubicado en el edificio del ayuntamiento, donde el ISP entregue el servicio de Internet.

También se incluye una UPS que proporciona alimentación de emergencia a la propia electrónica de red en caso de fallo de suministro, así como a las estaciones base. Se trata de una unidad enracable de 4 U, Liebert GXT3 On-Line (ver figura 19), de 5000 VA. Dado un consumo máximo estimado de 2572 W suponiendo que toda la electrónica de red y las estaciones base están trabajando al máximo de capacidad, esta UPS nos brinda un tiempo considerable de autonomía en caso de fallo del suministro, y además nos deja un margen de escalabilidad para

tipo	equipo	cantidad	consumo máximo	consumo total
estación base	AirMAX RocketM5	2	8 W	16 W
switch	Cisco 3560	1	496 W	496 W
router	Cisco 3925K9	1	420 W	420 W
servidor	Dell R410	4	400 W	1600 W
firewall	PaloAlto 2050	1	120 W	120 W
TOTAL				2652 W

Tabla 3: Consumos máximos según fabricante.

Figura 19: UPS Liebert GXT3 5000 VA On-Line.

futuras ampliaciones.

Se adjuntan en la tabla 3 los consumos máximos según fabricante de los equipos alojados en el ayuntamiento.

Fuera de lo que es la electrónica, se contempla la instalación de mástiles necesarios para las antenas, así como cableado estructurado FTP de blindaje global, categoría 5e, apto para instalación en exteriores, puesto que es capaz de derivar a tierra fenómenos ESD, utilizando los alimentadores PoE suministrados en los equipos Ubiquiti.

Para este último aspecto, es importante verificar y/o realizar las correcciones necesarias en la instalación eléctrica en los diferentes emplazamientos de modo que todos cuenten con puestas a tierra normalizadas y en buenas condiciones de aislamiento.

3.3.10. Tolerancia a fallos del sistema.

Con el objetivo de reducir el tiempo de un hipotético “fuera de servicio” de alguno de los componentes del sistema, se suministran los equipos de repuesto relacionados en la tabla 4,

descripción	modelo	cantidad	necesita configuración	reposición
switch Cisco	WS-C3560G-24TS-S	1	si	30 min.
estación base AirMAX	RM5-GPS	1	si	3 horas
antena sect. AirMAX	5G-16-120	1	no	1 hora
CPE AirMAX	NSM5	1	si	2 horas
punto de acceso UniFi	UAP-Outdoor	1	si	2 horas

Tabla 4: Repuestos suministrados.

con los que, dado el caso de avería de uno de estos componentes, bastaría con su sustitución y configuración para reponer la funcionalidad perdida.

En cuanto a la disponibilidad del servicio por avería de otros componentes, se ha diseñado el sistema de modo que se minimicen las caídas del servicio.

En concreto, la alimentación de la electrónica de red y de las estaciones base del ayuntamiento tolera un fallo de la red de suministro gracias a una UPS.

Los servidores se configurarán redundantes 1 + 1, y por otro lado, el *router* cuenta con doble fuente de alimentación redundante. En el caso del cortafuegos nivel 7, dado su alto coste, en caso de avería y hasta que que suministre uno nuevo, se puede optar por, bien detener el servicio, o bien, hacer un *bypass* del cortafuegos y prestar el servicio sin él. Esta operación no requiere re-configuración, dada la operación en modo transparente del mismo.

Todos los equipos cuentan con con garantía *in-situ* y un SLA (*Service Level Agreement*) de tipo NBD (*Next Business Day*).

Por otro lado, para reducir el tiempo de fallo debido a "cuelgues" de alguna unidad, los quipos de Ubiquiti Networks, disponen en su software de un recurso denominado *watchdog*. En este caso, el equipo en cuestión realiza PINGs de manera regular a una dirección IP previamente configurada (en nuestro caso el *router*). Si dicha operación supera un umbral de fallo, la unidad asume que ha perdido el enlace con su colateral, y se reiniciará automáticamente. Esto reduce de modo considerable el número de desplazamientos necesarios para reiniciar las unidades ubicadas en los *HotSpots*.

3.3.11. Interconexión de equipos en el ayuntamiento: Estaciones Base.

Tal y como indica el manual de las unidades RocketM5 GPS, ésta se acopla a la antena, en esta caso una AirMAX sector, mediante los latiguillos RP-SMA suministrados y haciendo uso de

los anclajes incorporados.

Al las unidades RocketM5 solo resta conectarles el RJ45 que dará conectividad de datos y de alimentación a través de PoE. Por lo tanto, al tejado del ayuntamiento solo es necesario subir dos cables *cat.5e* (uno por cada BS), siempre que la longitud de los mismos sea inferior a 100 metros (por las limitaciones de Ethernet y por la caída de tensión del PoE). A continuación, como se observa en la figura 20, se conectan los adaptadores PoE suministrados junto a con las unidades RocketM5, y a su vez estos irán conectados al *switch*.

3.3.12. Interconexión de equipos en los CPE / *Hotspots*.

En las ubicaciones correspondientes a los *HotSpots*, van instaladas una unidad Nanostation M (BS), además de la unidad UniFi (AP WiFi), en el caso del auditorio y el centro de ocio.

En el caso de de los *HotSpots* de la plaza y el campo de fútbol, la unidad empleada para la BS es una NanoStation Loco M, y el AP WiFi Unifi es el mismo.

Se conectan una a la otra para pasar de la red WiMax de 5.8 GHz a la WiFi de 2.4, mediante dos adaptadores PoE, según se refleja en las figuras 21 y 22. De este modo, interconectamos dichas unidades al tiempo que se les proporciona alimentación.

3.3.13. Requerimientos para instalación de equipos RF.

En el edificio del ayuntamiento, como ya se ha comentado, solo es necesario subir dos tiradas de cableado estructurado, por los que van tanto datos como alimentación PoE para las estaciones base, con el requisito de que dicha acometida no supere los 100 metros.

En los distintos CPE / *HotSpots* será necesario que en los lugares elegidos para la ubicación de los dispositivos exista alimentación de 230 VAC, a menos de 100 metros de distancia. De no ser posible, habría que tirar una acometida de alimentación hasta un punto más próximo, e instalar una caja con grado de protección[15] IP 66 o superior, que pueda alojar los dos adaptadores PoE necesarios.

3.3.14. Orientación de los enlaces AirMAX

La orientación de las antenas correspondientes a las estaciones base, ubicadas en el ayuntamiento, se detalla en la figura 23 y será la siguiente:

[15] http://es.wikipedia.org/wiki/Grado_de_protecccción_IP

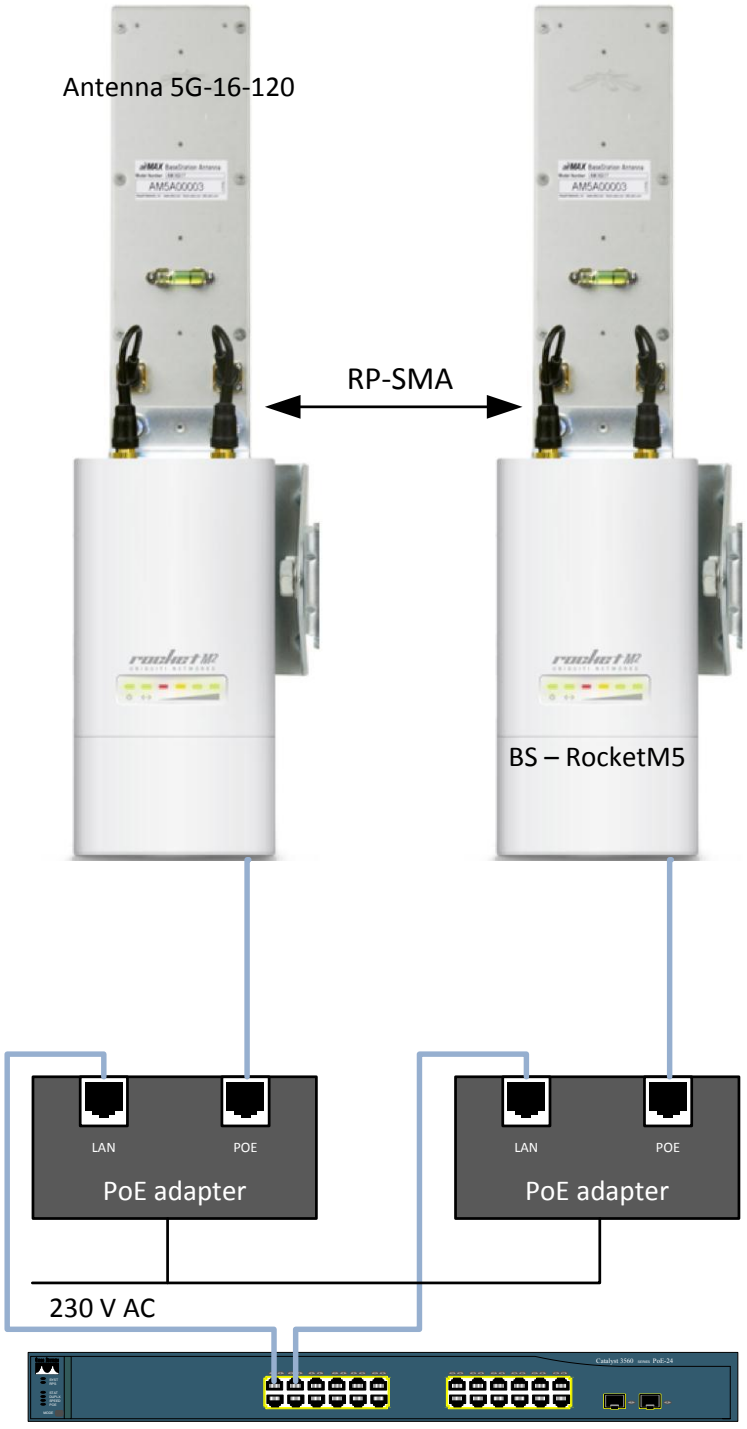

Figura 20: Interconexión de elementos de las estaciones base (Ayuntamiento).

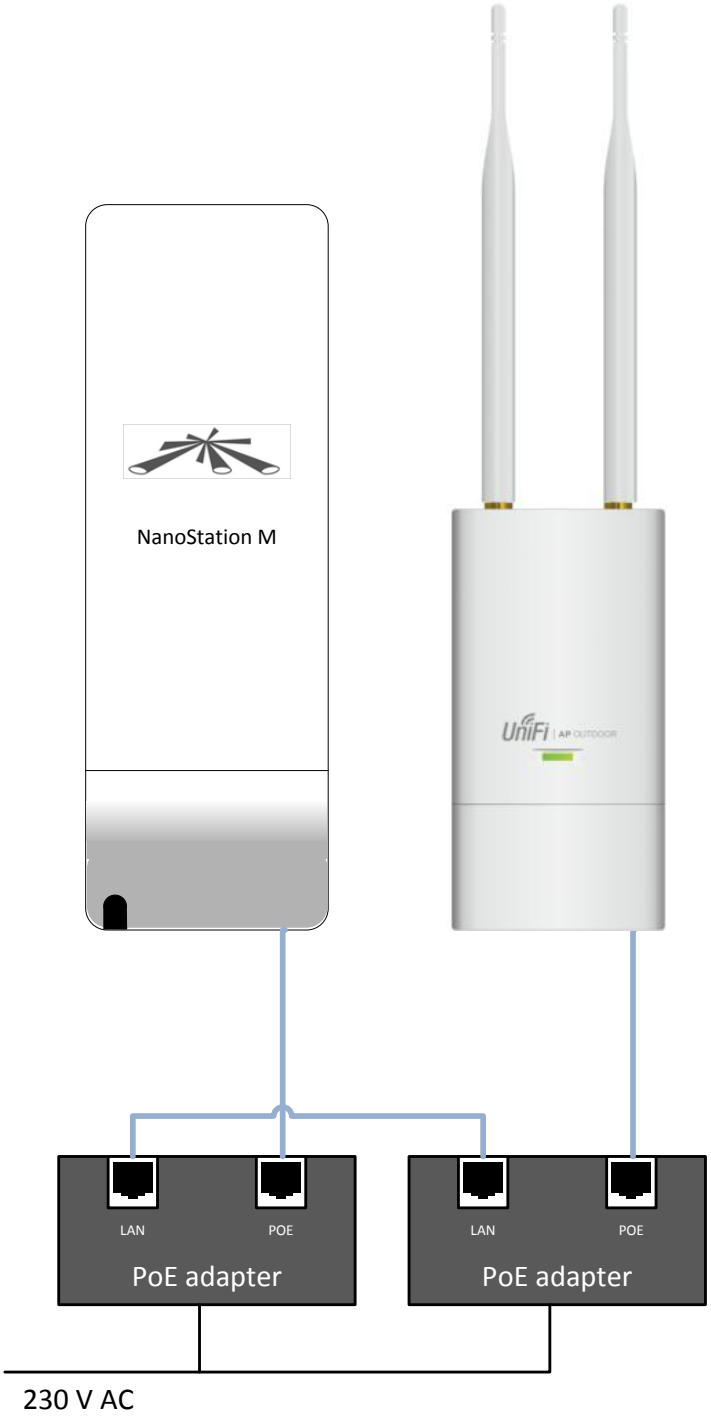

Figura 21: Interconexión de elementos en los CPE (Auditorio y centro de ocio).

Figura 22: Interconexión de elementos en los CPE (Plaza y campo de fútbol).

Figura 23: Orientación de las estaciones base del ayuntamiento.

Estación base 1: Esta asume los enlaces con el CPE del campo de fútbol, y con el CPE de la plaza. Deberá ir orientada a 210º de *azimut*.

Estación base 2: Esta asume los enlaces con el CPE del auditorio y el con el CPE del centro de ocio. Deberá ir orientada a 90º de *azimut*.

3.3.15. Posibles ampliaciones y fase 2.

Con objeto de dotar de mayor escalabilidad al proyecto, se ha incluido un Firewall de altas prestaciones, además de dotar de un segundo puerto Ethernet las unidades CPE de los emplazamientos del auditorio y el centro de ocio. Esto permite utilizar el enlace AirMAX que existe entre estos últimos y el ayuntamiento para dotar de conectividad LAN a estos edificios si el ayuntamiento lo necesita.

El equipamiento más costoso, el firewall, ya era recomendable incluirlo en el proyecto por cuestiones de control de los contenidos y seguridad de la red, por lo que además ahora supone un valor añadido de cara a un mejor aprovechamiento de la red inalámbrica.

Se deja también dimensionada la red para en una segunda fase, poder extender la red WiFi hasta el núcleo de la Hidalga, puesto que una de las estaciones base, que dispone de una antena sectorial de 120º de apertura, queda orientada de modo que sin modificar su instalación, puede establecer otro enlace PtMP con un futuro CPE + punto de acceso Wifi en dicho núcleo. También se ha tenido en cuenta este aspecto para dimensionar la capacidad de proceso tanto del *router* como del *firewall*.

4. Diseño de red

4.1. Direccionamiento de red

El esquema de direccionamiento de red consiste en tres VLANs:

descripción	nombre VLAN	VLAN id	red
default-admin	VLAN-1	1	192.168.1.0/24
clientes-wifi	VLAN-20	20	172.16.0.0/20
servicios-ayto.	VLAN-30	30	sin determinar

Tabla 5: Direccionamiento de VLANs.

4.1.1. VLAN 1: Administración de red.

Para la VLAN 1, usada para administración de la red, se usará una dirección privada de clase C, con máscara de 24 bits: 192.168.1.0/24.

Esto nos proporciona espacio para 254 dispositivos o máquinas de red, suficientes para direccionar los servidores, la electrónica de red, y los equipos WiMAX y WiFi.

La asignación de direcciones queda como se observa en la tabla 6.

4.1.2. VLAN 2: Clientes red WiFi.

Para la VLAN 2, usada para asignar direcciones mediante DHCP a los usuarios de la red WiFi pública, se usa una dirección VLSM basada en una dirección de clase B, con la máscara de red modificada a 20 bits: 172.16.0.0/20.

Este rango nos proporciona espacio para 4094 direcciones, de los que reservamos las primeras 10 para equipos propios, como el subinterfaz de red del *router*.

El esquema de direcciones para la VLAN 2 queda como se observa en la tabla 7

4.1.3. VLAN 3: Equipos propios del ayuntamiento.

Esta VLAN se reserva para que el ayuntamiento tenga la posibilidad de aprovechar la infraestructura para extender su propia LAN a los emplazamientos como el centro de ocio o el auditorio.

ubicación	equipo	interfaz	dirección IP	VLAN id
Ayuntamiento	Router	fa0/0	mismo rango ISP	
		fa0/1.0	192.168.1.1/24	1
		fa0/1.1	172.16.0.1/20	20
		fa0/1.2	por determinar	30
Ayuntamiento	firewall	IF 0/0	192.168.1.10/24	1
		IF 0/1	192.168.1.11/24	1
Ayuntamiento	Switch		192.168.1.20/24	1
Ayuntamiento	Servidor DNS/DHCP/RADIUS PRI		192.168.1.31/24	1
Ayuntamiento	Servidor DNS/DHCP/RADIUS SEC		192.168.1.32/24	1
Ayuntamiento	Servidor apps PRI		192.168.1.33/24	1
Ayuntamiento	Servidor apps SEC		192.168.1.34/24	1
Ayuntamiento	RocketM BS 1		192.168.1.101/24	1
Ayuntamiento	RocketM BS 2		192.168.1.102/24	1
Auditorio	NanostationM CPE 1		192.168.1.111/24	1
Centro de ocio	NanostationM CPE 2		192.168.1.112/24	1
Campo fútbol	Nanostation loco CPE 3		192.168.1.113/24	1
Plaza	Nanostation loco CPE 4		192.168.1.114/24	1
Auditorio	UniFi AP WiFi 1		192.168.1.121/24	1
Centro de ocio	UniFi AP WiFi 2		192.168.1.122/24	1
Campo fútbol	UniFi AP WiFi 3		192.168.1.123/24	1
Plaza	UniFi AP WiFi 4		192.168.1.124/24	1

Tabla 6: Asignación de direcciones IP en VLAN 1.

equipo	dirección IP	VLAN id
Router (fa0/1.1)	172.16.0.1/20	20
clientes DHCP	172.16.0.10 ... 172.16.15.254	

red:	172.16.0.0/20
máscara:	255.255.255.240
difusión:	172.16.15.255

Tabla 7: Asignación de direcciones IP en VLAN 2.

4.2. Autenticación de usuarios

Para la transacción AAA de los usuarios (*Authentication, Authorization and Accounting*), se usará un servidor RADIUS[16].

RADIUS es un protocolo de red que proporciona gestión AAA centralizada de modo que los clientes puedan hacer uso de un servicio de red. Tiene una arquitectura cliente / servidor que trabaja en la capa de aplicación usando UDP como transporte.

La transacción AAA consta de las siguientes fases:

- **Autenticación y autorización.** En esta fase, el usuario envía una solicitud con el fin de obtener acceso a una determinada red usando las credenciales dadas. Estas credenciales pueden ser un usuario y contraseña, por ejemplo, a través de un formulario HTTPS del portal cautivo. A continuación, el servidor RADIUS comprueba en una base de datos (que puede ser local, o puede ser externa si el ayuntamiento facilita su acceso a por ejemplo, el padrón de sus habitantes) si el usuario está autorizado al recurso solicitado, y contesta en consecuencia.

- ***Accounting***. En caso de que la fase de autenticación y autorización haya finalizado con una respuesta de acceso permitido por parte del servidor RADIUS, entonces se inicia la fase de *accounting*, donde el servidor va registrando el uso de recursos por parte del usuario. Esta tiene lugar hasta que finaliza la sesión del usuario, por lo que el servidor registra el fin de la misma. Esto permite, a posteriori, explotar estos datos registrados con fines de facturación, estadísticos o de supervisión de red.

4.2.1. Registro de accesos

Además del *Accounting* que tiene lugar en el servidor RADIUS, se guardarán registros de todas las conexiones realizadas en el cortafuegos, durante un período de 12 meses, conforme a la normativa vigente, ya mencionada en el apartado 2.1.

4.3. Tipo de tráfico permitido

Con el fin de ajustarse a la normativa de la CMT, y de adaptar las conexiones a la velocidad por usuario requerida (256 Kbits), se configurará el cortafuegos para bloquear explícitamente en la red pública los siguientes tipos de tráfico:

[16] http://en.wikipedia.org/wiki/RADIUS

- El tráfico P2P, FTP, SFTP, y demás aplicaciones o protocolos usados en la transferencia masiva de ficheros.
- Específicamente, los sitios web de descarga directa, así como servicios tipo DropBox o similares.
- El streaming de audio y vídeo, así como tráfico VoIP y/o videoconferencia.

Por otro lado, se permite el contenido web en general, redes sociales, y mensajería instantánea basada en HTTP, filtrando, por supuesto, todo aquel tráfico no apto para todas las edades, como pornografía, juegos de azar, apuestas o similares.

En todas y cada una de las conexiones, el cliente se autenticará contra el servidor RADIUS mediante un portal cautivo que se muestra en el navegador. Una vez el usuario acepte las condiciones de uso de la red, se le permitirá comenzar a usar la misma.

4.3.1. Control de recursos utilizados

Para no congestionar la red, y cumplir con los requisitos de la CMT en cuanto a ancho de banda disponible para los usuarios, el software UniFi Controller, junto con el software embebido en los puntos de acceso, puede gestionar, por un lado, el número de accesos concurrentes en un determinado punto de acceso, y por otro, el ancho de banda disponible para cada usuario.

Por lo tanto, se configurarán dichos puntos de acceso para que no permitan más de 100 usuarios concurrentes por cada punto de acceso, y para que ningún usuario utilice más de 250 Kbps de ancho de banda, de forma simétrica (ascendente y descendente). Con estos límites, tenemos margen disponible suficiente como para que no haya congestión en ninguno de los enlaces, tal y como se detalló en el punto 2.3.

4.4. Software utilizado

Además del software embebido en la electrónica de red (Cisco IOS, Palo Alto PAN-OS), se dispondrá del siguiente software para la gestión íntegra de la red:

4.4.1. Equipamiento RF AirMAX

Para la gestión del equipamiento RF AirMAX, se usa AirOS, que está integrado en las estaciones, AirView, que proporciona análisis espectrales en tiempo real y AirControl, que es una

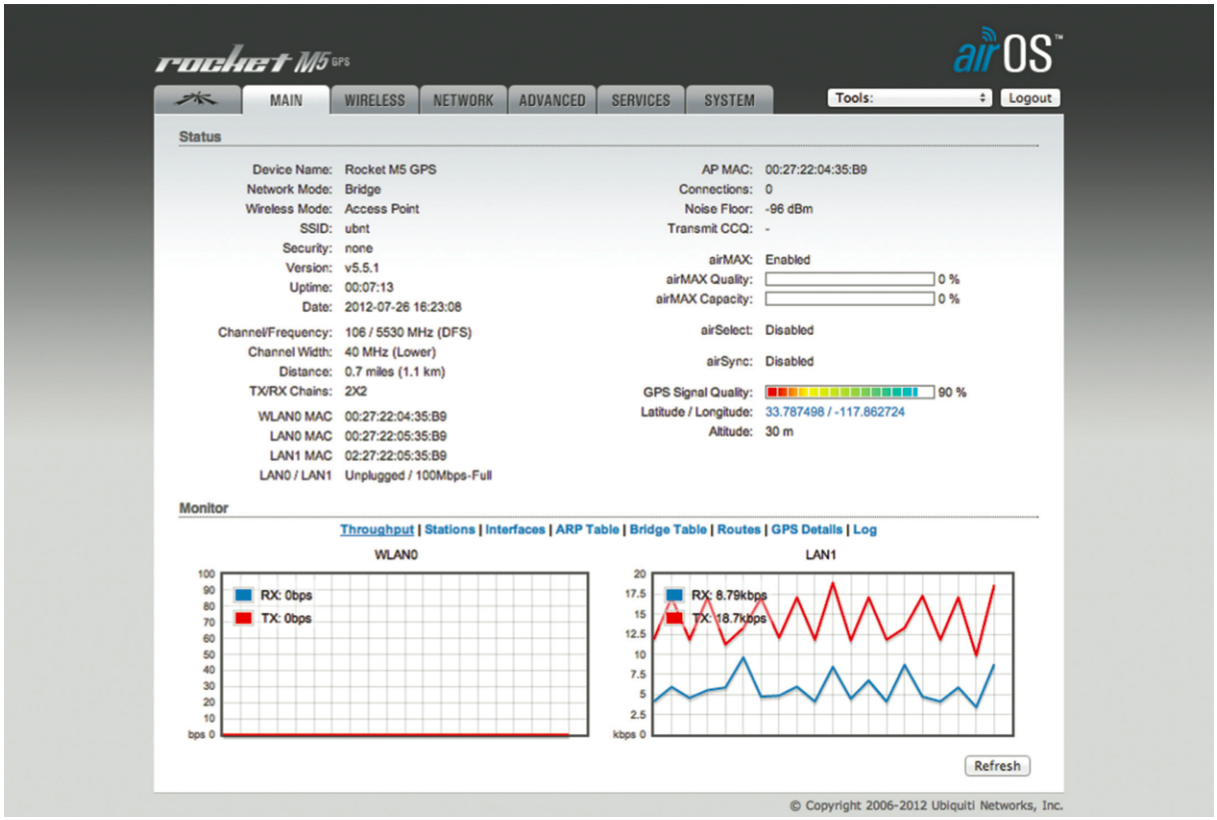

Figura 24: Software de gestión de estaciones AirOS

plataforma basada en servidor web, que es la que gestionará las estaciones y su configuración.

AirOS (en la figura 24) es el software embebido tanto en las estaciones base, como en los CPE. Con este software gestionaremos toda la configuración de dichos dispositivos. Además contiene herramientas para la instalación de las estaciones, como son la herramienta de orientación de antenas.

AirView (en la figura 25) está integrado dentro de AirOS, y es un analizador de espectro que nos permite visualizar el ruido existente en el espectro de nuestro entorno, para poder seleccionar la frecuencia óptima de trabajo, a la hora de configurar los enlaces AirMAX.

4.4.2. Equipamiento RF WiFi

Para la gestión de los puntos de acceso Wi-Fi de los *HotSpots*, se utiliza el software UniFi Controller del mismo fabricante, que gestiona dichos dispositivos, así como la configuración del portal cautivo.

Figura 25: Analizador de espectro AirView

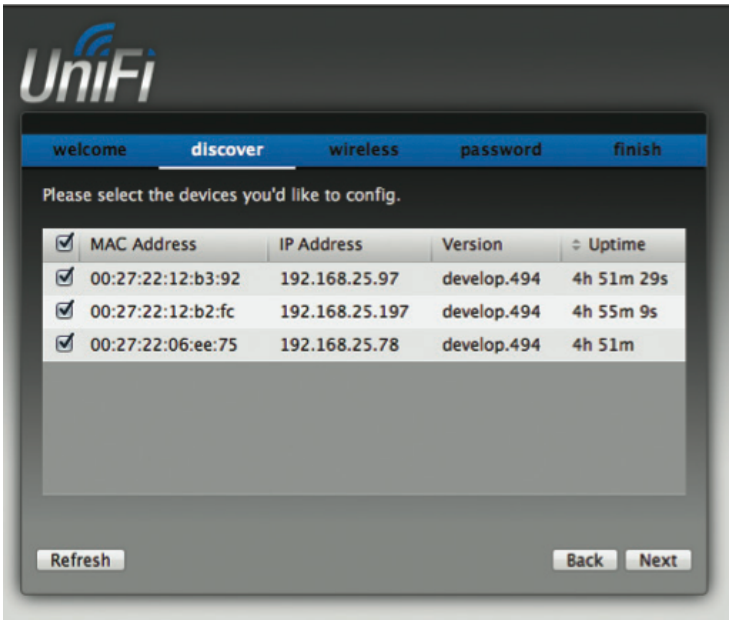

Figura 26: Instalando y configurando los puntos de acceso mediante UniFi Controller

UniFi Controller (en figura 27) es un software para instalar en nuestro caso en el portátil suministrado, de modo que nos permita configurar y gestionar todos los puntos de acceso.

Este software nos permite, una vez instalado en un PC, instalar, configurar y gestionar de forma remota todos los puntos de acceso. Bastará con conectar el punto de acceso a la red, y desde dicho software nos aparecerán todos los equipos UniFi, tanto los que ya estén configurados, como los que no, detalle que podemos ver en la figura 26.

Además este software permite gestionar el tráfico de la red, visualizar estadísticas de uso de cada punto de acceso, niveles de señal, gestión de usuarios, así como tareas más críticas como actualizar el *firmware* de los puntos de acceso, o cambiar la potencia de transmisión, todo de forma remota.

4.4.3. Servidores de aplicaciones y de servicios de red

Como ya se ha especificado con anterioridad, hay dos servidores en la red, uno con los servicios de red como DNS y DHCP, y otro con el software proporcionado por el fabricante de los dispositivos AirMAX. A su vez, cada servidor está redundado en configuración 1+1, por lo que disponemos de cuatro servidores en total. Estos servidores corren bajo la distribución de Linux Ubuntu Server, en su versión LTS 12.04.

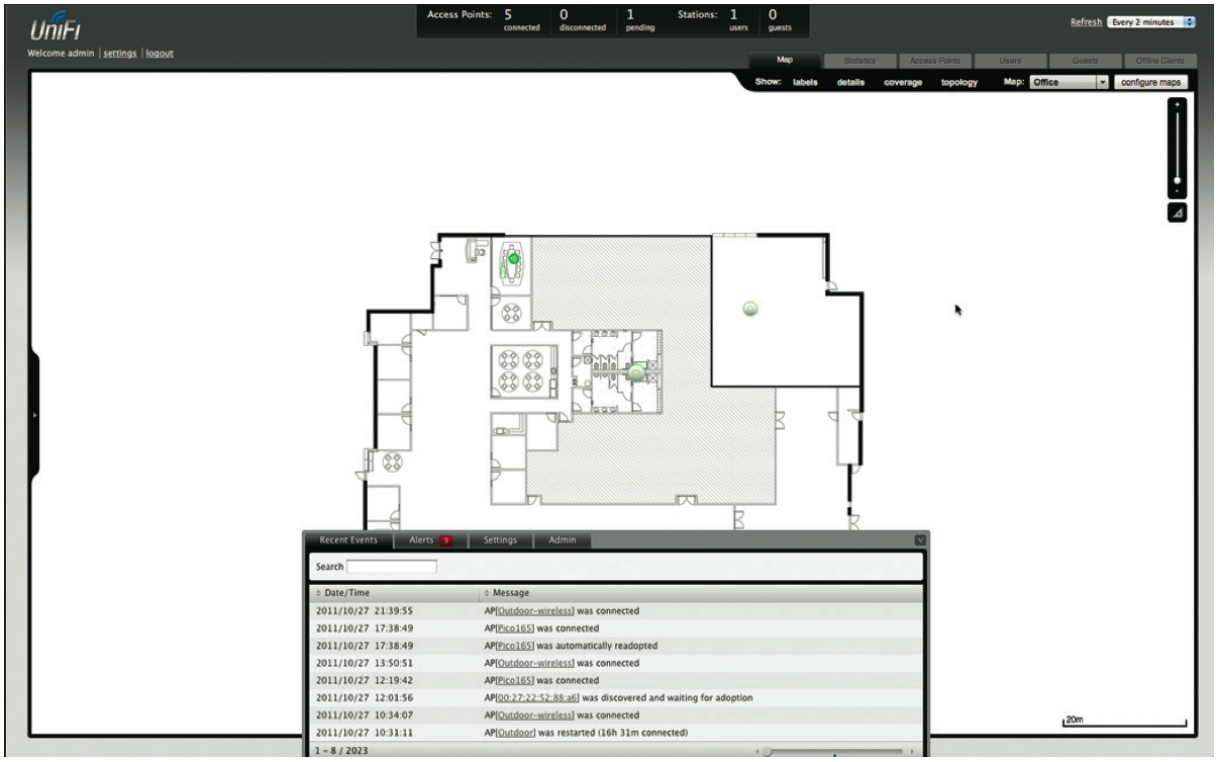

Figura 27: Software para la gestión de los AP UniFi Controller

En el servidor de aplicaciones correrá el software **AirControl** (figura 28), encargado de gestionar tanto los dispositivos AirMAX como el estado de los enlaces.

En el servidor de servicios de red se instalarán los servidores DNS, DHCP y el servidor RADIUS FreeRADIUS[17], así como el entorno de gestión daloRADIUS[18] (figura 29), para una gestión más cómoda del mismo.

[17] http://freeradius.org
[18] http://www.daloradius.com

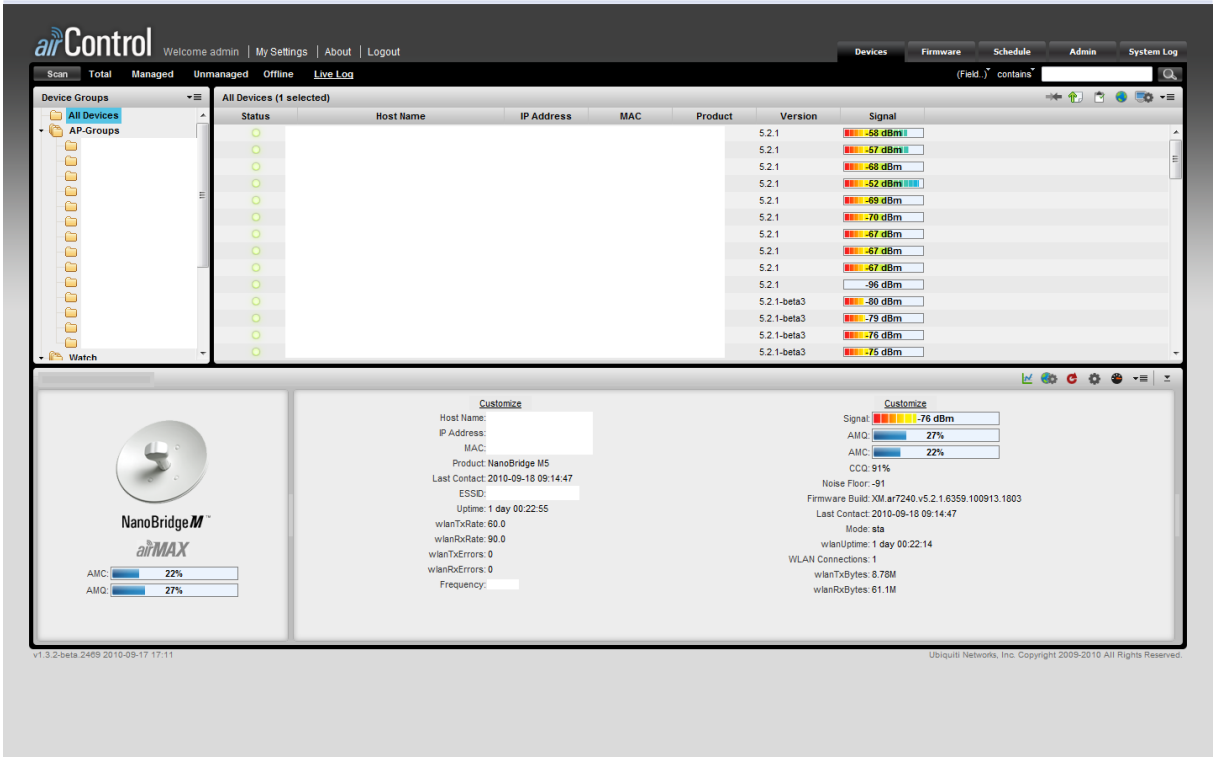

Figura 28: Software de gestión de dispositivos y enlaces AirMAX AirControl

5. Estudio de cobertura

El estudio de cobertura se divide en dos partes: Los enlaces entre dispositivos AirMAX, y las zonas a cubrir mediante los puntos de acceso WiFi o *HotSpots*.

5.1. Enlaces entre dispositivos AirMAX

El fabricante de los equipos RF, Ubiquity Networks, proporciona una herramienta[19] llamada AirLink, para el cálculo de los parámetros de calidad de los enlaces AirMAX.

Esta herramienta es propietaria, y calcula la zona de fresnel a lo largo del enlace, verificando que no hay obstáculos en el 60 % de dicha zona, así como los parámetros de distancia y frecuencia para calcular la atenuación, pero además tiene en cuenta otros factores para dar unos resultados más realistas, como el clima de la zona a cubrir por los enlaces, o el nivel de interferencias en dicha zona. Se ha preguntado al fabricante por la expresión detallada usada para dichos cálculos, pero como era de esperar, no ha facilitado dichos datos, al tratarse de una herramienta de cálculo propia.

Comparando valores ofrecidos por ficha herramienta, con valores calculados teóricamente

[19] http://www.ubnt.com/airlink/

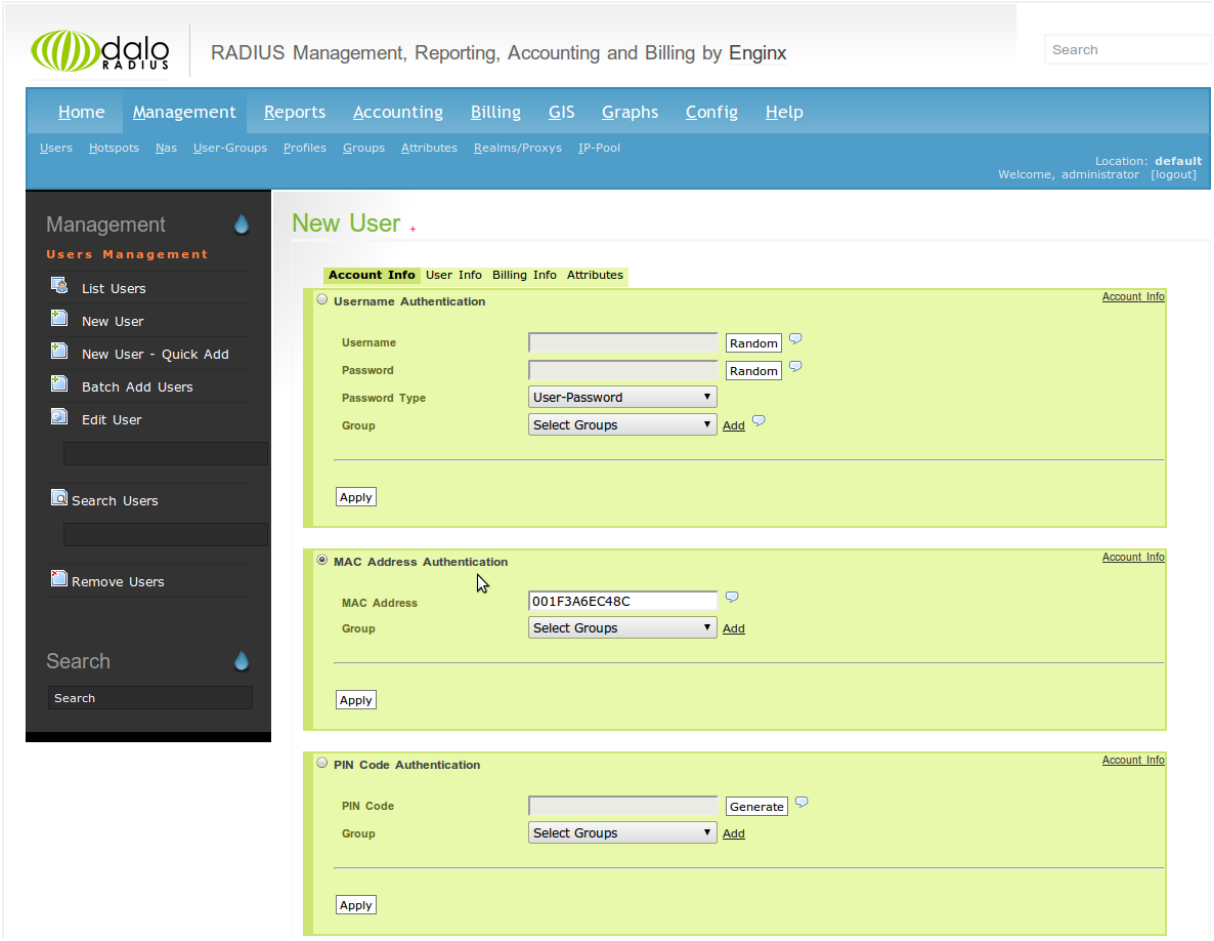

Figura 29: Entorno gráfico de gestión daloRADIUS

Nombre emplazamiento	Latitud	Longitud
Ayuntamiento	28°20'24.89"N	16°25'5.94"W
Auditorio Juan Carlos I	28°20'25.29"N	16°25'4.62"W
Plaza	28°20'24.48"N	16°25'7.82"W
Cento de ocio artesanal	28°20'25.03"N	16°24'55.63"W
Campo de fútbol	28°20'4.47"N	16°25'15.40"W

Tabla 8: Ubicación de estaciones.

con los métodos de espacio libre, o tierra plana + Egli, se observa que los valores que arroja la herramienta son menos optimistas que los teóricos, así que se dan por buenos a la hora de evaluar si los enlaces se establecerán con ciertas garantías de calidad.

La ubicación de todas las estaciones quedaría reflejada en la tabla 8. Hay que tener en cuenta que podría ser necesario instalar mástiles, para aumentar la altitud sobre el terreno de las antenas y así evitar obstáculos en la línea de vista y/o penetraciones en la zona de fresnel.

La zona de fresnel[20] es el volumen de espacio entre el emisor de una onda y el receptor correspondiente, de modo que el desfase de las ondas en dicho volumen no supere los 180º.

La obstrucción máxima permisible para considerar que no hay obstrucción es el 60 % de la primera zona de Fresnel, para una K (curvatura de la tierra) de 2/3.

Los parámetros que facilita la herramienta de cálculo, y que podemos observar en las capturas adjuntas, son:

- LoS Distance: *Line of sight distance*, o distancia de la línea de vista.
- FZ Clearance: Margen disponible en la zona de fresnel.
- FZ Max Radius: Radio máximo de la zona de fresnel.
- Signal Strenght: Nivel de señal recibida en la estación.
- Noise Floor: Nivel de ruido en la zona de la estación.
- Transmit CCQ: *Client connection quality*, que indica la efectividad de uso del ancho de banda teórico disponible.
- TX/RX rate: Velocidad negociada de transmisión y recepción.

[20] http://es.wikipedia.org/wiki/Zona_de_Fresnel

- Airmax: Enabled indica que se usa TDMA en lugar de CSMA, además de sus valores correspondientes de calidad y capacidad.

Para todos los enlaces se ha supuesto que el nivel de ruido en recepción es de 10dB, y que la banda de trabajo es 5.8 GHz.

Las alturas especificadas, son alturas sobre el terreno, que son las alturas de los edificios donde se instalarán las antenas.

En las estaciones base se supone una pérdida en el peor caso de 2 dB, en la unión entre la BS y la antena. (Esta unión consta de dos conectores y un latiguillo RP-SNA de varios centímetros).

En las unidades CPE dado que la antena está integrada en la propia unidad, suponemos una pérdida en el peor caso de 1 dB.

5.1.1. Enlace 1: Ayuntamiento - Campo de fútbol.

Este enlace está compuesto por una estación base RocketM5 GPS, y un CPE NanoStation Loco M5.

estación	tipo	latitud	longitud	alt.	pérdidas	ganancia ant.
ayto.	BS	28°20'24.89"N	16°25'5.94"W	18 m.	2 dB	16 dB
campo fut.	CPE	28°20'4.47"N	16°25'15.40"W	11 m.	1 dB	13 dB

La distancia a cubrir es de 680 metros, y como se observa en la figura 30, el nivel de señal en la estación base es de -58 dBm, y -54 dBm en el CPE, con los que se consigue una tasa de bits negociada de 300 Mbps.

5.1.2. Enlace 2: Ayuntamiento - Plaza.

Este enlace está compuesto por una estación base RocketM5 GPS, y un CPE NanoStation Loco M5.

estación	tipo	latitud	longitud	alt.	pérdidas	ganancia ant.
ayto.	BS	28°20'24.89"N	16°25'5.94"W	18 m.	2 dB	16 dB
plaza	CPE	28°20'24.48"N	16°25'7.82"W	9 m.	1 dB	13 dB

La distancia a cubrir es de 50 metros, y como se observa en la figura 31, el nivel de señal en la estación base es de -39 dBm, y -35 dBm en el CPE, con los que se consigue una tasa de bits negociada de 300 Mbps.

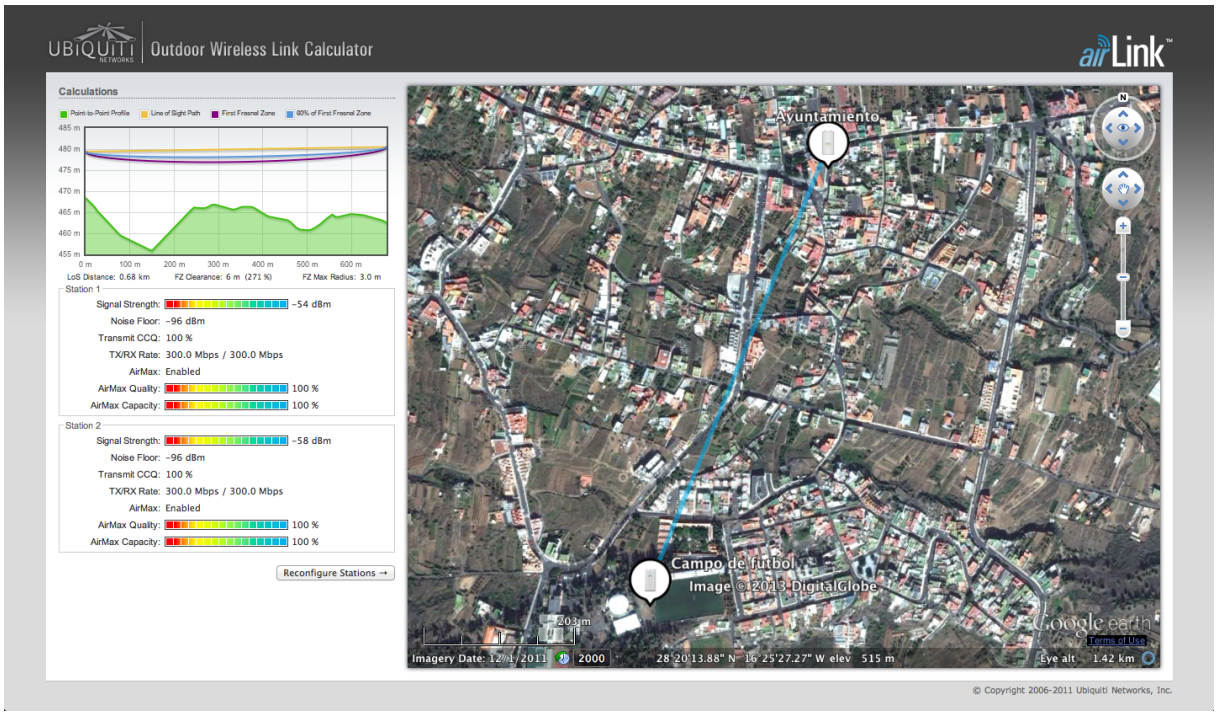

Figura 30: Cálculo de enlace entre ayuntamiento y campo de fútbol.

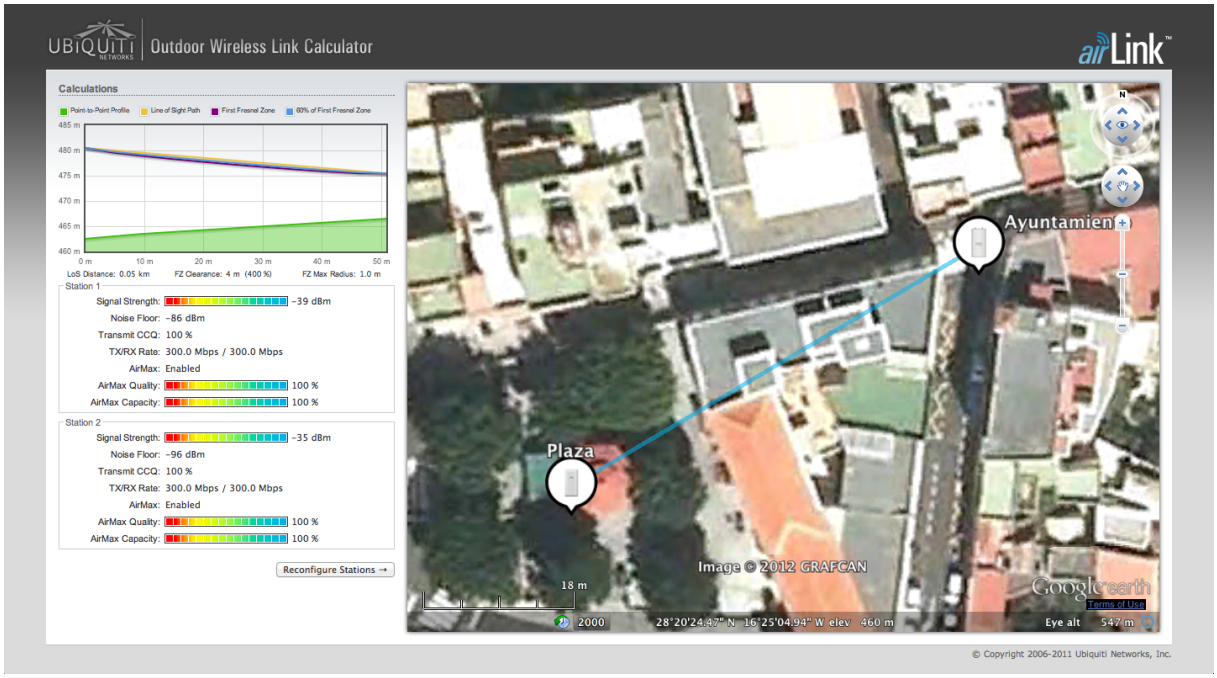

Figura 31: Cálculo de enlace entre ayuntamiento y plaza.

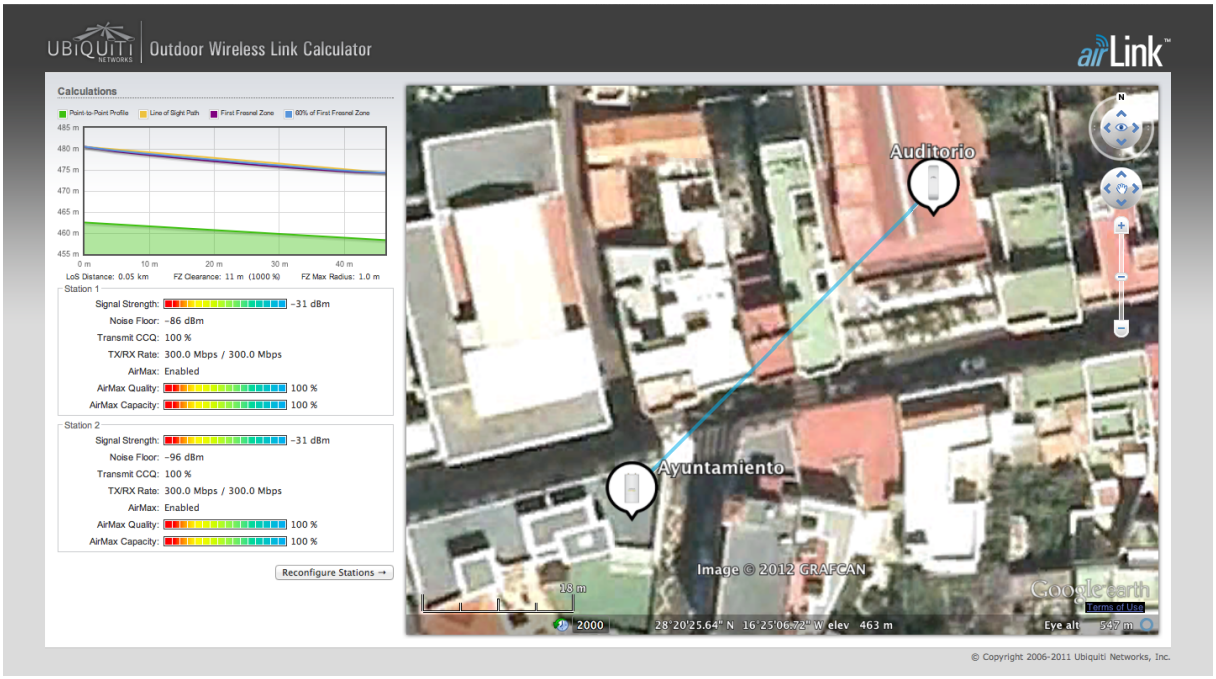

Figura 32: Cálculo de enlace entre ayuntamiento y auditorio.

5.1.3. Enlace 3: Ayuntamiento - Auditorio.

Este enlace está compuesto por una estación base RocketM5 GPS, y un CPE NanoStation M5.

estación	tipo	latitud	longitud	alt.	pérdidas	ganancia ant.
ayto.	BS	28°20'24.89"N	16°25'5.94"W	18 m.	2 dB	16 dB
auditorio	CPE	28°20'25.29"N	16°25'4.62"W	16 m.	1 dB	16.1 dB

La distancia a cubrir es de 50 metros, y como se observa en la figura 32, el nivel de señal en la estación base es de -31 dBm, y -31 dBm en el CPE, con los que se consigue una tasa de bits negociada de 300 Mbps.

5.1.4. Enlace 4: Ayuntamiento - Centro de ocio.

Este enlace está compuesto por una estación base RocketM5 GPS, y un CPE NanoStation M5.

estación	tipo	latitud	longitud	alt.	pérdidas	ganancia ant.
ayto.	BS	28°20'24.89"N	16°25'5.94"W	18 m.	2 dB	16 dB
centro ocio	CPE	28°20'25.03"N	16°24'55.63"W	6 m.	1 dB	16.1 dB

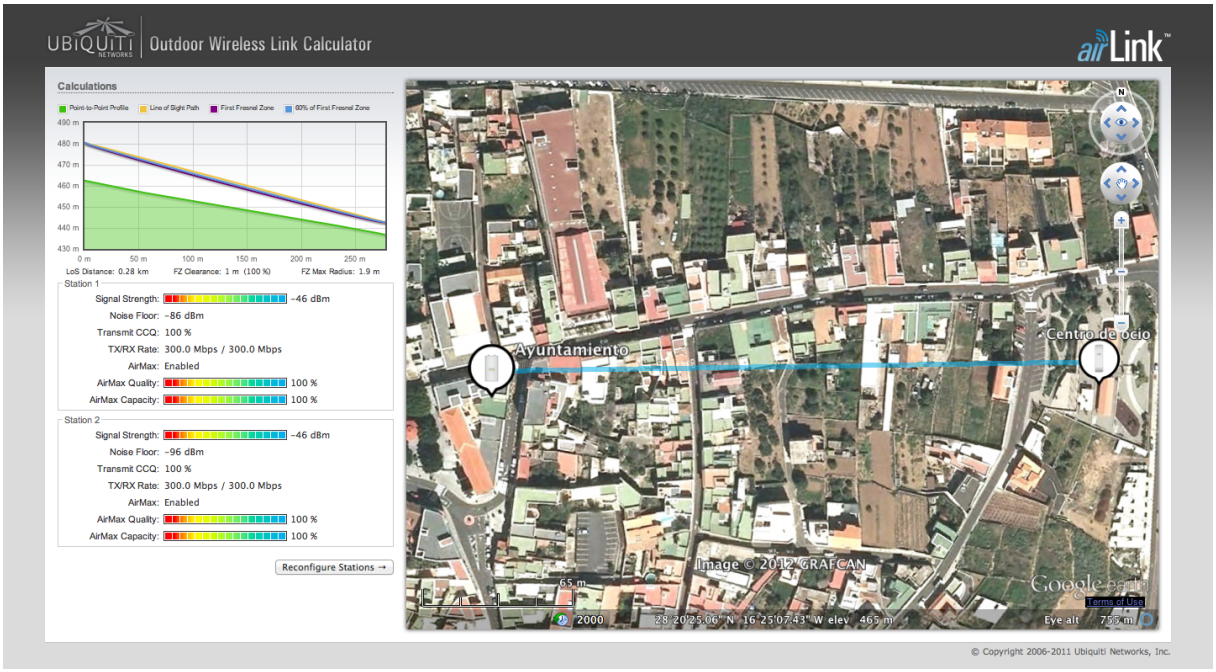

Figura 33: Cálculo de enlace entre ayuntamiento y el centro de ocio.

La distancia a cubrir es de 280 metros, y como se observa en la figura 33, el nivel de señal en la estación base es de -46 dBm, y -46 dBm en el CPE, con los que se consigue una tasa de bits negociada de 300 Mbps.

5.2. Cobertura en los *HotSpots*

Para el cálculo de cobertura en los *HotSpots*, y teniendo en cuenta la escasa distancia a cubrir, vamos a usar el modelo de propagación en el espacio libre, en donde la potencia recibida viene dada por la siguiente expresión:

$$P_R = P_T + G_T + G_R - 20 \cdot \log\left(\frac{4\pi d}{\lambda}\right)$$

En donde P_R es la potencia recibida (dBm), P_T es la potencia transmitida (dBm), G_T es la ganancia en transmisión (la de la antena, dB), G_R es la ganancia en recepción (la de la antena, dB), d es la distancia entre emisor y receptor, y λ es la longitud de onda, que a 2,4 GHz son 0,125 metros.

Puesto que no queremos que la señal llegue hasta los domicilios, o lo haga en las peores condiciones posibles, se ajustará la potencia de salida de los puntos de acceso, de modo que a la distancia límite deseada, la potencia recibida sea de -70 dBm. A esta potencia aún se puede negociar a los 54 Mbps que ofrece el estándar 802.11g, pero nos aseguramos que más lejos, o

al atravesar las paredes de una vivienda, la señal sea demasiado débil como para poder ser utilizada. Además de este modo, reducimos el consumo de los equipos y alargamos su vida útil.

Para todos los cálculos a continuación se ha usado como valores de ganancia de antena en transmisión el valor de 6 dBi facilitado por el fabricante de las unidades UniFi, y un valor típico de 2 dBi en recepción, para una antena de pequeñas dimensiones o integrada en un dispositivo WiFi portátil.

Veamos las necesidades de cobertura para cada emplazamiento por separado:

5.2.1. *HotSpot* 1: Plaza.

El área a cubrir en esta zona comprende aproximadamente una circunferencia de radio 25 metros, con centro situado en el centro de la plaza.

Aplicando la expresión para la propagación en el espacio libre, con una distancia de 25 metros, fijando la potencia recibida en -70 dBm, y despejando el valor de la potencia transmitida, obtenemos un valor de -10 dBm, que equivalen a unos 0,1 mW (milivatios). Sin embargo, teniendo en cuenta los múltiples obstáculos existentes en la plaza, fijaremos la potencia de transmisión de este punto de acceso en 0 dBm ó 1 mW.

La antena va ubicada en el punto señalado en la figura 34, y el nivel de señal en -70 dBm o mayor en la zona coloreada en la figura 35

Figura 34: Situación del punto de acceso WiFi en la plaza.

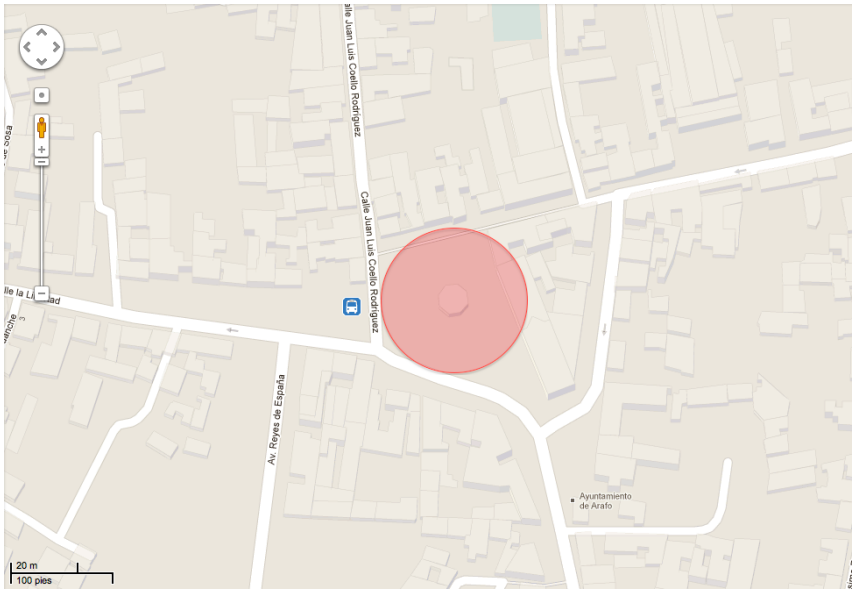

Figura 35: Cobertura del punto de acceso en la plaza a -70 dBm o mayor.

5.2.2. *HotSpot* 2: Campo de fútbol.

Dado que aquí la extensión a cubrir es mayor, se ajustará la potencia a 2 dBm (1,58 mW), para proporcionar un nivel de señal de -70 dBm en una circunferencia de radio 100 metros como la mostrada en la figura 36.

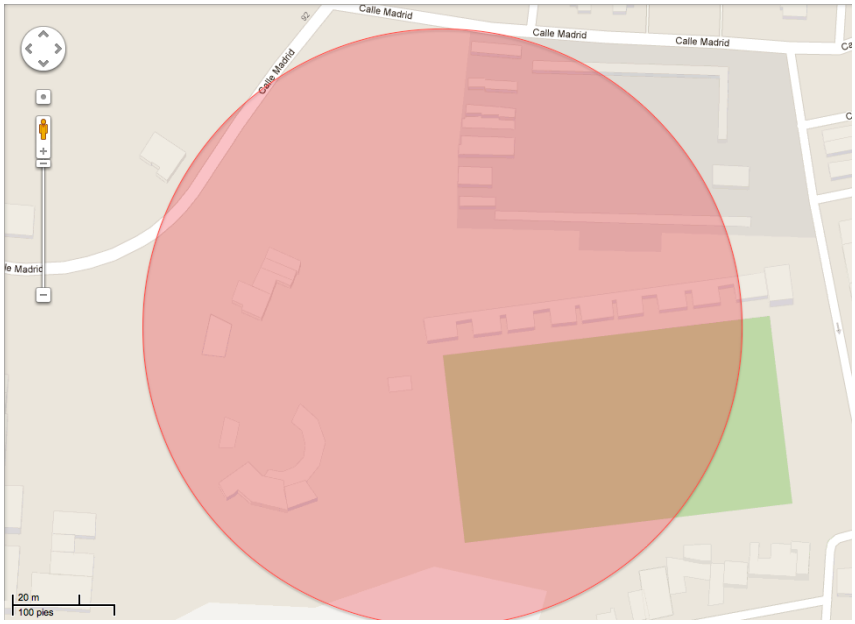

Figura 36: Cobertura del punto de acceso en el campo de fútbol a -70 dBm o mayor.

5.2.3. *HotSpot* 3: Auditorio.

El ajuste de potencia en este caso se hace a -10 dBm, para conseguir -70 dBm en una circunferencia de radio 25 metros. La antena va ubicada en el punto señalado en la figura 37, y el alcance de la señal a -70 dBm o mayor en la zona coloreada en la figura38.

Figura 37: Situación del punto de acceso WiFi en el auditorio.

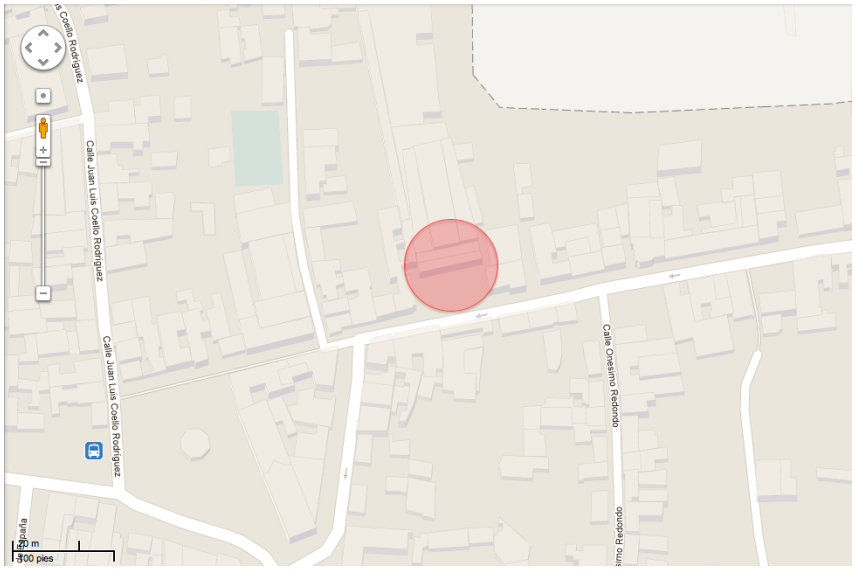

Figura 38: Cobertura del punto de acceso en el auditorio a -70 dBm o mayor.

5.2.4. *HotSpot 4*: Centro de ocio.

La antena va ubicada en el punto señalado en la figura 39, y se ajustará la potencia del punto de acceso a -8 dBm (0,15 mW) para proporcionar un nivel de señal de -70 dBm en una circunferencia de radio 50 metros, como vemos en la figura 40.

Figura 39: Situación del punto de acceso WiFi en el centro de ocio.

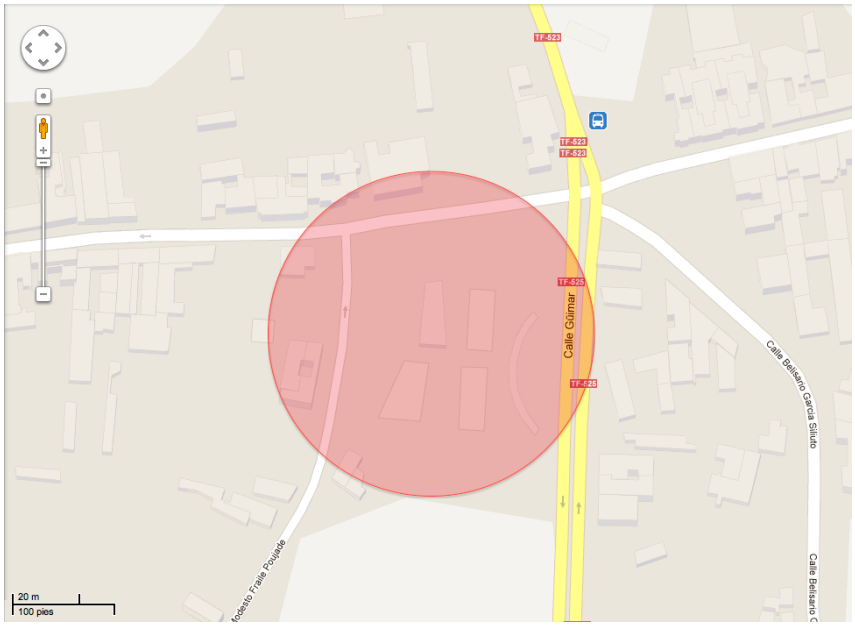

Figura 40: Cobertura del punto de acceso en el centro de ocio a -70 dBm o mayor.

6. Presupuesto del proyecto

fabricante	descripción	modelo	cant.	precio (€)	importe (€)
Ubiquiti Networks	AirMAX Rocket M Base Station	RM5-GPS	3	250,00	750,00
Ubiquiti Networks	AirMAX Sector Antenna	5G-16-120	3	90,00	270,00
Ubiquiti Networks	AirMAX Nanostation M CPE	NSM5	3	95,00	285,00
Ubiquiti Networks	AirMAX Nanostation loco M CPE	LOCOM5	2	70,00	140,00
Ubiquiti Networks	UniFi Access Point	UAP-Outdoor	5	150,00	750,00
CISCO	Router	3925/K9	1	5200,00	5200,00
Cisco	Switch	WS-C3560G-24TS-S	2	2800,00	5600,00
Palo Alto Networks	Firewall nivel 7	PAN-PA-2050	1	15000,00	15000,00
Dell	Server R410	-	4	1500,00	6000,00
Dell	Chasis 4220 42U	PowerEdge-4420	1	1400,00	1400,00
Dell	PC portátil	Vostro Notebook 3460	1	599,00	599,00
Emerson	UPS Liebert GXT3 5KVA	5000RT230	1	2500,00	2500,00
Ubiquiti Networks	Bobina 300m cat. 5e	UBN-TCL2	1	170,00	170,00
-	Herrajes y torretas/-mástiles	-	1	1000,00	1000,00
-	Diseño y desarrollo	-	1	6000,00	6000,00
-	Instalación y puesta en marcha	-	1	3400,00	3400,00
	TOTAL	(IGIC 7 % incluido)			49064,00

Tabla 9: Presupuesto del proyecto.

7. Entregables

Además de todo el hardware que queda instalado a la finalización del proyecto, se hace entrega al Servicio de Informática del Ayuntamiento de Arafo de los siguientes elementos:

- Todo el software original que acompaña a todos y cada uno de los equipos suministrados.
- Todos los manuales impresos o en soporte digital pertenecientes a los equipos suministrados.
- Documentación del proyecto, como diagramas de topología de red y conexión de equipos, y tablas de asignación de direcciones IP.
- Listado de contraseñas establecidas en los diferentes equipos.
- Conjunto de copias de seguridad de la configuración de los equipos de red.
- Los repuestos relacionados en la tabla 4.
- Un ordenador portátil Dell Vostro Notebook 3460 con el software necesario instalado.
- Todos los accesorios de montaje no utilizados en la instalación que formaban parte del contenido original de los equipos suministrados.

8. Conclusiones

8.1. Beneficios para la sociedad

El beneficio para la sociedad a la finalización del proyecto será una contribución a la reducción de barreras de acceso a las tecnologías como la brecha digital, además de permitir el acceso electrónico de los ciudadanos a los servicios públicos.

Del mismo modo, se facilita que sectores demográficos apartados de las tecnologías como pueden ser los mayores o la población más rural, tengan a través de esta red su primer contacto con las nuevas tecnologías.

8.2. Lecciones aprendidas

Varios han sido los beneficios al conocimiento personal tras la finalización de este proyecto.

Se ha tomado contacto con ciertos equipos existentes en el mercado de los que no se conocía su existencia, como la gama de equipos inalámbricos de Ubiquiti Networks. Del mismo modo, se ha profundizado en el funcionamiento de dispositivos como los cortafuegos o *firewalls* a nivel de aplicación, y descubierto cuáles son los fabricantes líderes en este segmento.

Además ha servido para familiarizarse con la no siempre agradable pero necesaria normativa legal que regula los servicios de telecomunicaciones, de manera que un futuro, sea más sencillo desarrollar una solución tecnológica adaptada al marco legal.

Y por último, y no menos importante, ha servido para afianzar multitud de conocimientos adquiridos a la lo largo y ancho de la carrera de Telecomunicaciones, y sirve de colofón y broche de oro al esfuerzo realizado durante cinco años de estudios compaginados con el trabajo.

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[13] WIKIPEDIA. LA ENCICLOPEDIA LIBRE. *IEEE 802.11.* URL: http://en.wikipedia.org/wiki/IEEE_802.11. Recuperado el 9-1-2013.

[14] WIKIPEDIA. LA ENCICLOPEDIA LIBRE. *MIMO.* URL: http://en.wikipedia.org/wiki/MIMO. Recuperado el 9-1-2013.

[15] WIKIPEDIA. LA ENCICLOPEDIA LIBRE. *Hidden node problem.* URL: http://en.wikipedia.org/wiki/Hidden_node_problem. Recuperado el 9-1-2013.

[16] WIKIPEDIA. LA ENCICLOPEDIA LIBRE. *Grado de protección IP.* URL: http://es.wikipedia.org/wiki/Grado_de_proteccción_IP. Recuperado el 9-1-2013.

[17] WIKIPEDIA. LA ENCICLOPEDIA LIBRE. *RADIUS.* URL: http://en.wikipedia.org/wiki/RADIUS. Recuperado el 9-1-2013.

A. Glosario de términos y abreviaturas utilizados.

BS *Base Station* o estación base.

CPE *Customer Premises Equipment* o equipo local de cliente.

CMT Comisión del mercado de las telecomunicaciones.

CNAF Cuadro nacional de atribución de frecuencias.

ESD *ElectroStatic Dischargue* o descarga electroestática.

IDS *Intrusion Detection System* o sistema de detección de intrusos.

IPS *Intrusion Prevention System* o sistema de prevención de intrusos.

ISP *Internet Service Provider* o proveedor de acceso a Internet.

LOS *Line of Sight* o linea de vista, visibilidad directa.

MIMO *Multiple Input Multiple Output*.

OS *Operating System* o sistema operativo.

PoE *Power over Ethernet* o alimentación a través de Ethernet.

PtMP *Point to MultiPoint* o punto a multipunto.

PtP *Point to Point* o punto a punto.

RF Radiofrecuencia.

SFP *Small form-factor pluggable transceiver* o transceptor enchufable de pequeño formato.

TDMA *Time Division Multiple Access* o acceso múltiple por división de tiempo.

UPS *Uninterruptible Power Supply* o sistema de alimentación ininterrumpida (SAI en castellano).

VLSM *Variable Length Subnet Mask* o Máscara de subred de tamaño variable.

B. Herramientas utilizadas

A continuación se detalla una relación de las herramientas software utilizadas para la realización del TFC:

- OmniPlan 2.2
- TexPad 1.4.3 + LaTeX (MacTEX 2012)
- Microsoft Visio 2010
- Google Docs
- Google Earth / Google Maps
- Ubiquiti Networks AirLink

C. Normativa utilizada

La normativa que se ha tenido en cuenta a la hora de definir los distintos parámetros de la red, han sido los siguientes:

- CNAF - UN85 (Transmisión en la banda de 2,4 GHz)
- CNAF - UN143 (Transmisión en la banda de 5,8 GHz)
- Circular 1/2010 de la CMT
- Ley 32/2003, de 3 de noviembre, General de Telecomunicaciones.

D. ANEXOS

D.1. Estación base AirMAX Rocket M GPS, modelo RM5-GPS

rocketM | Datasheet

rocketM

Powerful 2x2 MIMO AirMax BaseStation Platforms

Models: M2, M2GPS, M3, M365, M365GPS, M5, M5GPS, M900

Ultimate in RF Performance

Seamlessly Integrates with AirMax BaseStation and Rocket Antennas

Incredible Range and Speed

UBIQUITI NETWORKS

Overview

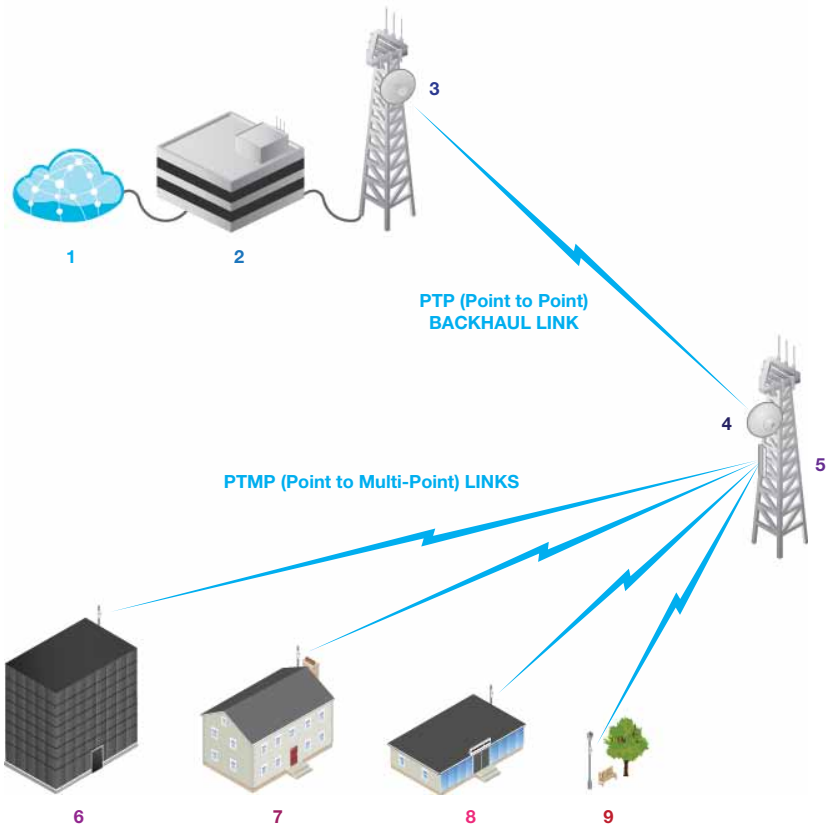
Versatile

Rocket M is a rugged, hi-power, very linear 2x2 MIMO radio with enhanced receiver performance. It features incredible range performance (50+km) and breakthrough speed (150+Mbps real TCP/IP).

Rocket M combines the “brains” in one robust unit; it can be paired with your choice of AirMax BaseStation or Rocket Antennas. This versatility gives network architects unparalleled flexibility and convenience.

On the right is one example of how Rockets can be deployed:

1 Internet Backbone
2 ISP Network
3 RocketDish with Rocket M
4 RocketDish with Rocket M
5 AirMax BaseStation with Rocket M
6 Corporate building with NanoStation M client.
7 House with NanoStation M client.
8 Small business with NanoStation M client.
9 Lightpole with NanoStation M daisy-chained to a PicoStation M to create a wireless hotspot.



Integrated AirMax Technology

Unlike standard WiFi protocol, Ubiquiti's Time Division Multiple Access (TDMA) AirMax protocol allows each client to send & receive data using pre-designated time slots scheduled by an intelligent AP controller.

This "time slot" method eliminates hidden node collisions & maximizes air time efficiency. It provides many magnitudes of performance improvements in latency, throughput, & scalability compared to all other outdoor systems in its class.

Intelligent QoS Priority is given to voice/video for seamless access.

Scalability High capacity and scalability.

Long Distance Capable of high speed 50km+ links

Latency Multiple features dramatically reduce noise.

GPS Synchronization*

Rocket M GPS units have integrated Ubiquiti AirSync technology. AirSync enhances the hardware and software of Rocket M to utilize GPS signals for precision timing.

GPS Signal Reporting AirOS was upgraded to take full advantage of the new GPS hardware in Rocket M GPS units; easily manage/monitor GPS satellite signals.

No Co-location Interference Synchronized transmission among Rocket M GPS powered BaseStations effectively eliminates co-location interference.

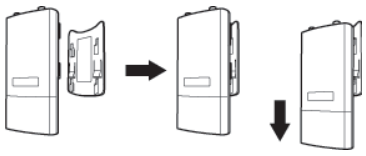
External GPS Antenna Included weather-proof external GPS Antenna (Rocket M GPS).

Two Ethernet Ports Second Ethernet port (only Rocket M GPS) capable of providing power to a secondary device using PoE.

Channel Re-use Frequency reuse for increased scalability.

Easy Installation

Rocket M and AirMax BaseStation/ Rocket Antennas have been designed to seamlessly work together.



Installing Rocket M on AirMax BaseStation and Rocket Antennas requires no special tools, you simply snap it securely into place with the universal Rocket mount built into the antennas.

* Only Rocket M GPS Models

Models

[top - Rocket M GPS Series] **RM2-GPS** (2.4 GHz), **RM365-GPS** (3.65-3.675 GHz), **RM5-GPS** (5 GHz)
[bottom - Rocket M Series] **RM2** (2.4 GHz), **RM3** (3.4-3.7 GHz), **RM365** (3.65-3.675 GHz), **RM5** (5GHz), **RM900** (900 MHz)

Software

airOS

AirOS is an intuitive, versatile, highly developed Ubiquiti firmware technology. It is exceptionally intuitive and was designed to require no training to operate. Behind the user interface is a powerful firmware architecture which enables hi-performance outdoor multipoint networking.

Protocol Support

Ubiquiti Channelization

Spectral Width Adjust

ACK Auto-Timing

AAP Technology

GPS Signal Reporting*

www.ubnt.com/airos

airView

Integrated on all Ubiquiti M products, AirView provides Advanced Spectrum Analyzer Functionality: Waterfall, waveform, and real-time spectral views allow operators to identify noise signatures and plan their networks to minimize noise interference.

Waterfall Aggregate energy over time for each frequency.

Waveform Aggregate energy collected.

Real-time Energy is shown real-time as a function of frequency.

Recording Automize AirView to record and report results.

www.ubnt.com/airview

airControl

AirControl is a powerful and intuitive web based server network management application which allows operators to centrally manage entire networks of Ubiqutii devices.

Network Map

Monitor Device Status

Mass Firmware Upgrade

Web UI Access

Manage Groups of Devices

Task Scheduling

www.ubnt.com/aircontrol

* Only Rocket M GPS Models

Specifications

System Information		
Processor Specs	Atheros MIPS 24KC, 400MHz	
Memory Information	64MB SDRAM, 8MB Flash	
	M	M GPS
Networking Interface	1 X 10/100 BASE-TX (Cat. 5, RJ-45) Ethernet	2 X 10/100 BASE-TX (Cat. 5, RJ-45) Ethernet

Regulatory / Compliance Information			
	M900, M2, M5, M2 GPS, M5 GPS	M3	M365, M365 GPS
Wireless Approvals	FCC Part 15.247, IC RS210, CE	-	FCC Part 90Y
RoHS Compliance	YES		

Physical / Electrical / Environmental		
Enclosure Size	17 x 8 x 3cm (length, width, height)	
Weight	0.5kg	
Enclosure Characteristics	Outdoor UV Stabilized Plastic	
Mounting Kit	Pole Mounting Kit included	
Power Supply	24V, 1A POE Supply included	
Power Method	Passive Power over Ethernet (pairs 4, 5+; 7, 8 return)	
Operating Temperature	-30C to 75C	
Operating Humidity	5 to 95% Condensing	
Shock and Vibration	ETSI300-019-1.4	
	M	M GPS
RF Connector	2x RP-SMA (Waterproof)	2x RP-SMA and 1x SMA (Waterproof)
	M (Except M5), M GPS (Except M5 GPS)	M5, M5 GPS
Max Power Consumption	6.5 Watts	8 Watts

Compatible Antennas				
M900	M2, M2 GPS	M3	M365, M365 GPS	M5, M5 GPS
AirMax Sector 900M-13-120	AirMax Sector 2G-16-90 2G-15-120	AirMax Sector 3G-18-120	AirMax Sector 3G-18-120	AirMax Sector 5G-17-90 5G-16-120 5G-20-90 5G-19-120
		Rocket Dish 3G-26	Rocket Dish 3G-26	
	Rocket Dish 2G-24			Rocket Dish 5G-30 5G-34

Specifications (cont.)

Operating Frequency Summary (MHz)				
M900	M2, M2 GPS	M3	M365, M365 GPS	M5, M5 GPS
902-928	2412-2462	3400-3700	3650-3675	5470-5825*

Rocket M900 - Operating Frequency 902-928 MHz							
OUTPUT POWER: 28 dBm							
900 MHz TX POWER SPECIFICATIONS					900 MHz RX POWER SPECIFICATIONS		
AirMax	MCS0	28 dBm	+/- 2 dB		AirMax	MCS0	-96 dBm	+/- 2 dB
	MCS1	28 dBm	+/- 2 dB			MCS1	-95 dBm	+/- 2 dB
	MCS2	28 dBm	+/- 2 dB			MCS2	-92 dBm	+/- 2 dB
	MCS3	28 dBm	+/- 2 dB			MCS3	-90 dBm	+/- 2 dB
	MCS4	28 dBm	+/- 2 dB			MCS4	-86 dBm	+/- 2 dB
	MCS5	24 dBm	+/- 2 dB			MCS5	-83 dBm	+/- 2 dB
	MCS6	22 dBm	+/- 2 dB			MCS6	-77 dBm	+/- 2 dB
	MCS7	21 dBm	+/- 2 dB			MCS7	-74 dBm	+/- 2 dB
	MCS8	28 dBm	+/- 2 dB			MCS8	-95 dBm	+/- 2 dB
	MCS9	28 dBm	+/- 2 dB			MCS9	-93 dBm	+/- 2 dB
	MCS10	28 dBm	+/- 2 dB			MCS10	-90 dBm	+/- 2 dB
	MCS11	28 dBm	+/- 2 dB			MCS11	-87 dBm	+/- 2 dB
	MCS12	28 dBm	+/- 2 dB			MCS12	-84 dBm	+/- 2 dB
	MCS13	24 dBm	+/- 2 dB			MCS13	-79 dBm	+/- 2 dB
	MCS14	22 dBm	+/- 2 dB			MCS14	-78 dBm	+/- 2 dB
	MCS15	21 dBm	+/- 2 dB			MCS15	-75 dBm	+/- 2 dB

Rocket M2 / M2 GPS - Operating Frequency 2412-2462 MHz							
OUTPUT POWER: 28 dBm							
2.4 GHz TX POWER SPECIFICATIONS					2.4 GHz RX POWER SPECIFICATIONS		
	DataRate	Avg. TX	Tolerance			DataRate	Avg. TX	Tolerance
11g	1-24 Mbps	28 dBm	+/- 2 dB		11g	1-24 Mbps	-97 dBm min	+/- 2 dB
	36 Mbps	26 dBm	+/- 2 dB			36 Mbps	-80 dBm	+/- 2 dB
	48 Mbps	25 dBm	+/- 2 dB			48 Mbps	-77 dBm	+/- 2 dB
	54 Mbps	24 dBm	+/- 2 dB			54 Mbps	-75 dBm	+/- 2 dB
11n / AirMax	MCS0	28 dBm	+/- 2 dB		11n / AirMax	MCS0	-96 dBm	+/- 2 dB
	MCS1	28 dBm	+/- 2 dB			MCS1	-95 dBm	+/- 2 dB
	MCS2	28 dBm	+/- 2 dB			MCS2	-92 dBm	+/- 2 dB
	MCS3	28 dBm	+/- 2 dB			MCS3	-90 dBm	+/- 2 dB
	MCS4	27 dBm	+/- 2 dB			MCS4	-86 dBm	+/- 2 dB
	MCS5	25 dBm	+/- 2 dB			MCS5	-83 dBm	+/- 2 dB
	MCS6	23 dBm	+/- 2 dB			MCS6	-77 dBm	+/- 2 dB
	MCS7	22 dBm	+/- 2 dB			MCS7	-74 dBm	+/- 2 dB
	MCS8	28 dBm	+/- 2 dB			MCS8	-95 dBm	+/- 2 dB
	MCS9	28 dBm	+/- 2 dB			MCS9	-93 dBm	+/- 2 dB
	MCS10	28 dBm	+/- 2 dB			MCS10	-90 dBm	+/- 2 dB
	MCS11	28 dBm	+/- 2 dB			MCS11	-87 dBm	+/- 2 dB
	MCS12	27 dBm	+/- 2 dB			MCS12	-84 dBm	+/- 2 dB
	MCS13	25 dBm	+/- 2 dB			MCS13	-79 dBm	+/- 2 dB
	MCS14	23 dBm	+/- 2 dB			MCS14	-78 dBm	+/- 2 dB
	MCS15	22 dBm	+/- 2 dB			MCS15	-75 dBm	+/- 2 dB

* Only 5745 - 5825 MHz is supported in the USA

Specifications (cont.)

Rocket M3 - Operating Frequency 3400-3700 MHz							
OUTPUT POWER: 25 dBm							
TX POWER SPECIFICATIONS				RX POWER SPECIFICATIONS			
AirMax	MCS0	25 dBm	+/- 2 dB	AirMax	MCS0	-94 dBm	+/- 2 dB
	MCS1	25 dBm	+/- 2 dB		MCS1	-93 dBm	+/- 2 dB
	MCS2	25 dBm	+/- 2 dB		MCS2	-90 dBm	+/- 2 dB
	MCS3	25 dBm	+/- 2 dB		MCS3	-89 dBm	+/- 2 dB
	MCS4	24 dBm	+/- 2 dB		MCS4	-86 dBm	+/- 2 dB
	MCS5	23 dBm	+/- 2 dB		MCS5	-83 dBm	+/- 2 dB
	MCS6	22 dBm	+/- 2 dB		MCS6	-77 dBm	+/- 2 dB
	MCS7	20 dBm	+/- 2 dB		MCS7	-74 dBm	+/- 2 dB
	MCS8	25 dBm	+/- 2 dB		MCS8	-93 dBm	+/- 2 dB
	MCS9	25 dBm	+/- 2 dB		MCS9	-91 dBm	+/- 2 dB
	MCS10	25 dBm	+/- 2 dB		MCS10	-89 dBm	+/- 2 dB
	MCS11	25 dBm	+/- 2 dB		MCS11	-87 dBm	+/- 2 dB
	MCS12	24 dBm	+/- 2 dB		MCS12	-84 dBm	+/- 2 dB
	MCS13	23 dBm	+/- 2 dB		MCS13	-79 dBm	+/- 2 dB
	MCS14	22 dBm	+/- 2 dB		MCS14	-78 dBm	+/- 2 dB
	MCS15	20 dBm	+/- 2 dB		MCS15	-75 dBm	+/- 2 dB

Rocket M365 / M365 GPS - Operating Frequency 3650-3675 MHz							
OUTPUT POWER: 25 dBm							
TX POWER SPECIFICATIONS				RX POWER SPECIFICATIONS			
AirMax	MCS0	25 dBm	+/- 2 dB	AirMax	MCS0	-94 dBm	+/- 2 dB
	MCS1	25 dBm	+/- 2 dB		MCS1	-93 dBm	+/- 2 dB
	MCS2	25 dBm	+/- 2 dB		MCS2	-90 dBm	+/- 2 dB
	MCS3	25 dBm	+/- 2 dB		MCS3	-89 dBm	+/- 2 dB
	MCS4	24 dBm	+/- 2 dB		MCS4	-86 dBm	+/- 2 dB
	MCS5	23 dBm	+/- 2 dB		MCS5	-83 dBm	+/- 2 dB
	MCS6	22 dBm	+/- 2 dB		MCS6	-77 dBm	+/- 2 dB
	MCS7	20 dBm	+/- 2 dB		MCS7	-74 dBm	+/- 2 dB
	MCS8	25 dBm	+/- 2 dB		MCS8	-93 dBm	+/- 2 dB
	MCS9	25 dBm	+/- 2 dB		MCS9	-91 dBm	+/- 2 dB
	MCS10	25 dBm	+/- 2 dB		MCS10	-89 dBm	+/- 2 dB
	MCS11	25 dBm	+/- 2 dB		MCS11	-87 dBm	+/- 2 dB
	MCS12	24 dBm	+/- 2 dB		MCS12	-84 dBm	+/- 2 dB
	MCS13	23 dBm	+/- 2 dB		MCS13	-79 dBm	+/- 2 dB
	MCS14	22 dBm	+/- 2 dB		MCS14	-78 dBm	+/- 2 dB
	MCS15	20 dBm	+/- 2 dB		MCS15	-75 dBm	+/- 2 dB

Specifications (cont.)

Rocket M5 / M5 GPS - Operating Frequency 5470-5825 MHz*							
OUTPUT POWER: 27 dBm							
5 GHz TX POWER SPECIFICATIONS					5 GHz RX POWER SPECIFICATIONS		
	DataRate	Avg. TX	Tolerance			DataRate	Avg. TX	Tolerance
11a	6-24 Mbps	27 dBm	+/- 2 dB		11a	6-24 Mbps	-94 dBm min	+/- 2 dB
	36 Mbps	25 dBm	+/- 2 dB			36 Mbps	-80 dBm	+/- 2 dB
	48 Mbps	23 dBm	+/- 2 dB			48 Mbps	-77 dBm	+/- 2 dB
	54 Mbps	22 dBm	+/- 2 dB			54 Mbps	-75 dBm	+/- 2 dB
11n / AirMax	MCS0	27 dBm	+/- 2 dB		11n / AirMax	MCS0	-96 dBm	+/- 2 dB
	MCS1	27 dBm	+/- 2 dB			MCS1	-95 dBm	+/- 2 dB
	MCS2	27 dBm	+/- 2 dB			MCS2	-92 dBm	+/- 2 dB
	MCS3	27 dBm	+/- 2 dB			MCS3	-90 dBm	+/- 2 dB
	MCS4	26 dBm	+/- 2 dB			MCS4	-86 dBm	+/- 2 dB
	MCS5	24 dBm	+/- 2 dB			MCS5	-83 dBm	+/- 2 dB
	MCS6	22 dBm	+/- 2 dB			MCS6	-77 dBm	+/- 2 dB
	MCS7	21 dBm	+/- 2 dB			MCS7	-74 dBm	+/- 2 dB
	MCS8	27 dBm	+/- 2 dB			MCS8	-95 dBm	+/- 2 dB
	MCS9	27 dBm	+/- 2 dB			MCS9	-93 dBm	+/- 2 dB
	MCS10	27 dBm	+/- 2 dB			MCS10	-90 dBm	+/- 2 dB
	MCS11	27 dBm	+/- 2 dB			MCS11	-87 dBm	+/- 2 dB
	MCS12	26 dBm	+/- 2 dB			MCS12	-84 dBm	+/- 2 dB
	MCS13	24 dBm	+/- 2 dB			MCS13	-79 dBm	+/- 2 dB
	MCS14	22 dBm	+/- 2 dB			MCS14	-78 dBm	+/- 2 dB
	MCS15	21 dBm	+/- 2 dB			MCS15	-75 dBm	+/- 2 dB

* Only 5745 - 5825 MHz is supported in the USA

* Only 5745 - 5825 MHz is supported in the USA

Misc

TOUGHCable

OUTDOOR CARRIER CLASS SHIELDED

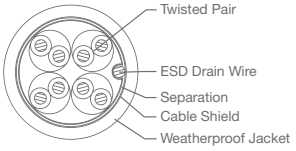
Protect your networks from the most brutal environments with Ubiquiti's industrial-grade shielded ethernet cable, TOUGHCable.

Increase Performance Dramatically improve your ethernet link states, speeds, and overall performance with Ubiquiti TOUGHCables.

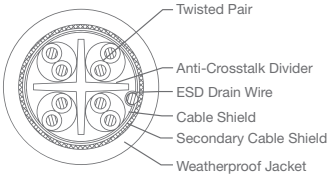
Extreme Weatherproof TOUGHCables have been built to perform even in the harshest weather and environments.

Eliminate ESD Attacks Protect your networks from devastating ESD Attacks, TOUGHCables eliminate ESD attacks and ethernet hardware damage.

Extended Cable Support TOUGHCables have been developed to have increased power handling performance for extended cable run lengths.



LEVEL1
SHIELDING PROTECTION



LEVEL2
SHIELDING PROTECTION

Bulletproof your networks

TOUGHCable is currently available in two versions: Level 1 Shielding Protection and Level 2 Shielding Protection.

Level 1 is a Category 5e (100Mbps Ethernet Support) Outdoor Carrier Class Shielded Cable.

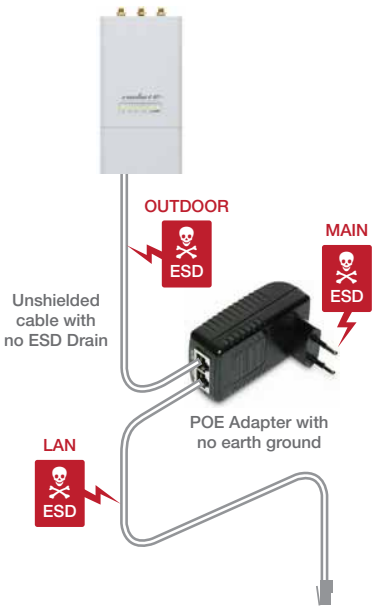
Level 2 is a Category 6 (1Gbps Ethernet Support) Outdoor Carrier Class Shielded Cable that is also capable of providing enhanced Category 5e performance.

Additional Information:

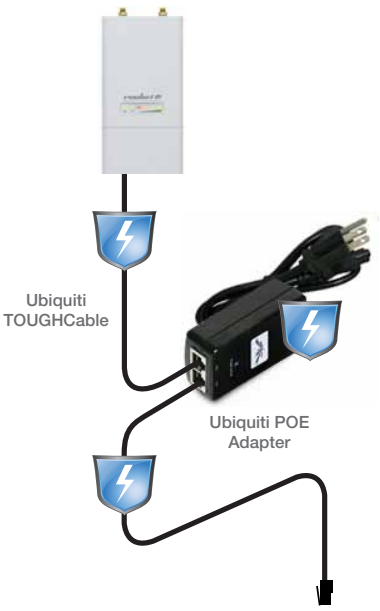
- 24 AWG copper conductor pairs
- ESD Drain Wire: 26 AWG integrated ESD Drain wire to prevent ESD attacks & damage.
- PVC outdoor rated jacket
- 0.35um foil shield
- Multi-Layered Shielding
- 1000ft (304.8m) length

Learn more:
www.ubnt.com/toughcable

ESD Attacks are overwhelmingly the leading cause for device failures. The diagram below illustrates the areas vulnerable to ESD Attacks in a defenseless network.



By using a grounded Ubiquiti POE adapter (included) along with Ubiquiti TOUGHCable (sold separately), you can effectively eliminate ESD Attacks.



UBIQUITI NETWORKS

TERMS OF USE: The Ubiquiti radio device must be professionally installed. Shielded ethernet cable and earth grounding must be used as conditions of product warranty. It is the installers responsibility to follow local country regulations including operation within legal frequency channels, output power, and Dynamic Frequency Selection (DFS) requirements.

For further information, please visit www.ubnt.com.

All specifications in this document are subject to change without notice.

RM-DS-080511

D.2. Antena sectorial AirMAX Sector, modelo 5G-16-120

UBIQUITI NETWORKS

TECHNICAL SPECS/DATASHEET

5GHz AirMax 2x2 MIMO Basestation Sector Antennas

Revolutionary, Cost/Performance Breakthrough Carrier Class MIMO BaseStation Antennas

AirMax Sector **5G-20-90**
Hi-gain 20dBi, 90deg.

AirMax Sector **5G-19-120**
Hi-Gain 19dBi, 120deg.

airMAX

MIMO TDMA Protocol System

AirMax Sector **5G-17-90**
Mid-Gain 17dBi, 90deg

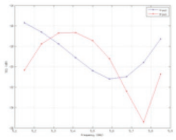
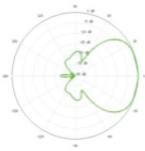
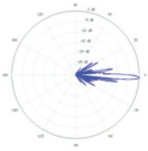
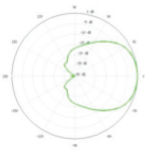
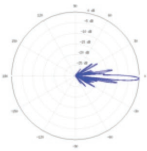
AirMax Sector **5G-16-120**
Mid-Gain 16dBi, 120 deg.

Ubiquiti Networks Inc., 91 E. Tasman Dr., San Jose, CA 95134 www.ubnt.com

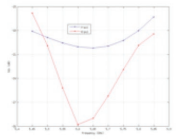
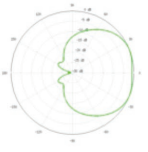
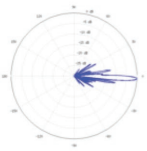
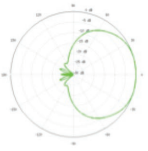
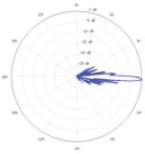
AirMax 5GHz Carrier Class Sector 2x2 MIMO Antennas

TECHNICAL SPECIFICATIONS

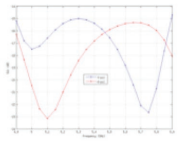
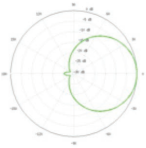
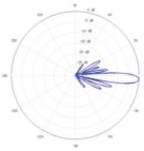
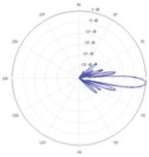
Hi-Gain Airmax Sector 5G-90-20

Antenna and Electrical Characteristics		Return Loss	V-Pol Azimuth	V-Pol Elevation	H-Pol Azimuth	H-Pol Elevation
	Frequency Range: 5.15-5.85 GHz Gain: 19.4-20.3 dBi Polarization: Dual Linear Cross-pol Isolation: 28dB min. Max VSWR: 1.5:1 Hpol Beamwidth (6dB): 91 deg. Vpol Beamwidth (6dB): 85 deg. Elevation Beamwidth: 4 deg. Electrical Downtilt: 2 deg. ETSI Specification: EN 302 326 DN2 Dimensions: 700x145x93mm Weight: 5.9 kg Windloading: 160 mph					

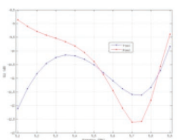
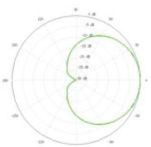
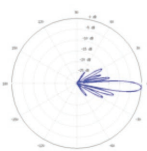
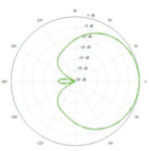
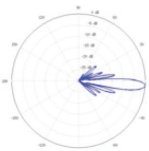
Hi-Gain Airmax Sector 5G-120-19

Antenna and Electrical Characteristics		Return Loss	V-Pol Azimuth	V-Pol Elevation	H-Pol Azimuth	H-Pol Elevation
	Frequency Range: 5.15-5.85 GHz Gain: 18.6-19.1dBi Polarization: Dual Linear Cross-pol Isolation: 28dB min. Max VSWR: 1.5:1 Hpol Beamwidth (6dB): 123 deg. Vpol Beamwidth (6dB): 123 deg. Elevation Beamwidth: 4 deg. Electrical Downtilt: 2 deg. ETSI Specification: EN 302 326 DN2 Dimensions: 700x145x79 mm Weight: 5.9 kg Windloading: 160 mph					

Mid-Gain Airmax Sector 5G-90-17

Antenna and Electrical Characteristics		Return Loss	V-Pol Azimuth	V-Pol Elevation	H-Pol Azimuth	H-Pol Elevation
	Frequency Range: 4.90-5.85 GHz Gain: 16.1-17.1dBi Polarization: Dual Linear Cross-pol Isolation: 22dB min. Max VSWR: 1.5:1 Hpol Beamwidth (6dB): 72 deg. Vpol Beamwidth (6dB): 93 deg. Elevation Beamwidth: 8 deg. Electrical Downtilt: 4 deg. ETSI Specification: EN 302 326 DN2 Dimensions: 367x63x41mm Weight: 1.1kg Windloading: 120 mph					

Mid-Gain Airmax Sector 5G-120-16

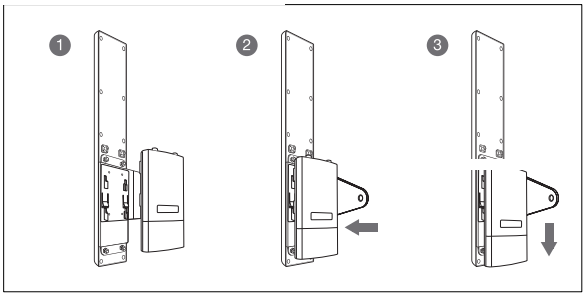
Antenna and Electrical Characteristics		Return Loss	V-Pol Azimuth	V-Pol Elevation	H-Pol Azimuth	H-Pol Elevation
	Frequency Range: 5.10-5.85 GHz Gain: 15.0-16.0dBi Polarization: Dual Linear Cross-pol Isolation: 22dB min Max VSWR: 1.5:1 Hpol Beamwidth (6dB): 137 deg. Vpol Beamwidth (6dB): 118 deg. Elevation Beamwidth: 8 deg. Electrical Downtilt: 4 deg. ETSI Specification: EN 302 326 DN2 Dimensions: 367x63x41mm Weight: 1.1 kg Windloading: 120 mph					

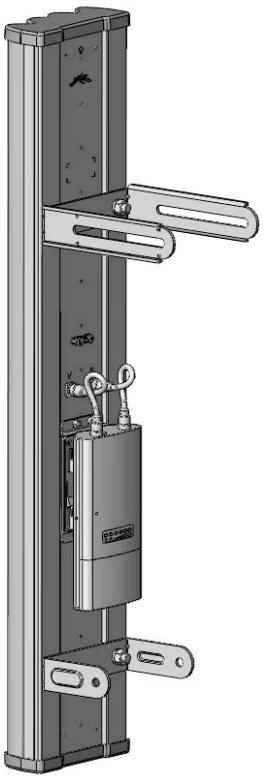
airMAX

MIMO TDMA Protocol System

Instantly pair with Rocket M5 to create a powerful AirMax 2x2 MIMO PtMP BaseStation. Mating bracket and weatherproof RF jumpers included.

rocket M5





Ubiquiti Networks Inc., 91 E. Tasman Dr., San Jose, CA 95134 www.ubnt.com

D.3. Unidades CPE AirMAX Nanostation M, modelos NSM5 y LOCOM5

NanoStation M | NanoStation loco M | Datasheet

NanoStation M
NanoStation loco M

Compact, Hi-Power, 2x2 MIMO AirMax TDMA Station

Models: NSM2, NSM3, NSM365, NSM5, LOCOM2, LOCOM5, LOCOM9

Cost Effective, Hi-Performance

Compact and Versatile Design

Powerful integrated Antenna

UBIQUITI NETWORKS

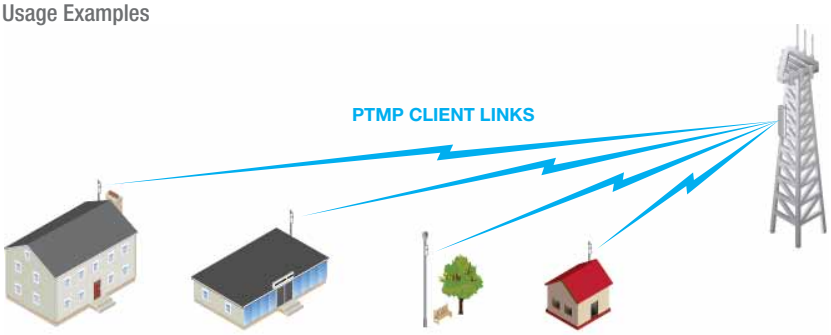
Overview

Leading Edge Industrial Design

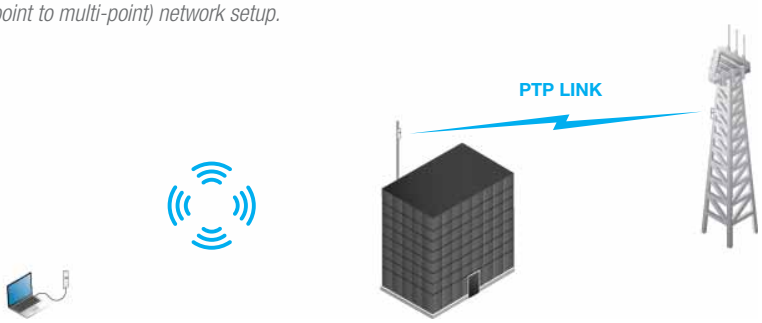
The original NanoStation set the bar for the world's first low-cost and efficiently designed outdoor broadband CPE. The new NanoStation M and NanoStation Loco M take the same concept to the future with new redesigned sleek and elegant form-factors along with integrated AirMax (MIMO TDMA Protocol) Technology.

The low cost, hi-performance, and small form factor of NanoStation M and NanoStation Loco M make them extremely versatile and ideal in several different applications (see diagrams on right for some usage examples).

Usage Examples



NanoStation M as powerful clients in an AirMax PTMP (point to multi-point) network setup.



NanoStation M as a powerful wireless client.

Use two NanoStation M to create a PTP link.

Integrated AirMax Technology

Unlike standard WiFi protocol, Ubiquiti's Time Division Multiple Access (TDMA) AirMax protocol allows each client to send & receive data using pre-designated time slots scheduled by an intelligent AP controller.

This "time slot" method eliminates hidden node collisions & maximizes air time efficiency. It provides many magnitudes of performance improvements in latency, throughput, & scalability compared to all other outdoor systems in its class.

Intelligent QoS Priority is given to voice/video for seamless access.

Scalability High capacity and scalability.

Long Distance Capable of high speed 50km+ links

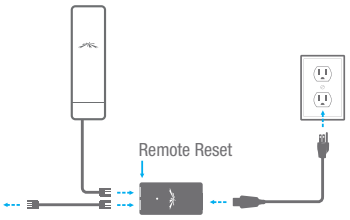
Latency Multiple features dramatically reduce noise.

Dual Ethernet Connectivity *

The New NanoStation M provides a secondary ethernet port with software enabled POE output for seamless IP Video integration.

Intelligent POE **

Remote hardware reset circuitry of NanoStation M allows for device to be reset remotely from power supply location. In addition, any NanoStation can easily become 802.3af 48V compliant through use of Ubiquiti's Instant 802.3af adapter (sold separately).



* Only NanoStation M models.
** Remote reset is an additional option. Nanostation M comes standard as 24V without remote reset.

Models

[top] **NSM2** (2.4GHz, 10.4-11.2dBi), **NSM3** (3.4-3.7GHz, 12.2-13.7dBi), **NSM365** (3.65GHz, 12.2-13.7dBi), **NSM5** (5GHz, 14.6-16.1dBi)
[bottom left] **LOCOM9** (900MHz, 8dBi) [bottom right] **LOCOM2** (2.4GHz, 8.5dBi), **LOCOM5** (5GHz, 13dBi)

Software

airOS

AirOS is an intuitive, versatile, highly developed Ubiquiti firmware technology. It is exceptionally intuitive and was designed to require no training to operate. Behind the user interface is a powerful firmware architecture which enables hi-performance outdoor multipoint networking.

Protocol Support

Ubiquiti Channelization

Spectral Width Adjust

ACK Auto-Timing

AAP Technology

Multi-Language Support

www.ubnt.com/airos

airView

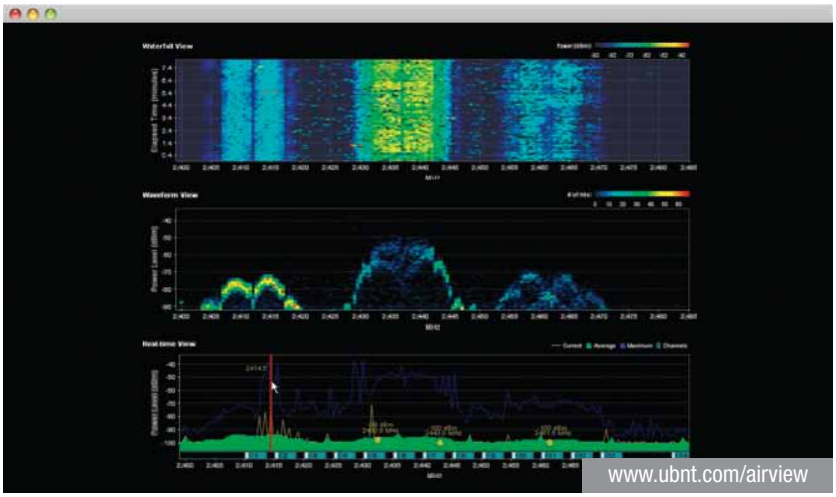
Integrated on all Ubiquiti M products, AirView provides Advanced Spectrum Analyzer Functionality: Waterfall, waveform, and real-time spectral views allow operators to identify noise signatures and plan their networks to minimize noise interference.

Waterfall Aggregate energy over time for each frequency.

Waveform Aggregate energy collected.

Real-time Energy is shown real-time as a function of frequency.

Recording Automize AirView to record and report results.



www.ubnt.com/airview

airControl

AirControl is a powerful and intuitive web based server network management application which allows operators to centrally manage entire networks of Ubiquitii devices.

Network Map

Monitor Device Status

Mass Firmware Upgrade

Web UI Access

Manage Groups of Devices

Task Scheduling

www.ubnt.com/aircontrol

Specifications

System Information		
Processor Specs		Atheros MIPS 24KC, 400MHz
	LOCOM9	LOCOM, NSM
Memory Information	64MB SDRAM, 8MB Flash	32MB SDRAM, 8MB Flash
	LOCOM	NSM
Networking Interface	1 X 10/100 BASE-TX (Cat. 5, RJ-45) Ethernet	2 X 10/100 BASE-TX (Cat. 5, RJ-45) Ethernet

Regulatory / Compliance Information				
	LOCOM9	M2, M5**	NSM3	NSM365
Wireless Approvals	FCC Part 15.247, IC RS210	FCC Part 15.247, IC RS210, CE	-	FCC Part 90Z
RoHS Compliance	YES			

Physical / Electrical / Environmental / Antenna			
Enclosure Characteristics	Outdoor UV Stabilized Plastic		
Mounting Kit	Pole Mounting Kit included		
Power Method	Passive Power over Ethernet (pairs 4, 5+; 7, 8 return)		
Operating Temperature	-30C to 75C		
Operating Humidity	5 to 95% Condensing		
Shock and Vibration	ETSI300-019-1.4		
	LOCOM9	LOCOM	NSM
Dimensions	164 x 72 x 199 mm	163 x 31 x 80 mm	294 x 31 x 80 mm
Weight	0.9 kg	0.18 kg	0.4 kg 0.5 kg (M3/M365)
Power Supply (included)	24V, 1A POE	24V, 0.5A POE	24V, 0.5A POE 24V, 1A POE (M3/M365)
Max Power Consumption	6.5 Watts	5.5 Watts	8 Watts
Antenna Gain	8 dBi	8 dBi (M2) 13 dBi (M5)	11 dBi (M2) 13.7 dBi (M3/M365) 16 dBi (M5)
Polarization	Dual Linear		
RF Connector	External RP-SMA	-	-

Operating Frequency Summary (MHz)				
LOCOM9	M2**	NSM3	NSM365	M5**
902-928	2412-2462	3400-3700	3650-3675	5470-5825*

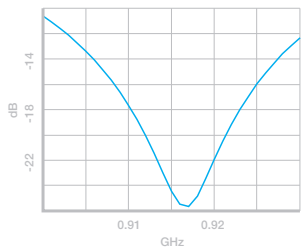
* Only 5745 - 5825 MHz is supported in the USA
** Applies to both NanoStation M and NanoStation Loco M models

Specifications (cont.) - LOCOM9

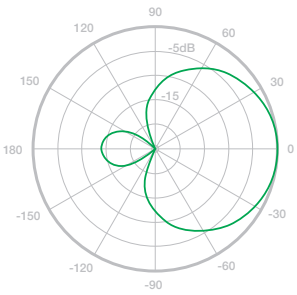
NanoStation Loco M9 - Operating Frequency 902-928 MHz								
OUTPUT POWER: 28 dBm								
900 MHz TX POWER SPECIFICATIONS					900 MHz RX POWER SPECIFICATIONS			
AirMax	MCS0	28 dBm	+/- 2 dB		AirMax	MCS0	-96 dBm	+/- 2 dB
	MCS1	28 dBm	+/- 2 dB			MCS1	-95 dBm	+/- 2 dB
	MCS2	28 dBm	+/- 2 dB			MCS2	-92 dBm	+/- 2 dB
	MCS3	28 dBm	+/- 2 dB			MCS3	-90 dBm	+/- 2 dB
	MCS4	28 dBm	+/- 2 dB			MCS4	-86 dBm	+/- 2 dB
	MCS5	24 dBm	+/- 2 dB			MCS5	-83 dBm	+/- 2 dB
	MCS6	22 dBm	+/- 2 dB			MCS6	-77 dBm	+/- 2 dB
	MCS7	21 dBm	+/- 2 dB			MCS7	-74 dBm	+/- 2 dB
	MCS8	28 dBm	+/- 2 dB			MCS8	-95 dBm	+/- 2 dB
	MCS9	28 dBm	+/- 2 dB			MCS9	-93 dBm	+/- 2 dB
	MCS10	28 dBm	+/- 2 dB			MCS10	-90 dBm	+/- 2 dB
	MCS11	28 dBm	+/- 2 dB			MCS11	-87 dBm	+/- 2 dB
	MCS12	28 dBm	+/- 2 dB			MCS12	-84 dBm	+/- 2 dB
	MCS13	24 dBm	+/- 2 dB			MCS13	-79 dBm	+/- 2 dB
	MCS14	22 dBm	+/- 2 dB			MCS14	-78 dBm	+/- 2 dB
	MCS15	21 dBm	+/- 2 dB			MCS15	-75 dBm	+/- 2 dB

NanoStation Loco M9 - Antenna Information (for integrated 2x2 MIMO Antenna)	
NanoStation Loco M9 also features a RP-SMA connector for a higher gain external antenna	
Gain	7.5 dBi
Cross-pol Isolation	28 dB minimum
Max VSWR	1.3:1
Beamwidth	60 deg. (H-pol) / 60 deg (V-pol) / 60 deg (Elevation)

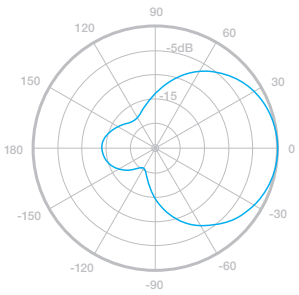
Return Loss



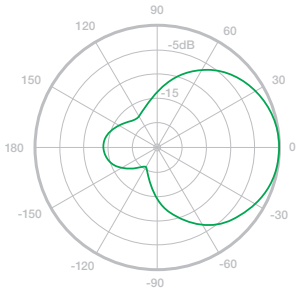
Vertical Azimuth



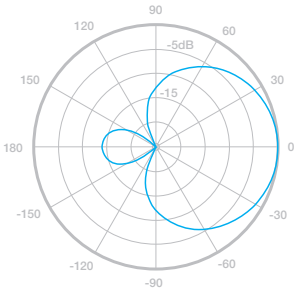
Vertical Elevation



Horizontal Azimuth



Horizontal Elevation

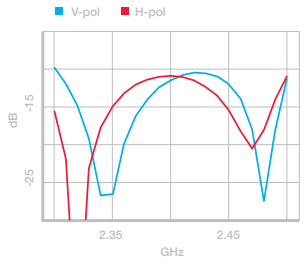


Specifications (cont.) - LOCOM2

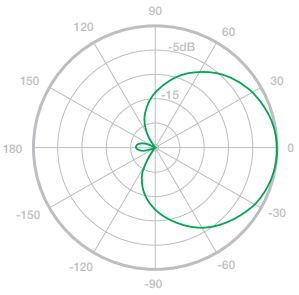
NanoStation Loco M2 - Operating Frequency 2412-2462 MHz							
OUTPUT POWER: 23 dBm							
2.4 GHz TX POWER SPECIFICATIONS					2.4 GHz RX POWER SPECIFICATIONS		
	DataRate	Avg. TX	Tolerance			DataRate	Avg. TX	Tolerance
11b / g	1-24 Mbps	23 dBm	+/- 2 dB		11b / g	1-24 Mbps	-83 dBm	+/- 2 dB
	36 Mbps	21 dBm	+/- 2 dB			36 Mbps	-80 dBm	+/- 2 dB
	48 Mbps	19 dBm	+/- 2 dB			48 Mbps	-77 dBm	+/- 2 dB
	54 Mbps	18 dBm	+/- 2 dB			54 Mbps	-75 dBm	+/- 2 dB
11n / AirMax	MCS0	23 dBm	+/- 2 dB		11n / AirMax	MCS0	-96 dBm	+/- 2 dB
	MCS1	23 dBm	+/- 2 dB			MCS1	-95 dBm	+/- 2 dB
	MCS2	23 dBm	+/- 2 dB			MCS2	-92 dBm	+/- 2 dB
	MCS3	23 dBm	+/- 2 dB			MCS3	-90 dBm	+/- 2 dB
	MCS4	22 dBm	+/- 2 dB			MCS4	-86 dBm	+/- 2 dB
	MCS5	20 dBm	+/- 2 dB			MCS5	-83 dBm	+/- 2 dB
	MCS6	18 dBm	+/- 2 dB			MCS6	-77 dBm	+/- 2 dB
	MCS7	17 dBm	+/- 2 dB			MCS7	-74 dBm	+/- 2 dB
	MCS8	23 dBm	+/- 2 dB			MCS8	-95 dBm	+/- 2 dB
	MCS9	23 dBm	+/- 2 dB			MCS9	-93 dBm	+/- 2 dB
	MCS10	23 dBm	+/- 2 dB			MCS10	-90 dBm	+/- 2 dB
	MCS11	23 dBm	+/- 2 dB			MCS11	-87 dBm	+/- 2 dB
	MCS12	22 dBm	+/- 2 dB			MCS12	-84 dBm	+/- 2 dB
	MCS13	20 dBm	+/- 2 dB			MCS13	-79 dBm	+/- 2 dB
	MCS14	18 dBm	+/- 2 dB			MCS14	-78 dBm	+/- 2 dB
	MCS15	17 dBm	+/- 2 dB			MCS15	-75 dBm	+/- 2 dB

NanoStation Loco M2 - Antenna Information	
Gain	8.5 dBi
Cross-pol Isolation	20 dB minimum
Max VSWR	1.4:1
Beamwidth	60 deg. (H-pol) / 60 deg (V-pol) / 60 deg (Elevation)

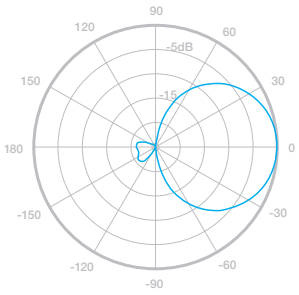
Return Loss



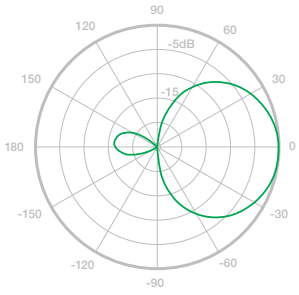
Vertical Azimuth



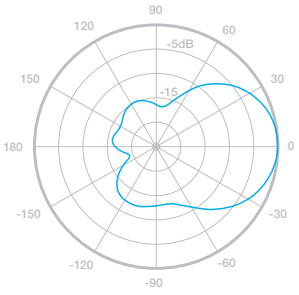
Vertical Elevation



Horizontal Azimuth



Horizontal Elevation

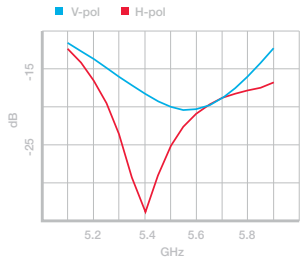


Specifications (cont.) - LOCOM5

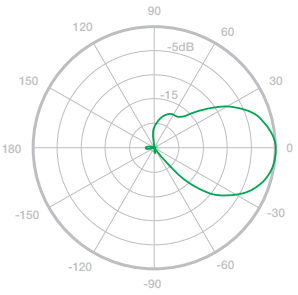
NanoStation Loco M5 - Operating Frequency 5470-5825 MHz*								
OUTPUT POWER: 23 dBm								
5 GHz TX POWER SPECIFICATIONS					5 GHz RX POWER SPECIFICATIONS			
	DataRate	Avg. TX	Tolerance			DataRate	Avg. TX	Tolerance
11a	6-24 Mbps	23 dBm	+/- 2 dB		11a	6-24 Mbps	-83 dBm	+/- 2 dB
	36 Mbps	21 dBm	+/- 2 dB			36 Mbps	-80 dBm	+/- 2 dB
	48 Mbps	19 dBm	+/- 2 dB			48 Mbps	-77 dBm	+/- 2 dB
	54 Mbps	18 dBm	+/- 2 dB			54 Mbps	-75 dBm	+/- 2 dB
11n / AirMax	MCS0	23 dBm	+/- 2 dB		11n / AirMax	MCS0	-96 dBm	+/- 2 dB
	MCS1	23 dBm	+/- 2 dB			MCS1	-95 dBm	+/- 2 dB
	MCS2	23 dBm	+/- 2 dB			MCS2	-92 dBm	+/- 2 dB
	MCS3	23 dBm	+/- 2 dB			MCS3	-90 dBm	+/- 2 dB
	MCS4	22 dBm	+/- 2 dB			MCS4	-86 dBm	+/- 2 dB
	MCS5	20 dBm	+/- 2 dB			MCS5	-83 dBm	+/- 2 dB
	MCS6	18 dBm	+/- 2 dB			MCS6	-77 dBm	+/- 2 dB
	MCS7	17 dBm	+/- 2 dB			MCS7	-74 dBm	+/- 2 dB
	MCS8	23 dBm	+/- 2 dB			MCS8	-95 dBm	+/- 2 dB
	MCS9	23 dBm	+/- 2 dB			MCS9	-93 dBm	+/- 2 dB
	MCS10	23 dBm	+/- 2 dB			MCS10	-90 dBm	+/- 2 dB
	MCS11	23 dBm	+/- 2 dB			MCS11	-87 dBm	+/- 2 dB
	MCS12	22 dBm	+/- 2 dB			MCS12	-84 dBm	+/- 2 dB
	MCS13	20 dBm	+/- 2 dB			MCS13	-79 dBm	+/- 2 dB
	MCS14	18 dBm	+/- 2 dB			MCS14	-78 dBm	+/- 2 dB
	MCS15	17 dBm	+/- 2 dB			MCS15	-75 dBm	+/- 2 dB

NanoStation Loco M5 - Antenna Information	
Gain	13 dBi
Cross-pol Isolation	20 dB minimum
Max VSWR	1.4:1
Beamwidth	45 deg. (H-pol) / 45 deg (V-pol) / 45 deg (Elevation)

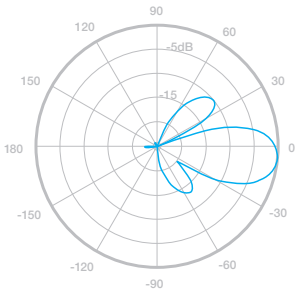
Return Loss



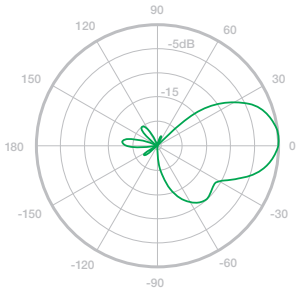
Vertical Azimuth



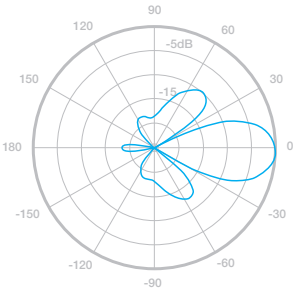
Vertical Elevation



Horizontal Azimuth



Horizontal Elevation



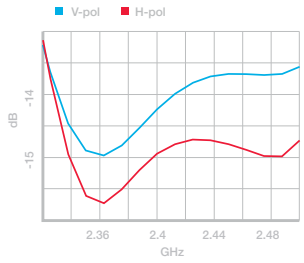
* Only 5745 - 5825 MHz is supported in the USA

Specifications (cont.) - NSM2

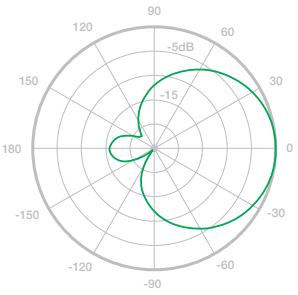
NanoStation M2 - Operating Frequency 2412-2462 MHz							
OUTPUT POWER: 28 dBm							
2.4 GHz TX POWER SPECIFICATIONS					2.4 GHz RX POWER SPECIFICATIONS		
	DataRate	Avg. TX	Tolerance			DataRate	Avg. TX	Tolerance
11b / g	1-24 Mbps	28 dBm	+/- 2 dB		11b / g	1-24 Mbps	-97 dBm min	+/- 2 dB
	36 Mbps	26 dBm	+/- 2 dB			36 Mbps	-80 dBm	+/- 2 dB
	48 Mbps	25 dBm	+/- 2 dB			48 Mbps	-77 dBm	+/- 2 dB
	54 Mbps	24 dBm	+/- 2 dB			54 Mbps	-75 dBm	+/- 2 dB
11n / AirMax	MCS0	28 dBm	+/- 2 dB		11n / AirMax	MCS0	-96 dBm	+/- 2 dB
	MCS1	28 dBm	+/- 2 dB			MCS1	-95 dBm	+/- 2 dB
	MCS2	28 dBm	+/- 2 dB			MCS2	-92 dBm	+/- 2 dB
	MCS3	28 dBm	+/- 2 dB			MCS3	-90 dBm	+/- 2 dB
	MCS4	27 dBm	+/- 2 dB			MCS4	-86 dBm	+/- 2 dB
	MCS5	25 dBm	+/- 2 dB			MCS5	-83 dBm	+/- 2 dB
	MCS6	23 dBm	+/- 2 dB			MCS6	-77 dBm	+/- 2 dB
	MCS7	22 dBm	+/- 2 dB			MCS7	-74 dBm	+/- 2 dB
	MCS8	28 dBm	+/- 2 dB			MCS8	-95 dBm	+/- 2 dB
	MCS9	28 dBm	+/- 2 dB			MCS9	-93 dBm	+/- 2 dB
	MCS10	28 dBm	+/- 2 dB			MCS10	-90 dBm	+/- 2 dB
	MCS11	28 dBm	+/- 2 dB			MCS11	-87 dBm	+/- 2 dB
	MCS12	27 dBm	+/- 2 dB			MCS12	-84 dBm	+/- 2 dB
	MCS13	25 dBm	+/- 2 dB			MCS13	-79 dBm	+/- 2 dB
	MCS14	23 dBm	+/- 2 dB			MCS14	-78 dBm	+/- 2 dB
	MCS15	22 dBm	+/- 2 dB			MCS15	-75 dBm	+/- 2 dB

NanoStation M2 - Antenna Information	
Gain	10.4-11.2 dBi
Cross-pol Isolation	23 dB minimum
Max VSWR	1.6:1
Beamwidth	55 deg. (H-pol) / 53 deg (V-pol) / 27 deg (Elevation)

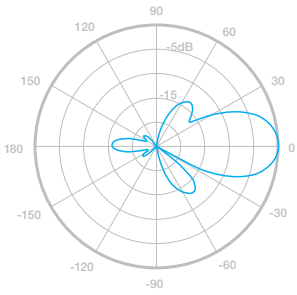
Return Loss



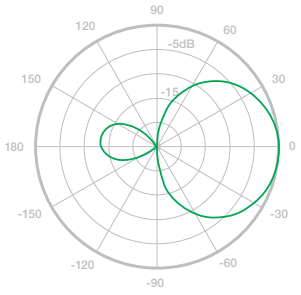
Vertical Azimuth



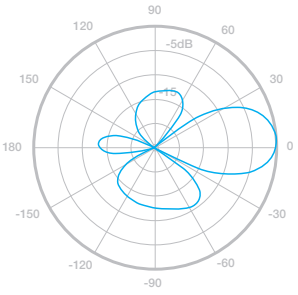
Vertical Elevation



Horizontal Azimuth



Horizontal Elevation

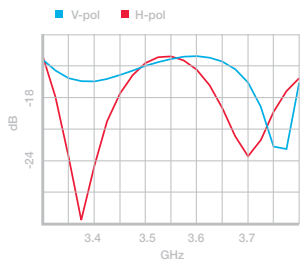


Specifications (cont.) - NSM3/NSM365

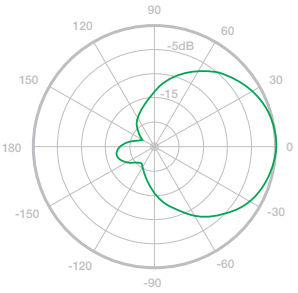
NanoStation M3 (3400-3700 MHz) / NanoStation M365 (3650-3675 MHz)							
OUTPUT POWER: 25 dBm							
TX POWER SPECIFICATIONS				RX POWER SPECIFICATIONS			
AirMax	MCS0	25 dBm	+/- 2 dB	AirMax	MCS0	-94 dBm	+/- 2 dB
	MCS1	25 dBm	+/- 2 dB		MCS1	-93 dBm	+/- 2 dB
	MCS2	25 dBm	+/- 2 dB		MCS2	-90 dBm	+/- 2 dB
	MCS3	25 dBm	+/- 2 dB		MCS3	-89 dBm	+/- 2 dB
	MCS4	24 dBm	+/- 2 dB		MCS4	-86 dBm	+/- 2 dB
	MCS5	23 dBm	+/- 2 dB		MCS5	-83 dBm	+/- 2 dB
	MCS6	22 dBm	+/- 2 dB		MCS6	-77 dBm	+/- 2 dB
	MCS7	20 dBm	+/- 2 dB		MCS7	-74 dBm	+/- 2 dB
	MCS8	25 dBm	+/- 2 dB		MCS8	-93 dBm	+/- 2 dB
	MCS9	25 dBm	+/- 2 dB		MCS9	-91 dBm	+/- 2 dB
	MCS10	25 dBm	+/- 2 dB		MCS10	-89 dBm	+/- 2 dB
	MCS11	25 dBm	+/- 2 dB		MCS11	-87 dBm	+/- 2 dB
	MCS12	24 dBm	+/- 2 dB		MCS12	-84 dBm	+/- 2 dB
	MCS13	23 dBm	+/- 2 dB		MCS13	-79 dBm	+/- 2 dB
	MCS14	22 dBm	+/- 2 dB		MCS14	-78 dBm	+/- 2 dB
	MCS15	20 dBm	+/- 2 dB		MCS15	-75 dBm	+/- 2 dB

NanoStation M3 / M365 - Antenna Information	
Gain	12.2 - 13.7 dBi
Cross-pol Isolation	28 dB minimum
Max VSWR	1.4:1
Beamwidth	60 deg. (H-pol) / 60 deg (V-pol) / 20 deg (Elevation)

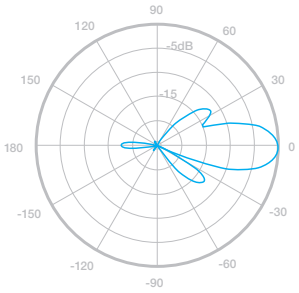
Return Loss



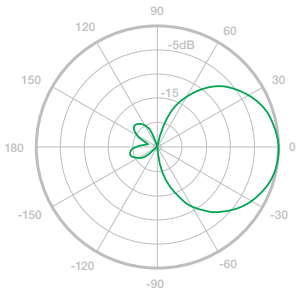
Vertical Azimuth



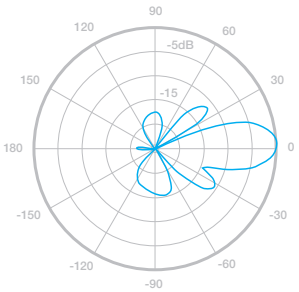
Vertical Elevation



Horizontal Azimuth



Horizontal Elevation

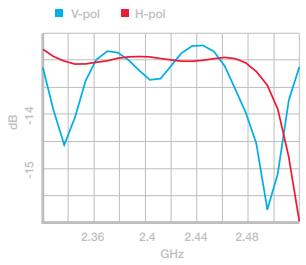


Specifications (cont.) - NSM5

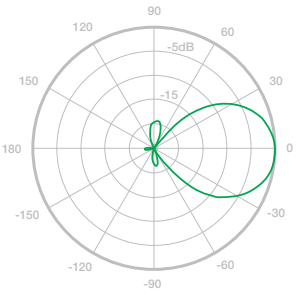
NanoStation M5 - Operating Frequency 5470-5825 MHz							
OUTPUT POWER: 27 dBm							
5 GHz TX POWER SPECIFICATIONS					5 GHz RX POWER SPECIFICATIONS		
	DataRate	Avg. TX	Tolerance			DataRate	Avg. TX	Tolerance
11a	6-24 Mbps	27 dBm	+/- 2 dB		11a	6-24 Mbps	-94 dBm min	+/- 2 dB
	36 Mbps	25 dBm	+/- 2 dB			36 Mbps	-80 dBm	+/- 2 dB
	48 Mbps	23 dBm	+/- 2 dB			48 Mbps	-77 dBm	+/- 2 dB
	54 Mbps	22 dBm	+/- 2 dB			54 Mbps	-75 dBm	+/- 2 dB
11n / AirMax	MCS0	27 dBm	+/- 2 dB		11n / AirMax	MCS0	-96 dBm	+/- 2 dB
	MCS1	27 dBm	+/- 2 dB			MCS1	-95 dBm	+/- 2 dB
	MCS2	27 dBm	+/- 2 dB			MCS2	-92 dBm	+/- 2 dB
	MCS3	27 dBm	+/- 2 dB			MCS3	-90 dBm	+/- 2 dB
	MCS4	26 dBm	+/- 2 dB			MCS4	-86 dBm	+/- 2 dB
	MCS5	24 dBm	+/- 2 dB			MCS5	-83 dBm	+/- 2 dB
	MCS6	22 dBm	+/- 2 dB			MCS6	-77 dBm	+/- 2 dB
	MCS7	21 dBm	+/- 2 dB			MCS7	-74 dBm	+/- 2 dB
	MCS8	27 dBm	+/- 2 dB			MCS8	-95 dBm	+/- 2 dB
	MCS9	27 dBm	+/- 2 dB			MCS9	-93 dBm	+/- 2 dB
	MCS10	27 dBm	+/- 2 dB			MCS10	-90 dBm	+/- 2 dB
	MCS11	27 dBm	+/- 2 dB			MCS11	-87 dBm	+/- 2 dB
	MCS12	26 dBm	+/- 2 dB			MCS12	-84 dBm	+/- 2 dB
	MCS13	24 dBm	+/- 2 dB			MCS13	-79 dBm	+/- 2 dB
	MCS14	22 dBm	+/- 2 dB			MCS14	-78 dBm	+/- 2 dB
	MCS15	21 dBm	+/- 2 dB			MCS15	-75 dBm	+/- 2 dB

NanoStation M5 - Antenna Information	
Gain	14.6 - 16.1 dBi
Cross-pol Isolation	22 dB minimum
Max VSWR	1.6:1
Beamwidth	43 deg. (H-pol) / 41 deg (V-pol) / 15 deg (Elevation)

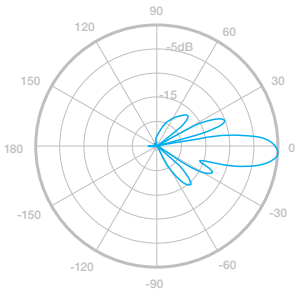
Return Loss



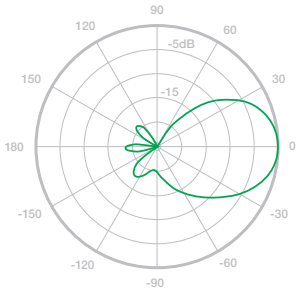
Vertical Azimuth



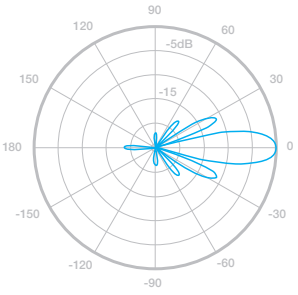
Vertical Elevation



Horizontal Azimuth



Horizontal Elevation



* Only 5745 - 5825 MHz is supported in the USA

Misc

TOUGHCable
OUTDOOR CARRIER CLASS SHIELDED

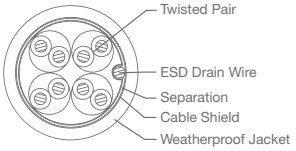
Protect your networks from the most brutal environments with Ubiquiti's industrial-grade shielded ethernet cable, TOUGHCable.

Increase Performance Dramatically improve your ethernet link states, speeds, and overall performance with Ubiquiti TOUGHCables.

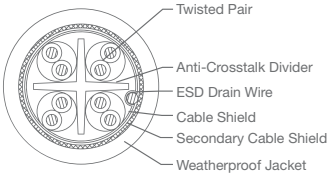
Extreme Weatherproof TOUGHCables have been built to perform even in the harshest weather and environments.

Eliminate ESD Attacks Protect your networks from devastating ESD Attacks, TOUGHCables eliminate ESD attacks and ethernet hardware damage.

Extended Cable Support TOUGHCables have been developed to have increased power handling performance for extended cable run lengths.



LEVEL1
SHIELDING PROTECTION



LEVEL2
SHIELDING PROTECTION

Bulletproof your networks

TOUGHCable is currently available in two versions: Level 1 Shielding Protection and Level 2 Shielding Protection.

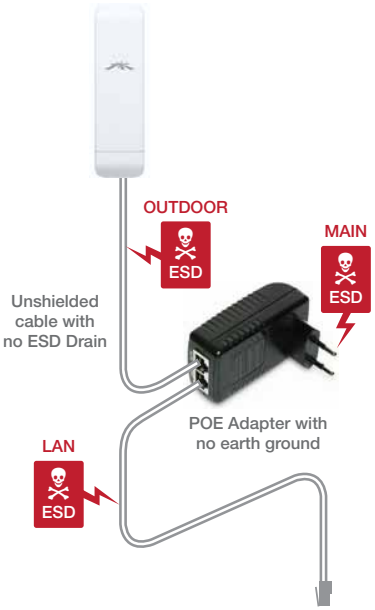
Level 1 is a Category 5e (Up to 1Gbps Ethernet Support) Outdoor Carrier Class Shielded Cable.

Level 2 is a Category 5e Enhanced Gigabit Performance (1Gbps Ethernet Support) Outdoor Carrier Class Shielded Cable.

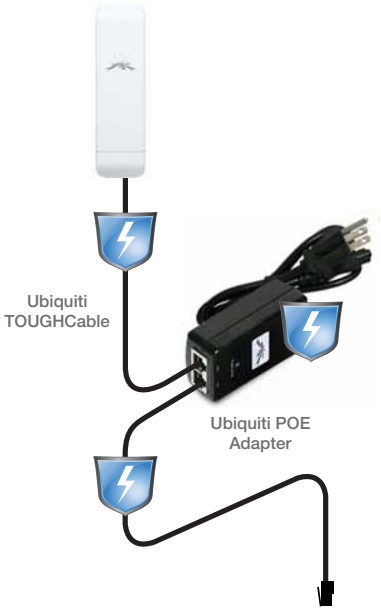
Additional Information:
- 24 AWG copper conductor pairs
- ESD Drain Wire: 26 AWG integrated ESD Drain wire to prevent ESD attacks & damage.
- PVC outdoor rated jacket
- 0.35um foil shield
- Multi-Layered Shielding
- 1000ft (304.8m) length
- Use with TOUGHCable Connectors (sold separately) for optimal performance

Learn more:
www.ubnt.com/toughcable

ESD Attacks are overwhelmingly the leading cause for device failures. The diagram below illustrates the areas vulnerable to ESD Attacks in a defenseless network.



By using a grounded Ubiquiti POE adapter (included) along with Ubiquiti TOUGHCable (sold separately), you can effectively eliminate ESD Attacks.



UBIQUITI NETWORKS

TERMS OF USE: The Ubiquiti radio device must be professionally installed. Shielded ethernet cable and earth grounding must be used as conditions of product warranty. It is the installers responsibility to follow local country regulations including operation within legal frequency channels, output power, and Dynamic Frequency Selection (DFS) requirements.

For further information, please visit www.ubnt.com.

All specifications in this document are subject to change without notice.

D.4. Punto de acceso UniFi WiFi UAP-Outdoor

Datasheet

UniFi

UniFi™

Enterprise WiFi System

Models: UAP, UAP-LR, UAP-Pro,
UAP-Outdoor, UAP-Outdoor5

Unlimited Indoor/Outdoor AP Scalability in a Unified Management System

Breakthrough Capacity up to 750 Mbps

Intuitive UniFi Controller Software

Hotspot Management – Customization and Built-In Billing Options

UBIQUITI NETWORKS

Scalable and Unified Enterprise WiFi Management

The UniFi Enterprise WiFi System is a scalable enterprise access point solution designed to be easily deployed and managed. UniFi Access Point indoor models have a sleek design and can be easily mounted to a ceiling tile or wall using the included mounting hardware. UniFi Access Point outdoor models have a form factor built to last outdoors.

The UniFi Enterprise WiFi System includes the UniFi Controller software. The software installs on any PC or Mac within the network and is easily accessible through any standard Web browser. Using the UniFi Controller software, an Enterprise WiFi network can be instantly configured and administered without any special training. Real-time status, automatic UAP device detection, map loading, and advanced security options are all seamlessly integrated.

Features

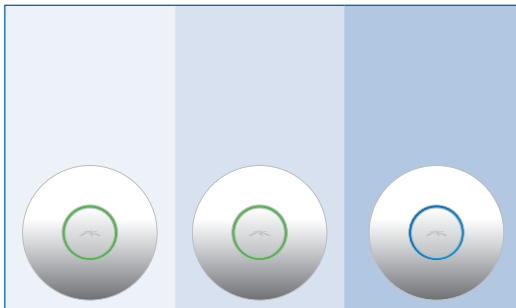
Save money and save time Unlike traditional enterprise WiFi systems utilizing a hardware WiFi switch, UniFi uses a virtual client/server application that requires zero cost and no additional hardware.

Powerful Hardware UniFi AP devices feature the latest in WiFi 802.11n technology, breakthrough speeds, and incredible range.

Intuitive UniFi Controller Software Install, configure, and manage all of your UniFi AP devices with the intuitive and easy-to-learn UniFi Controller user interface (no special training needed).

Expandable Unlimited scalability. Build wireless networks as small or big as needed. Start with one (or upgrade to a 3-pack) and expand to thousands while maintaining a single unified management system.

Product Comparison




	UniFi AP (UAP)	UniFi AP-LR (UAP-LR)	UniFi AP-Pro (UAP-Pro)	UniFi AP-Outdoor (UAP-Outdoor)	UniFi AP-Outdoor 5G (UAP-Outdoor5)
Speed*	300 Mbps	300 Mbps	300 + 450 Mbps	300 Mbps	300 Mbps
Range*	400'	600'	400'	600'	600'
Secondary Ethernet Port			√	√	√
Gigabit Ethernet			√		
2.4 GHz	√	√	√	√	
5 GHz			√		√
Simultaneous Dual-Band			√		
Ubiquiti PoE	√	√	√	√	√
802.3af Compliant			√		
Wall Mount	√	√	√	√	√
Ceiling Mount	√	√	√		
Pole Mount				√	√
Security Lock			√		
External Antennas				√	√
Usage	Indoor			Outdoor	

* *Speed* and *Range* values may vary and are based on optimal environments.

Indoor Models

Features

Easy Mounting Sleek wall or ceiling mount design (all accessories included).

Design Aesthetic industrial design with a unique LED provisioning ring, which provides administrator location tracking and alerts for each device.

Power over Ethernet (PoE) Includes Power over Ethernet (PoE) functionality, which allows both power and data to be carried over a single Ethernet cable to the device.

The UniFi AP-Pro includes a Power Over Ethernet Gig E Adapter. It can also be powered by an 802.3af compliant switch.

UniFi indoor models available in single-pack and 3-pack.

Included:

- Wall and Ceiling Mount Adapter Kit
- Power Over Ethernet Adapter
- UniFi Controller Software Installation CD

UniFi AP-Pro (UAP-Pro)

The fastest UniFi model with speeds of up to 300 Mbps in the 5 GHz radio band and up to 450 Mbps in the 2.4 GHz radio band. The UAP-Pro offers simultaneous dual-band operation with 2x2 and 3x3 MIMO technology. It has a range of up to 400 ft and 2 Gigabit Ethernet ports.

UniFi AP-Long Range (UAP-LR)

The UAP-LR has a larger range than the base model UAP with a range of up to 600 ft. It also offers 802.11n MIMO, with speeds of up to 300 Mbps.

UniFi AP (UAP)

Our standard model 802.11n MIMO UniFi AP. Capable of speeds up to 300 Mbps with a range of up to 400 ft.

Outdoor Models

All the same features packed in the indoor UniFi models, but in a form factor built to last outdoors.

Features

Easy Mounting Sleek wall or pole mount design (all accessories included).

Design for the Great Outdoors
Weather-resistent case designed specifically for outdoor installations. Dual, omni-directional antennas provide for complete 360° wireless coverage.

2G or 5G Models Choose the frequency best suited to your environment - 2 GHz (UAP-Outdoor) or 5 GHz (UAP-Outdoor5). Both models offer astonishing range of up to 600 ft.

Power over Ethernet (PoE) Includes Power over Ethernet (PoE) functionality, which allows both power and data to be carried over a single Ethernet cable to the device.

UniFi outdoor models available in single-pack.

Included:

- Wall and Pole Mount Kit
- Power Over Ethernet Adapter
- UniFi Controller Software Installation CD

UniFi AP-Outdoor (UAP-Outdoor)

Take UniFi outdoors and link farther than the standard UAP with the UAP-Outdoor. The UAP-Outdoor includes 2 external omni antennas and a secondary Ethernet port for bridging. It supports 802.11n MIMO, with speeds of up to 300 Mbps and a range of up to 600 ft.

UniFi AP-Outdoor 5G (UAP-Outdoor5)

Outdoor UniFi model operates in the 5 GHz frequency spectrum. The UAP-Outdoor5 includes 2 external omni antennas and a secondary Ethernet port for bridging. It supports 802.11n MIMO, with speeds of up to 300 Mbps and a range of up to 600 ft.

UniFi Controller Software

Packed with Features

After the UniFi Controller software is installed on a Mac or PC, the UniFi Controller can be accessed through any device using a Web browser. The UniFi Controller allows the administrator to instantly provision thousands of UniFi APs, map out networks, quickly manage system traffic, and further provision individual UniFi AP devices.

Users and Guests

Keep track and control access of specific users and guests connected to your network(s).

Remote Firmware Upgrade

Save time and effort by remotely upgrading device firmware.

Guest Portal/Hotspot Support

Easy customization and advanced options for Guest Portals include authentication, Hotspot setup options, and the ability to run as an external portal server. Take advantage of UniFi's rate limiting for your Guest Portal and Hotspot package offerings. Apply different bandwidth rates (download/upload), limit total data usage, and limit duration of use.

All UniFi APs include Hotspot functionality:

- Built-in support for billing integration using major credit cards via PayPal™.
- Built-in support for voucher-based authentication.
- Built-in Hotspot Manager for voucher creation, guest management, and payment refund.
- Full customization of Hotspot portal pages.

Google Maps™ Integration

Upload your own custom coverage maps or configure your map using the built-in Google Maps API.

Events and Alerts

UniFi makes it easy to view and set up email delivery of alerts and recent event notifications on your network(s).

One UniFied Network

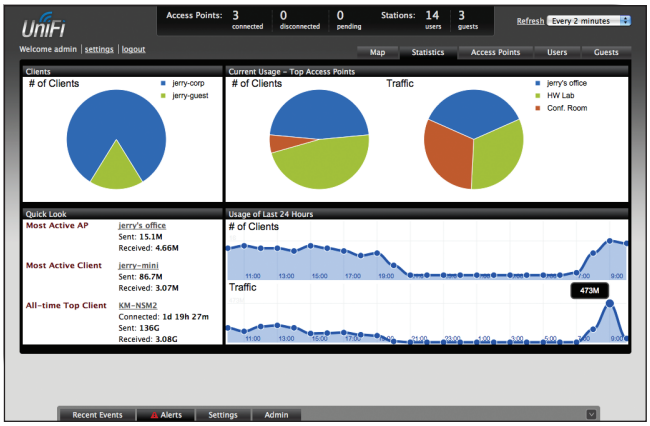
Option to create one large wireless network across multiple APs that lets users seamlessly roam.

L3 Manageability

With L3 manageability, the UniFi Controller software can be run on a different subnet than the UniFi APs it manages, allowing "no-touch" AP provisioning.

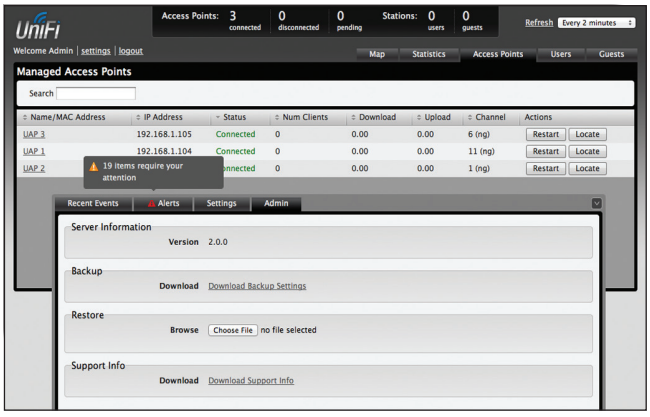
Maps

Upload map images of your location(s) for a visual representation of your wireless network.



Statistics

UniFi organizes and visualizes your network(s) traffic in clear and easy-to-read graphs.



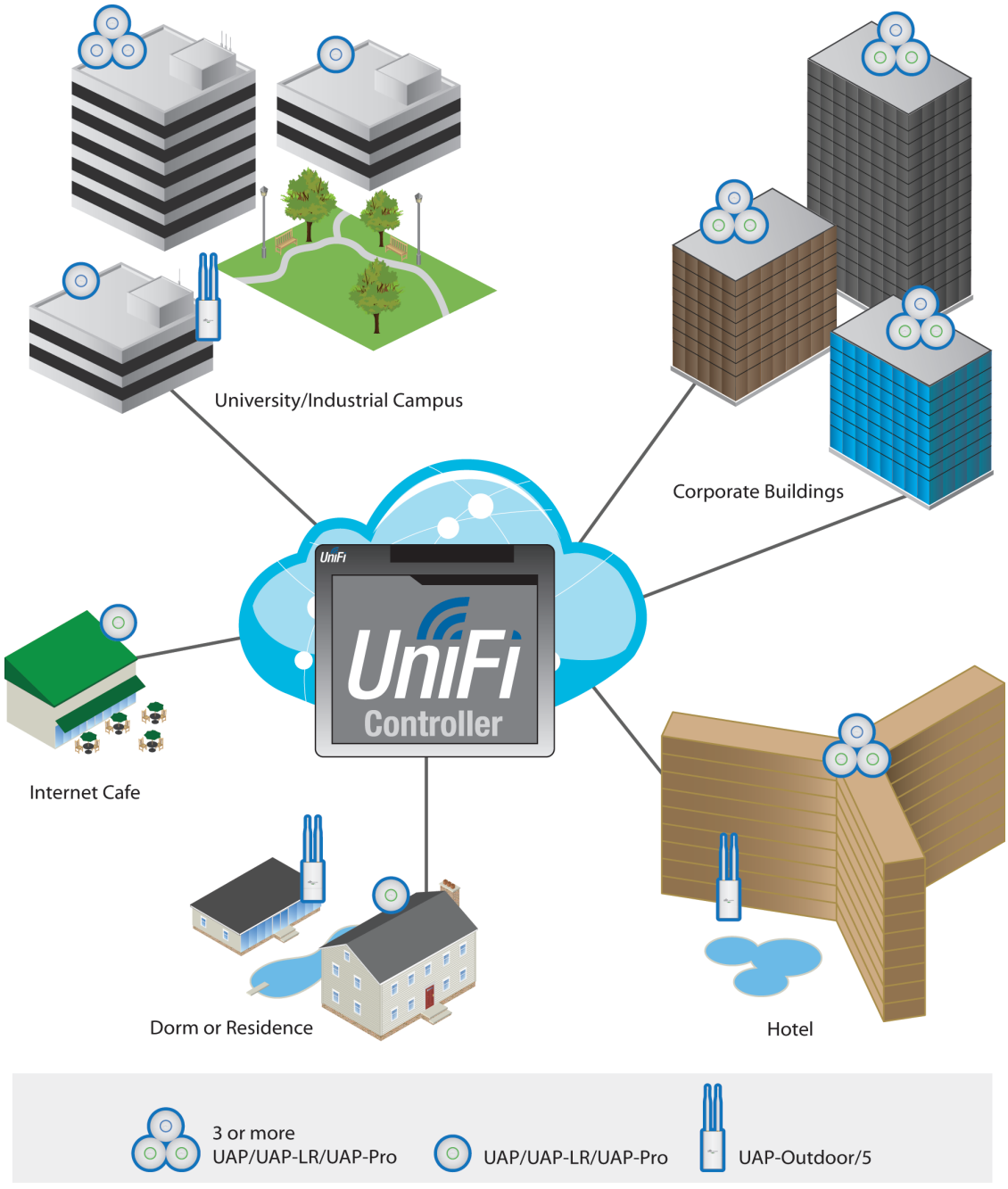
Access Points (APs)

Easily install, configure, and manage all access points from one location.

Extend Your Coverage

With the UniFi Controller software running in a NOC or in the cloud, administrators can extend and centrally manage wide areas of indoor and outdoor coverage using any combination of UniFi AP devices.

Below are some examples of how UniFi APs can be deployed.



Extend Wirelessly Take advantage of wireless downlinking. One wired UniFi AP uplink supports 4 wireless downlinks, allowing wireless adoption of devices in their default state and real-time changes to network topology.

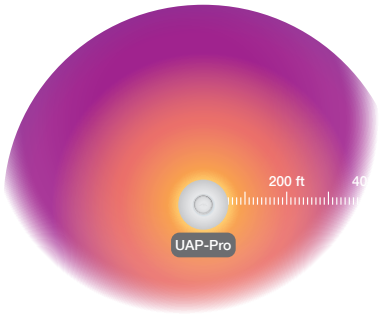
Manage Hotspots and Control Billing Use Hotspot Manager to customize portal login pages and bill customers using major credit cards via PayPal™. Or, use Hotspot Manager to set up a voucher-based authentication system for voucher creation, user administration, guest management, and payment refunds.

Specifications (UAP-Pro)

UniFi AP Pro	
Dimensions	20 x 20 x 3.65 cm
Weight	298 g (358 g with Mounting Kits)
Networking Interface	(2) 10/100/1000 Ethernet Ports
Buttons	Reset
Wi-Fi Standards	802.11 a/b/g/n
Power Method	Passive Power over Ethernet (48V), 802.3af Supported
Power Supply	48V, 0.5A PoE Adapter (Included)
Maximum Power Consumption	12 W
BSSID	Up to Four Per Radio
Power Save	Supported
Wireless Security	WEP, WPA-PSK, WPA-TKIP, WPA2 AES, 802.11i
Certifications	CE, FCC, IC
Mounting	Wall/Ceiling (Kits Included)
Operating Temperature	-10 to 70°C (14 to 158° F)
Operating Humidity	5 - 80% Condensing
Antennas	
2.4 GHz	3 Integrated (Supports 3x3 MIMO with Spatial Diversity)
5 GHz	2 Integrated (Supports 2x2 MIMO with Spatial Diversity)
Max. TX Power	
2.4 GHz	30 dBm
5 GHz	22 dBm

Advanced Traffic Management	
VLAN	802.1Q
Advanced QoS	Per-User Rate Limiting
Guest traffic isolation	Supported
WMM	Voice, Video, Best Effort, and Background
Concurrent Clients	200+

Supported Data Rates (Mbps)	
Standards	Data Rates
802.11a	6, 9, 12, 18, 24, 36, 48, 54 Mbps
802.11n (2.4 GHz 3x3)	6.5 Mbps to 450 Mbps (MCS0 - MCS23, HT 20/40)
802.11n (5 GHz 2x2)	6.5 Mbps to 300 Mbps (MCS0 - MCS15, HT 20/40)
802.11b	1, 2, 5.5, 11 Mbps
802.11g	6, 9, 12, 18, 24, 36, 48, 54 Mbps



Specifications (UAP-LR)

UniFi AP Long-Range	
Dimensions	20 x 20 x 3.65 cm
Weight	290 g (430 g with Mounting Kits)
Networking Interface	(1) 10/100 Ethernet Port
Buttons	Reset
Antennas	2 Integrated (Supports 2x2 MIMO with Spatial Diversity)
Wi-Fi Standards	802.11 b/g/n*
Power Method	Passive Power over Ethernet (12-24V)
Power Supply	24V, 0.5A PoE Adapter Included
Maximum Power Consumption	6 W
Max TX Power	27 dBm
BSSID	Up to Four Per Radio
Power Save	Supported
Wireless Security	WEP, WPA-PSK, WPA-TKIP, WPA2 AES, 802.11i
Certifications	CE, FCC, IC
Mounting	Wall/Ceiling (Kits Included)
Operating Temperature	-10 to 70°C (14 to 158° F)
Operating Humidity	5 - 80% Condensing

Advanced Traffic Management	
VLAN	802.1Q
Advanced QoS	Per-User Rate Limiting
Guest Traffic Isolation	Supported
WMM	Voice, Video, Best Effort, and Background
Concurrent Clients	100+

Supported Data Rates (Mbps)	
Standards	Data Rates
802.11n	6.5 Mbps to 300 Mbps (MCS0 - MCS15, HT 20/40)
802.11b	1, 2, 5.5, 11 Mbps
802.11g	6, 9, 12, 18, 24, 36, 48, 54 Mbps

* 2.4 GHz

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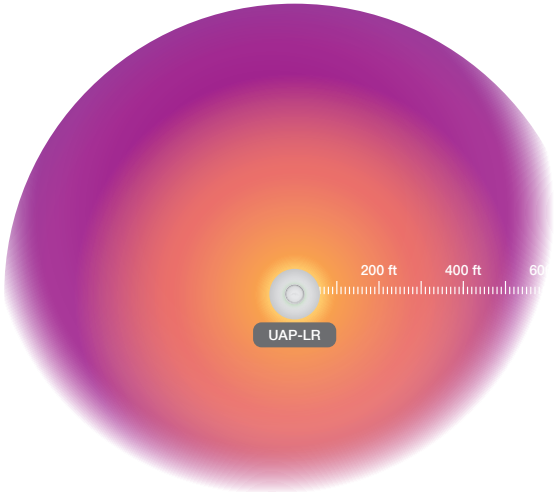

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Specifications (UAP)

UniFi AP	
Dimensions	20 x 20 x 3.65 cm
Weight	290 g (430 g with Mounting Kits)
Networking Interface	(1) 10/100 Ethernet Port
Buttons	Reset
Antennas	2 Integrated (Supports 2x2 MIMO with Spatial Diversity)
Wi-Fi Standards	802.11 b/g/n*
Power Method	Passive Power over Ethernet (12-24V)
Power Supply	24V, 0.5A PoE Adapter Included
Maximum Power Consumption	4 W
Max TX Power	20 dBm
BSSID	Up to Four Per Radio
Power Save	Supported
Wireless Security	WEP, WPA-PSK, WPA-TKIP, WPA2 AES, 802.11i
Certifications	CE, FCC, IC
Mounting	Wall/Ceiling (Kits Included)
Operating Temperature	-10 to 70°C (14 to 158° F)
Operating Humidity	5 - 80% Condensing

Advanced Traffic Management	
VLAN	802.1Q
Advanced QoS	Per-User Rate Limiting
Guest Traffic Isolation	Supported
WMM	Voice, Video, Best Effort, and Background
Concurrent Clients	100+

Supported Data Rates (Mbps)	
Standards	Data Rates
802.11n	6.5 Mbps to 300 Mbps (MCS0 - MCS15, HT 20/40)
802.11b	1, 2, 5.5, 11 Mbps
802.11g	6, 9, 12, 18, 24, 36, 48, 54 Mbps

* 2.4 GHz

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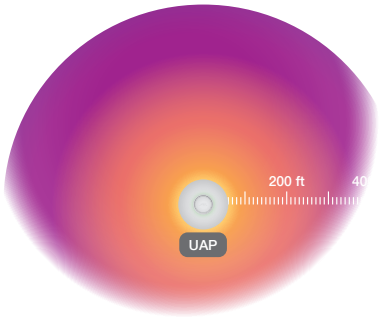

Specifications (UAP-Outdoor)

UniFi AP-Outdoor	
Dimensions	17 x 8 x 3 cm
Weight	230 g (without Antennas) 274 g (with Antennas)
Networking Interface	(2) 10/100 Ethernet Ports
Buttons	Reset
Antennas	(2) External 6 dBi Omni Antennas Included 191 mm (Length), 13mm (Diameter)
Wi-Fi Standards	802.11 b/g/n*
Power Method	Passive Power over Ethernet (12-24V)
Power Supply	24V, 1A PoE Adapter Included
Maximum Power Consumption	4.6 W
Max TX Power	27 dBm
BSSID	Up to Four Per Radio
Power Save	Supported
Wireless Security	WEP, WPA-PSK, WPA-TKIP, WPA2 AES, 802.11i
Certifications	CE, FCC, IC
Mounting	Wall/Ceiling (Kits Included)
Operating Temperature	-30 to 75°C (-22 to 167° F)
Operating Humidity	5 - 95% Condensing

Advanced Traffic Management	
VLAN	802.1Q
Advanced QoS	Per-User Rate Limiting
Guest Traffic Isolation	Supported
WMM	Voice, Video, Best Effort, and Background
Concurrent Clients	100+

Supported Data Rates (Mbps)	
Standards	Data Rates
802.11n	6.5 Mbps to 300 Mbps (MCS0 - MCS15, HT 20/40)
802.11b	1, 2, 5.5, 11 Mbps
802.11g	6, 9, 12, 18, 24, 36, 48, 54 Mbps

* 2.4 GHz

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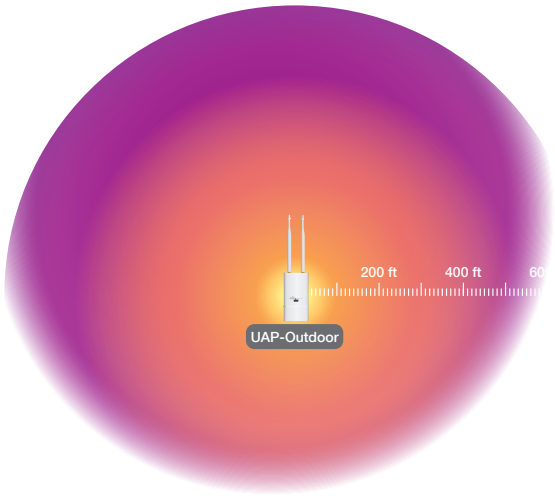

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Specifications (UAP-Outdoor5)

UniFi AP-Outdoor 5G (UAP-Outdoor 5)	
Dimensions	17 x 8 x 3 cm
Weight	230 g (without Antennas) 274 g (with Antennas)
Networking Interface	(2) 10/100 Ethernet Ports
Buttons	Reset
Antennas	(2) External 6 dBi Omni Antennas Included 191 mm (Length), 13 mm (Diameter)
Wi-Fi Standards	802.11a/n*
Power Method	Passive Power over Ethernet (12-24V)
Power Supply	24V, 1A PoE Adapter Included
Max. Power Consumption	6.5 W
Max. TX Power	27 dBm
BSSID	Up to Four Per Radio
Power Save	Supported
Wireless Security	WEP, WPA-PSK, WPA-TKIP, WPA2 AES, 802.11i
Certifications	CE, FCC, IC
Mounting	Wall and Pole (Kits Included)
Operating Temperature	-30 to 75°C (-22 to 167° F)
Operating Humidity	5 to 95% Condensing

Advanced Traffic Management	
VLAN	802.1Q
Advanced QoS	Per-User Rate Limiting
Guest Traffic Isolation	Supported
WMM	Voice, Video, Best Effort, and Background
Concurrent Clients	100+

Supported Data Rates (Mbps)	
Standards	Data Rates
802.11a	6, 9, 12, 18, 24, 36, 48, 54 Mbps
802.11n	6.5 Mbps to 300 Mbps (MCS0 - MCS15, HT 20/40)

* 5 GHz

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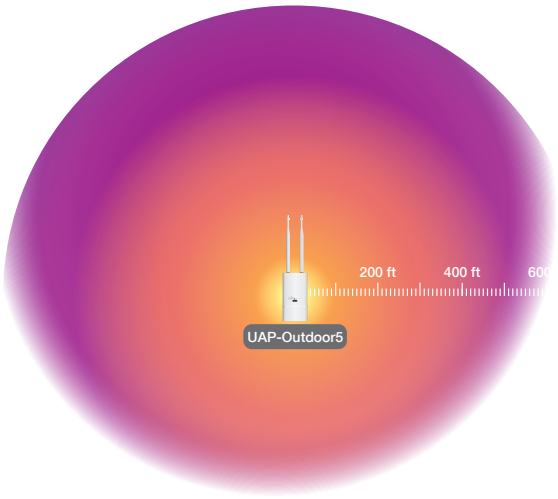

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TOUGHCable™

OUTDOOR CARRIER CLASS SHIELDED

Protect your networks from the most brutal environments with Ubiquiti's industrial-grade shielded Ethernet cable, TOUGHCable.

Increase Performance
Dramatically improve your Ethernet link states, speeds, and overall performance with Ubiquiti TOUGHCables.

Extreme Weatherproof
Designed for outdoor use, TOUGHCables have been built to perform even in the harshest weather and environments.

ESD Damage Protection
Protect your networks from devastating electrostatic discharge (ESD) attacks.

Extended Cable Support
TOUGHCables have been developed to increase power handling performance for extended cable run lengths.

TOUGHCable Connectors

Specifically designed for use with Ubiquiti TOUGHCables and available in 100-pc. bags, TOUGHCable Connectors protect against ESD attacks and Ethernet hardware damage while allowing rapid field deployment without soldering.

Bulletproof your networks

TOUGHCable is currently available in two versions: PRO Shielding Protection and CARRIER Shielding Protection.

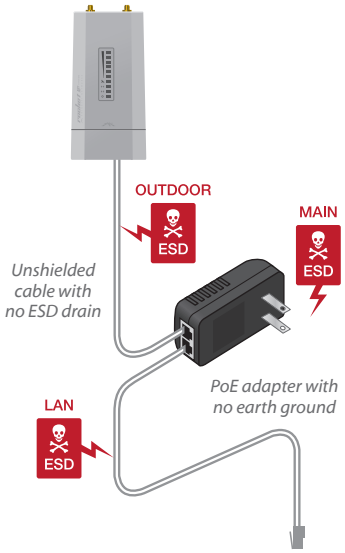
TOUGHCable PRO is a Category 5e, outdoor, carrier-class shielded cable with an integrated ESD drain wire.

TOUGHCable CARRIER is a Category 5e, outdoor, carrier-class shielded cable that features an integrated ESD drain wire, anti-crosstalk divider, and secondary shielding. It is rated to provide optimal performance on Gigabit Ethernet networks.

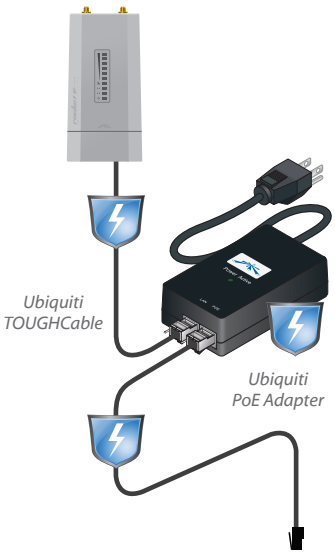
Additional Information:

- 24 AWG copper conductor pairs
- 26 AWG integrated ESD drain wire to prevent ESD attacks and damage
- PE outdoor-rated, weatherproof jacket
- Multi-layered shielding
- Available in lengths of 1000 ft (304.8 m)

ESD attacks are the leading cause for device failures. The diagram below illustrates the areas vulnerable to ESD attacks in a network.



By using a grounded Ubiquiti Power over Ethernet (PoE) Adapter along with Ubiquiti TOUGHCable and TOUGHCable Connectors, you can effectively protect against ESD attacks.



TERMS OF USE: Ubiquiti radio devices must be professionally installed. Shielded Ethernet cable and earth grounding must be used as conditions of product warranty. TOUGHCable is designed for outdoor installations. It is the installer's responsibility to follow local country regulations, including operation within legal frequency channels, output power, indoor cabling requirements, and Dynamic Frequency Selection (DFS) requirements.

For further information, please visit www.ubnt.com.

All specifications in this document are subject to change without notice.

UBIQUITI NETWORKS

www.ubnt.com

PHRRJL042312

D.5. Router Cisco 3925/K9

Cisco 3900 Series Integrated Services Routers

Cisco® 3900 Series Integrated Services Routers build on 25 years of Cisco innovation and product leadership. The new Cisco Integrated Services Routers Generation 2 (ISR G2) platforms are architected to enable the next phase of branch-office evolution, providing rich-media collaboration and virtualization to the branch office while maximizing operational cost savings. The new routers support new high-capacity digital signal processors (DSPs) for future enhanced video capabilities, high-powered service modules with improved availability, multicore CPUs, Gigabit Ethernet switching with Cisco Enhanced Power over Ethernet (ePoE), and new energy visibility and control capabilities while enhancing overall system performance. Additionally, a new Cisco IOS® Software Universal image and Cisco Services Ready Engine (SRE) module enable you to decouple the deployment of hardware and software, providing a flexible technology foundation that can quickly adapt to evolving network requirements. Overall, the Cisco 3900 Series offers exceptional total cost of ownership (TCO) savings and network agility through the intelligent integration of market-leading security, unified communications, wireless, and application services.

Figure 1. Cisco 3900 Series Integrated Services Routers

Product Overview

The Cisco 3900 Series builds on the best-in-class offering of the existing Cisco 3800 Series Integrated Services Routers by now offering four platforms (Figure 1): the Cisco 3945E, Cisco 3925E, Cisco 3945, and Cisco 3925 Integrated Services Routers.

The Cisco 3900 Series offers embedded hardware encryption acceleration, voice- and video-capable DSP slots, optional firewall, intrusion prevention, call processing, voicemail, and application services. In addition, the platforms support the industry's widest range of wired and wireless connectivity options such as T1/E1, T3/E3, xDSL, copper, and fiber Gigabit Ethernet.

The Cisco 3900 Series offers superior performance and flexibility for flexible network deployments from small business offices to large enterprise offices - all while providing industry-leading investment protection.

Key Business Benefits

The Cisco® ISR G2 routers provide superior services integration and agility. Designed for scalability, the modular architecture of these platforms enables you to evolve and adapt with your growing business needs. Table 1 lists the business benefits of the Cisco 3900 Series.

Table 1. Cisco 3900 Series Business Benefits

Benefits	Description
Services integration	• The Cisco 3900 Series routers offer increased levels of services integration with voice, video, security, mobility, and data services. • The Cisco 3900 Series provides the highest performance and slot densities among the routers in the Cisco ISR G2 portfolio, enabling you to maximize services integration and reducing overall capital expenditures (CapEx) and operating expenses (OpEx).
Services on demand	• A single Cisco IOS Software Universal image is installed on each Cisco ISR G2. The Universal image contains all of the Cisco IOS Software technology sets, which you can activate with a software license. With the Universal image your business can quickly deploy advanced features without downloading a new Cisco IOS Software image. Additionally, larger default memory is included to support the new capabilities. • The Cisco SRE enables a new operational model that allows you to reduce CapEx and deploy a variety of application services as needed on a single integrated compute services module.
High performance with integrated services	• The Cisco 3900 Series enables deployment in high-speed WAN environments with concurrent services enabled up to 350 Mbps. • A multigigabit fabric (MGF) enables high-bandwidth module-to-module communication without compromising router performance.
Network agility	• Designed to address customer business requirements, the Cisco 3900 Series with the modular architecture offers increased capacity and performance as your network needs grow. • The Cisco Services Performance Engine (SPE) modular motherboard enables upgrades to processing capability in the future. • Dual integrated power supplies provide power redundancy; you can also configure them to provide additional Cisco ePoE power to endpoints. • Modular interfaces offer increased bandwidth, a diversity of connection options, and network resiliency.
Energy efficiency	• The Cisco 3900 Series architecture provides energy-savings features that include the following: ◦ The Cisco 3900 Series offers intelligent power management and allows you to control power to the modules based on the time of day. Cisco EnergyWise technology will be supported in the future. ◦ Services integration and modularity on a single platform allows you to perform multiple functions, optimizing consumption of raw materials and energy usage. ◦ Platform flexibility and ongoing development of both hardware and software capabilities lead to a longer product lifecycle, lowering all aspects of the TCO - including materials and energy use. ◦ High-efficiency power supplies and scalable power consumption are based on your network needs.
Investment protection	• The Cisco 3900 Series maximizes investment protection by supporting: ◦ Reuse of a broad array of existing modules supported on the original Cisco Integrated Services Routers to provide a lower TCO. ◦ A rich set of Cisco IOS Software features carried forward from the original Cisco Integrated Services Routers and delivered in a single universal image. • The Cisco 3900 Series offers extensive growth possibilities as your network expands: ◦ The SPE modular motherboard enables flexibility for future upgrades. ◦ The highest scale for module density provides flexibility to add services as your business needs expand. ◦ A 1-Gb default memory provides headroom to minimize field upgrades.

Platform Architecture and Modularity

The Cisco 3900 Series is architected to meet the application demands of today's branch offices with design flexibility for future applications. The modular architecture is designed to support increasing bandwidth requirements, time-division multiplexing (TDM) interconnections, and fully integrated power distribution to modules supporting 802.3af PoE and Cisco ePoE. Table 2 lists the architectural features and benefits of the Cisco 3900 Series.

Table 2. Architectural Features and Benefits of Cisco 3900 Series

Architectural Features	Benefits
Modular platform	• The Cisco 3900 Series routers are highly modular platforms with several types of module slots to add connectivity and services for varied branch-office network requirements. • The routers offer an industry-leading breadth of LAN and WAN connectivity options through modules to accommodate field upgrades to future technologies without requiring platform replacement. • The Cisco SPE on the Cisco 3900 offers the ability to increase the performance of the router with a field-upgradable motherboard as your network needs grow.
Processors	• The Cisco 3900 Series routers are powered by high-performance multicore processors that can support the growing demands of high-speed WAN connections to the branch office while also running multiple concurrent services.
Embedded IP Security with Secure Sockets Layer (IPSec/SSL) VPN hardware acceleration	• Embedded hardware encryption acceleration is enhanced to provide higher scalability, which, combined with an optional Cisco IOS Software Security license, enables WAN link security and VPN services (both IPSec and SSL acceleration). • The onboard encryption hardware outperforms the advanced integration modules (AIMs) of previous generations.
Multigigabit fabric (MGF)	• The Cisco 3900 Series introduces an innovative MGF that allows for efficient module-to-module communication, enabling tighter services interactions across modules while reducing the overhead on the router processor.
TDM interconnectivity fabric	• Unified communications services in the branch office are significantly enhanced with the use of TDM interconnectivity fabric in the router architecture, allowing for scaling of DS-0 channel capacity.
Integrated Gigabit Ethernet ports	• The Cisco 3900 Series provides up to four 10/100/1000 Ethernet WAN ports. • Two of the 10/100/1000 Ethernet WAN ports on the Cisco 3900 Series can support Small Form-Factor Pluggable (SFP)-based connectivity in lieu of RJ-45 ports, enabling fiber connectivity.
Innovative universal-serial-bus (USB)-based console access	• A new, innovative, mini-B USB console port supports management connectivity when traditional serial ports are not available. • Traditional console and auxiliary ports are also available.
Optional integrated power supply for distribution of PoE and universal DC power supply	• An optional upgrade to the internal power supply provides inline power (802.3af-compliant PoE, Cisco ePoE, and Cisco Inline Power) to optional integrated switch modules. • An optional DC power supply that extends possible deployment environments such as central offices and industrial environments will be available in the future.
Optional integrated redundant power supply (RPS) and PoE boost	• Power redundancy is available by installing an optional integrated RPS, thereby decreasing network downtime and protecting the network from power-supply failures. • When populated with dual integrated power supplies, the Cisco 3900 Series can operate in a configurable PoE boost mode in lieu of redundant power mode whereby the power capacity of the platform is increased to almost twice the normal power to support additional PoE ports.
Designed for flexible deployments	• The Cisco 3945 and 3925 are designed for Network Equipment Building Systems (NEBS) environments.

Modularity Features and Benefits

The Cisco 3900 Series provides significantly enhanced modular capabilities (refer to Table 3) while maintaining investment protection for customers. Most of the modules available on previous generations of Cisco routers, such as the Cisco 3800 Series Integrated Services Routers, are supported on the Cisco 3900 Series. Additionally, modules used on the Cisco 3900 Series can easily be supported on other routers in the Cisco Integrated Services Router portfolio to provide maximum investment protection. Taking advantage of common interface cards across a network greatly reduces the complexity of managing inventory requirements, implementing large network rollouts, and maintaining configurations across a variety of branch-office sizes.

A complete list of supported modules, including a list of supported SFPs for the Cisco 3900 Series, is available at: http://www.cisco.com/en/US/products/ps10536/products_relevant_interfaces_and_modules.html.

Table 3. Modularity Features and Benefits

Architectural Features	Benefits
Cisco Services Performance Engine (SPE) 	• The Cisco 3900 Series offers field-replaceable SPEs. • These SPEs allow you to protect your initial investment in the Cisco 3900 platform for a longer time period and scale router performance as your network and branch-office needs grow.
Cisco Services Module 	• A service-module slot replaces the network module and the extension module for voice and fax (EVM) slots and is offered on Cisco 3900 Integrated Services Routers. • Each service-module slot offers high data-throughput capability: ◦ Up to 4-Gbps aggregate toward the router processor. ◦ Up to 2-Gbps aggregate to other module slots over the MGF. • Service-module slots are highly flexible, with support for doublewide service modules, which are service modules that require two service-module slots. Doublewide service modules provide flexibility for higher-density modules. • Service-module slots provide twice the power capabilities relative to the network-module slots, allowing flexibility for higher-scale and better-performance modules. • An adapter module enables backward compatibility with existing network modules, enhanced network modules (NMEs), and EVMs. • You can manage power to service-module slots by extensions similar to the Cisco EnergyWise framework, so your organization can reduce energy consumption in your network infrastructure. Full Cisco EnergyWise support will be available in future software releases.
Cisco Enhanced High Speed WAN Interface Card (EHWIC) 	• The EHWIC slot replaces the high-speed WAN interface card (HWIC) slot and can natively support HWICs, WAN interface cards (WICs), voice interface cards (VICs), and voice/WAN interface cards (VWICs). • Three integrated EHWIC slots on the Cisco 3945E and Cisco 3925E or four integrated EHWIC slots on the Cisco 3945 and Cisco 3925 allow for flexible configurations. • Each HWIC slot offers high-data-throughput capability: ◦ Up to 1.6-Gbps aggregate toward the router processor. ◦ Up to 2-Gbps aggregate to other module slots over the MGF. • Flexibility to support doublewide modules is enabled by combining two EHWIC slots. Up to 2 doublewide HWIC (HWIC-D) modules are supported.
Cisco Internal Services Module (ISM) 	• A single ISM slot provides flexibility to integrate intelligent services modules that do not require interface connections in the Cisco 3945 and Cisco 3925. • Each ISM slot offers high-data-throughput capability: ◦ Up to 4-Gbps aggregate toward the route processor. ◦ Up to 2-Gbps aggregate to other module slots over the MGF. • The ISM replaces the AIM slot; existing AIM modules are not supported in the ISM slot. • You can manage power to ISM slots by extensions similar to the Cisco EnergyWise framework, so your organization can reduce energy consumption in your network infrastructure. Full Cisco EnergyWise support will be available in future software releases.
Cisco High-Density Packet Voice Digital Signal Processor (DSP) Module (PVDM3) Slots on Motherboard 	• PVDM3 slots natively support PVDM3 modules, providing support for richer density for rich-media voice and video. • Each PVDM3 slot connects back to the system architecture through a 2-Gbps aggregate link through the MGF. • Investment protection for PVDM2 modules is supported through an adapter module. • You can manage power to the PVDM slots by extensions similar to the Cisco EnergyWise framework, so your organization can reduce energy consumption in your network infrastructure. Full Cisco EnergyWise support will be available in future software releases.
Compact Flash Slots	• Two external Compact Flash slots are available on the Cisco 3900 Series Integrated Services Routers. Each slot can support high-speed storage densities upgradable to 4 GB in density.
USB 2.0 Ports	• Two high-speed USB 2.0 ports are supported; they provide secure token capabilities and storage.

Cisco IOS Software

Cisco 3900 Series Integrated Services Routers deliver innovative technologies running on industry-leading Cisco IOS Software. Developed for wide deployment in the world's most demanding enterprise, access, and service provider networks, Cisco IOS Software Releases 15M and T support a comprehensive portfolio of Cisco technologies, including the functions and features delivered in Releases 12.4 and 12.4T. New innovations in Release 15.0(1)M span multiple technology areas, including security, voice, high availability, IP Routing and Multicast, quality of service (QoS), IP Mobility, Multiprotocol Label Switching (MPLS), VPNs, and embedded management. Available immediately for the Cisco 3900 Integrated Services Routers, Release 15.0(1)M will be an extended support release. For more information about Release 15.0(1)M, please visit http://www.cisco.com/go/ios.

Cisco IOS Software Licensing and Packaging

A single Cisco IOS Universal image encompassing all functions is delivered with the platforms. You can enable advanced features by activating a software license on the Universal image. In previous generations of access routers, these feature sets required you to download a new software image. Technology packages and feature licenses, enabled through the Cisco software licensing infrastructure, simplify software delivery and decrease the operational costs of deploying new features.

Four major technology licenses are available on the Cisco 3900 Series Integrated Services Routers; you can activate the licenses through the Cisco software activation process identified at http://www.cisco.com/go/sa. The following licenses are available:

- IP Base: This technology package is available as default.
- Data
- Unified Communications
- Security (SEC) or Security with No Payload Encryption (SEC-NPE)

For additional information and details about Cisco IOS Software licensing and packaging on Cisco 3900 Series Integrated Services Routers, please visit http://www.cisco.com/go/g2licensing.

Key Branch-Office Services

The industry-leading Cisco Integrated Services Routers offer unprecedented levels of services integration. Designed to meet the requirements of the branch office, these platforms provide a complete solution with voice, video, security, mobility, and application services. Businesses enjoy the benefits by deploying a single device that meets all their needs, reducing CapEx and OpEx.

Unified Communications, Collaboration, and Voice-Gateway Services

The Cisco 3900 Integrated Services Router is the foundation for collaboration in branch offices of any size and is a critical component of Cisco's video architecture (Medianet) and enterprise Unified Communications solution. With embedded voice services and a wide range of telephony interfaces supported, the Cisco 3900 Series delivers maximum deployment flexibility for the distributed enterprise. Unified communications is enabled through a rich signaling and media-processing infrastructure, including a variety of protocols, media interworking, signal and media security, transcoding, conferencing, and QoS. Cisco Integrated Services Routers feature a wide range of voice-gateway interfaces, supporting a broad array of signaling and physical network interfaces. The performance improvements introduced with the Cisco 3900 Series help ensure that branch-office employees benefit from the

same productivity advantages and wide breadth of services and applications as those enjoyed by the headquarters-based employees.

The Cisco 3900 Series enables a full range of existing and emerging video services, with scaling improvement to support Cisco TelePresence® conferencing, security, and session control. Cisco Unified Border Element extends these capabilities for business-to-business TelePresence communications.

The Cisco 3900 Series adds support for the new Cisco High-Density Packet Voice Digital Signal Processor Module (PVDM3), which has been optimized for concurrent voice and video support. The PVDM3 modules support all voice-gateway functions of earlier generations of PVDMs, and add higher density and more processing power to support emerging rich-media applications. The Cisco 3900 Series can support up to 4 onboard PVDM3 slots, able to scale up to 768 G.729a channels.

Cisco Unified Communications Manager Express and Survivable Remote Site Telephony

The Cisco Integrated Services Routers inherently provide optional unified communications services within the Cisco IOS Software, delivering the advantage of server hardware reduction and lower energy costs at the branch office. Cisco Unified Communications Manager Express (CME) provides the broad range of IP private-branch-exchange (PBX) and key-system features integrated into the router for branch offices. Cisco Survivable Remote Site Telephony (SRST), also inherently available in Cisco IOS Software and an option on the Cisco 3900 Series, helps ensure that branch-office employees have uninterrupted telephony services and features, even if the connection to a centralized Cisco Unified Communications Manager is disrupted. Coupled with Cisco Unity® Express, the integrated solution for voicemail, Automated Attendant, and interactive voice response (IVR), the Cisco 3900 Series offers the branch office a complete range of unified communications services while delivering industry-leading security within a single platform.

Cisco Unified Border Element

The Cisco Unified Border Element capabilities supported on the Cisco 3900 address the emerging requirements in an IP-centric interconnect for branch-office unified communications between enterprises and service provider networks. Cisco Unified Border Element provides intelligent border-element functions such as physical and logical ingress and egress demarcation points, signaling and media control, and consolidated security and management features. The Cisco 3900 Series supports higher scale than previously provided on the Cisco 3800 Series, with up to 2.5 times the number of sessions.

VoiceXML Application Services

The Cisco 3900 Series inherently provides standards-certified VoiceXML browser services. VoiceXML is an open-standard markup language used to create voice-enabled web browsers and IVR applications. Just as HTML enables you to retrieve data with a PC, VoiceXML enables you to retrieve data using voice or dual-tone-multifrequency (DTMF) telephony input. The Cisco 3900 Series can deliver a much higher range of concurrent voice-gateway services combined with VoiceXML browser services, for more than 300 sessions on the Cisco 3945.

Integrated Network Security for Data, Voice, Video, and Mobility

Security is essential to protect a business' intellectual property while also ensuring business continuity and providing the ability to extend the corporate workplace to employees who need anytime, anywhere access to company resources. As part of the Cisco Self-Defending Network (SDN) - an architectural framework that allows organizations to identify, prevent, and adapt to network security threats - the Cisco 3900 Series Integrated Services Routers facilitate secure data transactions and secure collaboration.

The Cisco IOS Software Security technology package for the Cisco 3900 Series offers a wide array of common security features such as advanced application inspection and control, threat protection, and encryption architectures for enabling more scalable and manageable VPN networks. The Cisco 3900 Series offers onboard hardware-based encryption acceleration to provide greater IPSec throughput with less overhead for the route processor when compared with software-based encryption solutions. Cisco Integrated Services Routers offer a comprehensive and adaptable security solution for branch offices that includes features such as:

- **Secure connectivity:** Secure collaborative communications with Group Encrypted Transport VPN, Dynamic Multipoint VPN (DMVPN), or Enhanced Easy VPN
- **Integrated threat control:** Responding to sophisticated network attacks and threats using Cisco IOS Firewall, Cisco IOS Zone-Based Firewall, Cisco IOS IPS, Cisco IOS Content Filtering, and Flexible Packet Matching (FPM)
- **Identity management:** Intelligently protecting endpoints using technologies such as authentication, authorization, and accounting (AAA) and public key infrastructure (PKI)

Detailed information about the security features and solutions supported on the Cisco 3900 Series is available at http://www.cisco.com/go/routersecurity.

Wireless and Mobility Services

Wireless LAN

The Cisco Integrated Services Routers supporting the Cisco Unified Wireless Architecture enable deployment of secure, manageable wireless LANs (WLANs) optimized for remote sites and branch offices, including fast, secure mobility; survivable authentication; and simplified management. The Cisco Wireless LAN Controller Module on the Cisco 3900 Series routers allows small and medium-sized businesses and enterprise branch offices to cost-effectively deploy and manage secure WLANs. Cisco Wireless LAN Controllers work in conjunction with Cisco lightweight access points and the Cisco Wireless Control System (WCS) to provide systemwide WLAN functions, managing up to 6, 12, and 25 access points. As components of the Cisco Unified Wireless Architecture, Cisco Wireless LAN Controllers present network administrators with the visibility and control necessary to effectively and securely manage business-class WLANs and mobility services such as enhanced security, voice, guest access, and location services.

Wireless WAN

Cisco third-generation (3G) wireless WAN (WWAN) modules combine traditional enterprise router functions such as remote management, advanced IP services such as voice over IP (VoIP), and security with mobility capabilities of 3G WAN access. Using high-speed 3G wireless networks, routers can replace or complement existing landline infrastructure, such as dialup, Frame Relay, and ISDN. Cisco 3G solutions support 3G standards High-Speed Packet Access (HSPA) and Evolution Data Only/Evolution Data Optimized (EVDO), offering you a true multipath WAN backup and the ability to rapidly deploy primary WAN connectivity. For more information about 3G solutions on Cisco Integrated Services Routers, please visit http://www.cisco.com/go/3g.

Integrated LAN Switching

The Cisco 3900 Integrated Services Routers support the new Cisco Enhanced EtherSwitch® Service Modules, which greatly expand router capabilities by integrating industry-leading Layer 2 or Layer 3 switching with feature sets identical to those found in the Cisco Catalyst® 3560-E and Catalyst 2960 Series Switches performing local line-rate switching and routing.

The new Cisco Enhanced EtherSwitch Service Modules take advantage of the increased power capabilities on the Cisco 3900 Series platforms. Additionally, the modules enable Cisco energy and power initiatives: Cisco EnergyWise, Cisco ePoE and per-port PoE power monitoring, and integrated redundant power system (RPS)-enabled PoE boost. These technologies allow you to meet increased endpoint power requirements without increasing the total power consumption of the branch office.

Application Services

As organizations continue to centralize and consolidate their branch-office IT infrastructure in an effort to reduce cost and complexity, they are challenged to provide adequate user experience, ensure continuous service availability, and deliver business-relevant applications when and where they are needed. To address these challenges, the Cisco 3900 Series enables you to host Cisco, third-party, and custom applications on a portfolio of high-performance Cisco SRE modules that transparently integrate into the router. The modules have their own processors, hard disks, network interfaces, and memory that operate independently of the host router resources, helping to ensure maximum concurrent routing and application performance while reducing physical space requirements, lowering power consumption, and consolidating management.

Application Acceleration

The Cisco 3900 Series transparently combines industry-leading security, Cisco IOS Software-based traffic control, and visibility with Cisco application-acceleration solutions. Cisco IOS Software features such as Network-Based Application Recognition (NBAR), IP service-level agreement (IP SLA), and NetFlow provide visibility and monitoring of traffic patterns and application performance while Cisco IOS Software features such as QoS, access control lists (ACLs), and Performance Routing intelligently control the traffic to maximize the quality of the user experience and employee productivity. You can further enhance user experience by adding a Cisco Wide Area Application Services (WAAS) Network Module to securely provide more advanced WAN optimization techniques such as TCP optimization, caching, compression, and application acceleration. Cisco Integrated Services Routers combined with Cisco WAAS Network Modules provide optimal performance for applications delivered from a central data center to branch-office users. The solution allows you to consolidate costly server, storage, and backup infrastructure into data centers while maintaining LAN-like service levels for remote users.

Cisco Services Ready Engine

The Cisco Services Ready Engine solution is available in service-module (SM) and ISM form factors. The service-module hardware offers up to a seven-times performance improvement over the previous-generation network modules and provides a multicore x86 processor. The SRE modules also support up to 1 terabyte of storage, Redundant Array of Independent Disks (RAID) configurations, hardware-assisted virtualization, and cryptography options. The Cisco SRE module enables on-demand provisioning of branch-office applications on the Cisco 3900 Series platforms so that you can deploy the right application, at the right time, in the right place. The hardware and software decoupling provided by the service-ready deployment model enables you to provision applications on the module at the time of its installation, or remotely anytime thereafter. Supported solutions include Cisco WAAS, Cisco Unity Express, Cisco Application Extension Platform (AXP), Cisco Wireless LAN Controller (WLC), Cisco Video Surveillance, and other applications under development. The SRE enables organizations of various sizes to quickly deploy new branch-office applications without deploying new hardware, reducing the cost of rolling out branch-office services and helping ensure that the network applications will be compatible with future versions.

WAAS Express

Organizations today face several unique wide area network (WAN) challenges: the need to provide employees with constant access to centrally located information, the requirement to continuously back up and replicate mission-critical data to centrally managed data centers, the desire to provide satisfactory experience for IP phone and video communication, and the mandate to control bandwidth costs without sacrificing application availability and performance.

Cisco WAAS Express is designed to help organizations address these challenges. Cisco WAAS Express extends the Cisco WAAS product portfolio, with a small-footprint, cost-effective IOS-based software solution integrated into the ISR G2 to offer bandwidth optimization and application acceleration capabilities. Cisco WAAS Express increases remote user productivity, reduces WAN bandwidth costs, and offers investment protection by interoperating with existing Cisco WAAS infrastructure. Cisco WAAS Express is unique in providing network transparency, improving deployment flexibility with on-demand service enablement, and integrating with native IOS-based services such as security, Netflow, and QoS.

Cisco WAAS Express is fully interoperable with WAAS on SM-SRE modules, WAAS appliances and can be managed by a common WAAS Central Manager.

Cisco WAAS Express is available in IOS from version 15.1(2)T1.

Further information on Cisco WAAS Express can be found at http://wwwin.cisco.com/artg/products/waas/.

Medianet for 3900 ISRs

As video becomes pervasive in an organization and more video devices are used, new demands are placed on the network. It can be challenging to accommodate video needs while reducing complexity, planning for capacity, and providing the best possible user experience.

Smarter Network, Endpoints, and Services

Traditional IP networks need to evolve to medianets to accommodate these changes. A medianet is an end-to-end IP architecture that helps to enable pervasive media experiences.

The medianet architecture includes a smarter network, smarter endpoints, shared media services, cloud services, and shared media services.

More Medianet Benefits

A medianet reduces total cost of ownership and scales video through features such as auto-configuration and media monitoring. At the same time, it helps to ensure a quality user experience while optimizing bandwidth use and efficiency.

For more information on Medianet for 3900 ISR, please go to http://www.cisco.com/en/US/netsol/ns1094/index.html.

Managing Your Integrated Services Routers

Network management applications are instrumental in lowering OpEx while improving network availability by simplifying and automating many of the day-to-day tasks associated with managing an end-to-end network. “Day-one device support” provides immediate manageability support for the integrated services router, enabling quick and easy deployment, monitoring, and troubleshooting from Cisco and third-party applications.

Organizations rely on Cisco, third-party, and in-house developed network management applications to achieve their OpEx and productivity goals. Underpinning those applications are the embedded management features available in every integrated services router. The new integrated services routers continue a tradition of broad and deep manageability features within the devices. Features such as IP SLA, Cisco IOS Embedded Event Manager (EEM), and NetFlow allow you to know the status of your network at all times. These features, along with Simple Network Management Protocol (SNMP) and syslog support, enable your organization's management applications.

Refer to Tables 4, 5, and 6 for details about Cisco IOS Software, network management, and manageability support on Cisco 3900 Series Integrated Services Routers.

Table 4. Cisco 3900 with Cisco IOS Software Feature and Protocol High-Level Support

Protocols	• IPv4, IPv6, static routes, Open Shortest Path First (OSPF), Enhanced IGRP (EIGRP), Border Gateway Protocol (BGP), BGP Router Reflector, Intermediate System-to-Intermediate System (IS-IS), Multicast Internet Group Management Protocol (IGMPv3), Protocol Independent Multicast sparse mode (PIM SM), PIM Source Specific Multicast (SSM), Distance Vector Multicast Routing Protocol (DVMRP), IPv4-to-IPv6 Multicast, MPLS, Layer 2 and Layer 3 VPN, IPSec, Layer 2 Tunneling Protocol Version 3 (L2TPv3), Bidirectional Forwarding Detection (BFD), IEEE802.1ag, and IEEE802.3ah.
Encapsulations	• Generic routing encapsulation (GRE), Ethernet, 802.1q VLAN, Point-to-Point Protocol (PPP), Multilink Point-to-Point Protocol (MLPPP), Frame Relay, Multilink Frame Relay (MLFR) (FR.15 and FR.16), High-Level Data Link Control (HDLC), Serial (RS-232, RS-449, X.21, V.35, and EIA-530), PPP over Ethernet (PPPoE), and ATM.
Traffic management	• QoS, Class-Based Weighted Fair Queuing (CBWFQ), Weighted Random Early Detection (WRED), Hierarchical QoS, Policy-Based Routing (PBR), Performance Routing, and NBAR.

For more details about Cisco IOS Software features, refer to http://www.cisco.com/go/fn.

Table 5. Embedded Management features available with Cisco IOS Software

Feature	Description of Feature Supported by Cisco Integrated Services Routers
WSMA	• The Web Services Management Agent (WSMA) defines a mechanism through which you can manage a network device, retrieve configuration data information, and upload and manipulate new configuration data. WSMA uses XML-based data encoding that is transported by the Simple Object Access Protocol (SOAP) for the configuration data and protocol messages.
EEM	• Cisco IOS Embedded Event Manager (EEM) is a distributed and customized approach to event detection and recovery offered directly in a Cisco IOS Software device. It offers the ability to monitor events and take informational, corrective, or any desired EEM action when the monitored events occur or when a threshold is reached.
IPSLA	• Cisco IOS IP Service-Level Agreements enable you to assure new business-critical IP applications as well as IP services that use data, voice, and video in an IP network.
SNMP, RMON, Syslog, NetFlow, TR-069	• Cisco 3900 Series Integrated Services Routers also support SNMP, Remote Monitoring (RMON), syslog, NetFlow, and TR-069, in addition to the embedded management features mentioned.

The Cisco network management applications listed in Table 6 are standalone products that you can purchase or download to manage your Cisco network devices. The applications are built specifically for the different operational phases; you can select the ones that best fit your needs.

Table 6. Network Management Solutions

Operational Phase	Application	Description
Device staging and configuration	Cisco Configuration Professional	• Cisco Configuration Professional is a GUI device-management tool for Cisco IOS Software-based access routers. This tool simplifies routing, firewall, IPS, VPN, unified communications, and WAN and LAN configuration through GUI-based easy-to-use wizards.
Networkwide deployment, configuration, monitoring, and troubleshooting	CiscoWorks LMS	• CiscoWorks LAN Management Solution (LMS) is a suite of integrated applications for simplifying day-to-day management of a Cisco end-to-end network, lowering OpEx while increasing network availability. CiscoWorks LMS offers network managers an easy-to-use web-based interface for configuring, administering, and troubleshooting the Cisco Integrated Services Routers, using new instrumentation such as Cisco IOS EEM. • In addition to supporting basic platform services of the integrated services router, CiscoWorks also provides added-value support for the Cisco SRE, enabling the management and distribution of software images to the SRE, thereby reducing the time and complexities associated with image management.

Operational Phase	Application	Description
Networkwide staging, configuration, and compliance	CiscoWorks NCM	• CiscoWorks Network Compliance Manager (NCM) tracks and regulates configuration and software changes throughout a multivendor network infrastructure. It provides superior visibility into network changes and can track compliance with a broad variety of regulatory, IT, corporate governance, and technology requirements.
Security staging, configuration, and monitoring	Cisco Security Manager	• Cisco Security Manager is a leading enterprise-class application for managing security. It delivers provisioning of firewall, VPN, and intrusion-prevention-system (IPS) services across Cisco routers, security appliances, and switch service modules. The suite also includes the Cisco Security Monitoring, Analysis and Response System (Cisco Security MARS) for monitoring and mitigation.
Voice and unified communications configuration and provisioning	Cisco Unified Provisioning Manager	• Cisco Unified Provisioning Manager provides a reliable and scalable web-based solution for managing a company's crucial next-generation communications services. It manages unified communications services in an integrated IP telephony, voicemail, and messaging environment.
Staging, deployment, and changes of licenses	Cisco License Manager	• Cisco License Manager, a secure client-server application, can help you easily manage Cisco IOS Software activation and licenses for a wide range of Cisco platforms running Cisco IOS Software as well as other operating systems.
Staging, deployment, and changes to configuration and image files	Cisco Configuration Engine	• Cisco Configuration Engine is a secure network management product that provides zero-touch image and configuration distribution through centralized, template-based management.

Summary

Businesses need more intelligent branch-office solutions as they strive to lower the TCO for running their network and increase their overall employee productivity with more centralized and collaborative network applications. The Cisco 3900 Series offers these solutions by providing enhanced performance and increased modular density to support multiple concurrent services. The Cisco 3900 Series is designed to consolidate the functions of many separate devices into a single system that you can manage remotely. Table 7 lists the specifications of the Cisco 3945E, 3925E, 3945, and 3925 Integrated Services Routers.

Table 7. Specifications of Cisco 3945E, 3925E, 3945, and 3925 Integrated Services Routers

Services and Slot Density	Cisco 3945E	Cisco 3925E	Cisco 3945	Cisco 3925
Embedded hardware-based cryptography acceleration (IPSec + Secure Sockets Layer [SSL])	Yes	Yes	Yes	Yes
Cisco Unified Communications Manager Express Sessions**	450	400	350	250
Cisco Unified SRST sessions	1500	1350	1200	730
Total onboard WAN or LAN 10/100/1000 ports	4	4	3	3
RJ-45-based ports	4	4	3	3
SFP-based ports	2	2	2	2
Service-module slots	4	2	4	2
Doublewide service-module slots	1	1	1	1
EHWIC slots	3	3	4	4
Doublewide EHWIC slots	1	1	2	2
ISM slots	0	0	1	1
Online insertion and removal (OIR)	Services modules	Services modules	Services modules	Services modules
Onboard DSP (PVDM) slots	3	3	4	4
Memory DDR2 ECC DRAM: Default	1 GB	1 GB	1 GB	1 GB
Memory DDR2 ECC DRAM: Maximum	2 GB	2 GB	2 GB***	2 GB***
Compact Flash (external): Default	Slot 0: 256 MB Slot 1: None	Slot 0: 256 MB Slot 1: None	Slot 0: 256 MB Slot 1: None	Slot 0: 256 MB Slot 1: None

Services and Slot Density	Cisco 3945E	Cisco 3925E	Cisco 3945	Cisco 3925
Compact Flash (external): Maximum	Slot 0: 4 GB Slot 1: 4 GB	Slot 0: 4 GB Slot 1: 4 GB	Slot 0: 4 GB Slot 1: 4 GB	Slot 0: 4 GB Slot 1: 4 GB
External USB 2.0 slots (Type A)	2	2	2	2
USB console port (Type B) (up to 115.2 kbps)	1	1	1	1
Serial console port (up to 115.2 kbps)	1	1	1	1
Serial auxiliary port (up to 115.2 kbps)	1	1	1	1
Power-supply options	Internal: AC, PoE, and DC*	Internal: AC, PoE, and DC*	Internal: AC, PoE, and DC*	Internal: AC, PoE, and DC*
Redundant power supply	Internal: AC, PoE, and DC*	Internal: AC, PoE, and DC*	Internal: AC, PoE, and DC*	Internal: AC, PoE, and DC*
Power Specifications				
AC input voltage	100 to 240 VAC autoranging	100 to 240 VAC autoranging	100 to 240 VAC autoranging	100 to 240 VAC autoranging
AC input frequency	47 to 63 Hz	47 to 63 Hz	47 to 63 Hz	47 to 63 Hz
AC input current range, AC power supply (maximum)	7.1 to 3.0A	7.1 to 3.0A	7.1 to 3.0A	7.1 to 3.0A
AC input surge current	<50A	<50A	<50A	<50A
DC Operating Input Voltage	24Vdc - 60Vdc	24Vdc - 60Vdc	24Vdc - 60Vdc	24Vdc - 60Vdc
Max Input Current range, DC power supply (A)	33.2 - 12.4	33.2 - 12.4	33.2 - 12.4	33.2 - 12.4
DC Input Surge Current	<50A	<50A	<50A	<50A
Typical power (no modules) (watts)	158	150	105	100
Maximum power with AC power supply (watts)	540	420	540	420
Maximum power with PoE power supply (platform only) (watts)	540	420	540	420
Maximum endpoint PoE power available from PoE power supply (watts)	520	520	520	520
Max power with DC input (W)	574	446	574	446
Maximum endpoint PoE power capacity with PoE boost (watts)	1040	1040	1040	1040
Dimensions (H x W x D)	5.25 x 17.25 x 18.75 in. (133.35 x 438.15 x 476.25 mm)	5.25 x 17.25 x 18.75 in. (133.35 x 438.15 x 476.25 mm)	5.25 x 17.25 x 18.75 in. (133.35 x 438.15 x 476.25 mm)	5.25 x 17.25 x 18.75 in. (133.35 x 438.15 x 476.25 mm)
Rack height	3 rack units (3RU)	3RU	3 RU	3RU
Rack-mount 19in. (48.3 cm) EIA	Included	Included	Included	Included
Rack-mount 23in. (58.4 cm) EIA	Optional	Optional	Optional	Optional
Wall-mount	No	No	No	No
Weight with AC power supply (no modules)	39 lb (17.7 kg)	39 lb (17.7 kg)	39 lb (17.7 kg)	39 lb (17.7 kg)
Weight with PoE power supply (no modules)	40 lb (18.1 kg)	40 lb (18.1 kg)	40 lb (18.1 kg)	40 lb (18.1 kg)
Typical weight (with modules)	60 lb (27.2 kg)	60 lb (27.2 kg)	60 lb (27.2 kg)	60 lb (27.2 kg)
Airflow	Back and sides to front	Back and sides to front	Back and sides to front	Back and sides to front
Optional airflow kit (includes filter)	None	None	Front to back and sides	Front to back and sides
Environmental specifications **Operating conditions**				
Temperature: 5906 ft (1800m) maximum altitude	32 to 104°F (0 to 40°C)	32 to 104°F (0 to 40°C)	32 to 104°F (0 to 40°C)	32 to 104°F (0 to 40°C)
Temperature: 9843 ft (3000m) maximum altitude	32 to 104°F (0 to 40°C)	32 to 104°F (0 to 40°C)	32 to 104°F (0 to 40°C)	32 to 104°F (0 to 40°C)

Services and Slot Density	Cisco 3945E	Cisco 3925E	Cisco 3945	Cisco 3925
Temperature: 13123 ft (4000m) maximum altitude'	32 to 86ºF (0 to 30ºC)	32 to 86ºF (0 to 30ºC)	32 to 86ºF (0 to 30ºC)	32 to 86ºF (0 to 30ºC)
Temperature: Short-term per NEBS/5906 ft (1800m) maximum altitude	23 to 122℉ (-5 to 50℃)	23 to 122℉ (-5 to 50℃)	23 to 122℉ (-5 to 50℃)	23 to 122℉ (-5 to 50℃)
Altitude	4000m (13000 ft)	4000m (13000 ft)	4000m (13000 ft)	4000m (13000 ft)
Relative humidity	5 to 85%	5 to 85%	5 to 85%	5 to 85%
Short-term (per NEBS) humidity	5% to 90%, not to exceed 0.024 kg water/kg of dry air	5% to 90%, not to exceed 0.024 kg water/kg of dry air	5% to 90%, not to exceed 0.024 kg water/kg of dry air	5% to 90%, not to exceed 0.024 kg water/kg of dry air
Acoustic: Sound pressure (typical/maximum)	57.6/77.6	57.6/77.6	57.6/77.6	57.6/77.6
Acoustic: Sound power (typical/maximum)	67.8/84.7	67.8/84.7	67.8/84.7	67.8/84.7
Nonoperating conditions			2	
Temperature	-40 to 158ºF (-40 to 70ºC)	-40 to 158ºF (-40 to 70ºC)	-40 to 158ºF (-40 to 70ºC)	-40 to 158ºF (-40 to 70ºC)
Relative humidity	5 to 95%	5 to 95%	5 to 95%	5 to 95%
Altitude	15,584 ft (4750m)	15,584 ft (4570m)	15,584 ft (4750m)	15,584 ft (4570m)
Regulatory and Compliance				
Safety	UL 60950-1 CAN/CSA C22.2 No. 60950-1 EN 60950-1 AS/NZS 60950-1 IEC 60950-1	UL 60950-1 CAN/CSA C22.2 No. 60950-1 EN 60950-1 AS/NZS 60950-1 IEC 60950-1	UL 60950-1 CAN/CSA C22.2 No. 60950-1 EN 60950-1 AS/NZS 60950-1 IEC 60950-1	UL 60950-1 CAN/CSA C22.2 No. 60950-1 EN 60950-1 AS/NZS 60950-1 IEC 60950-1
EMC	47 CFR, Part 15 ICES-003 Class A EN55022 Class A CISPR22 Class A AS/NZS 3548 Class A VCCI V-3 CNS 13438 EN 300-386 EN 61000 (Immunity) EN 55024, CISPR 24 EN50082-1	47 CFR, Part 15 ICES-003 Class A EN55022 Class A CISPR22 Class A AS/NZS 3548 Class A VCCI V-3 CNS 13438 EN 300-386 EN 61000 (Immunity) EN 55024, CISPR 24 EN50082-1	47 CFR, Part 15 ICES-003 Class A EN55022 Class A CISPR22 Class A AS/NZS 3548 Class A VCCI V-3 CNS 13438 EN 300-386 EN 61000 (Immunity) EN 55024, CISPR 24 EN50082-1	47 CFR, Part 15 ICES-003 Class A EN55022 Class A CISPR22 Class A AS/NZS 3548 Class A VCCI V-3 CNS 13438 EN 300-386 EN 61000 (Immunity) EN 55024, CISPR 24 EN50082-1
Telecom	TIA/EIA/IS-968 CS-03 ANSI T1.101 ITU-T G.823, G.824 IEEE 802.3 RTTE Directive	TIA/EIA/IS-968 CS-03 ANSI T1.101 ITU-T G.823, G.824 IEEE 802.3 RTTE Directive	TIA/EIA/IS-968 CS-03 ANSI T1.101 ITU-T G.823, G.824 IEEE 802.3 RTTE Directive	TIA/EIA/IS-968 CS-03 ANSI T1.101 ITU-T G.823, G.824 IEEE 802.3 RTTE Directive

* DC power supplies available in H1CY2010
*** 2GB is the maximum IOS addressable memory but the system can support up to 4GB

The Cisco 3900 Series supports a wide range of modules that span industry-leading breadth of services at the branch office. For a list of modules supported on the Cisco 3900 Series, please visit: http://www.cisco.com/en/US/products/ps10536/products_relevant_interfaces_and_modules.html.

Ordering Information

The Cisco 3900 Series Integrated Services Routers are orderable and shipping. For more information about how to order the Cisco 3900 Series, please visit the ISR G2 Ordering Guide. To place an order, visit the Cisco Ordering Home Page and refer to Table 8.

For additional product numbers, including the Cisco 3900 Series bundle offerings, please check the Cisco 3900 Series Integrated Services Router Price List or contact your local Cisco account representative. To place an order, visit the Cisco Ordering Home Page. To download software, visit the Cisco Software Center.

Table 8. Cisco 3900 Ordering Information

Product Name	Product Description
CISCO3945E/K9	• Cisco 3945 with 4 onboard GE, C3900-SPE250/K9, 3 EHWIC slots, 3 DSP slots, 4 SM slots, 256MB CF default, 1 GB DRAM default, IP Base
CISCO3925E/K9	• Cisco 3925 with 4 onboard GE, C3900-SPE200/K9, 3 EHWIC slots, 3DSP slots, 2 SM slots, 256MB CF default, 1 GB DRAM default, IP Base
CISCO3945/K9	• Cisco 3945 with 3 onboard GE, C3900-SPE150/K9, 4 EHWIC slots, 4 DSP slots, 1 ISM slot, 4 SM slots, 256MB CF default, 1 GB DRAM default, IP Base
CISCO3925/K9	• Cisco 3925 with 3 onboard GE, C3900-SPE100/K9, 4 EHWIC slots, 4 DSP slots, 1 ISM slot, 2 SM slots, 256MB CF default, 1 GB DRAM default, IP Base

Integrated Services Router Migration Options

Cisco 3900 Series Integrated Services Routers are included in the standard Cisco Technology Migration Program (TMP). Refer to http://www.cisco.com/go/tmp and contact your local Cisco account representative for program details.

Warranty Information

The Cisco 3900 Series Integrated Services Routers have a 90-day limited liability warranty.

Cisco and Partner Services for the Branch

Services from Cisco and our certified partners can help you transform the branch-office experience and accelerate business innovation and growth in the Borderless Network. We have the depth and breadth of expertise to create a clear, replicable, optimized branch-office footprint across technologies. Planning and design services align technology with business goals and can increase the accuracy, speed, and efficiency of deployment. Technical services can help you improve operational efficiency, save money, and mitigate risk. Optimization services are designed to continuously improve performance and help your team succeed with new technologies. For more information, please visit http://www.cisco.com/go/services.

Cisco SMARTnet® technical support for the Cisco 3900 Series is available on a one-time or annual contract basis. Support options range from help-desk assistance to proactive, onsite consultation. All support contracts include:

- Major Cisco IOS Software updates in protocol, security, bandwidth, and feature improvements
- Full access rights to Cisco.com technical libraries for technical assistance, electronic commerce, and product information
- Access 24 hours a day to the industry's largest dedicated technical support staff

For More Information

For more information about the Cisco 3900 Series, visit http://www.cisco.com/go/3900 or contact your local Cisco account representative.

Americas Headquarters
Cisco Systems, Inc.
San Jose, CA

Asia Pacific Headquarters
Cisco Systems (USA) Pte. Ltd.
Singapore

Europe Headquarters
Cisco Systems International BV Amsterdam,
The Netherlands

Cisco has more than 200 offices worldwide. Addresses, phone numbers, and fax numbers are listed on the Cisco Website at www.cisco.com/go/offices.

Printed in USA C78-553924-06 03/12

D.6. Switch Cisco WS-C3560G-24TS-S

Cisco Catalyst 3560 Series Switches

Product Overview

The Cisco® Catalyst® 3560 Series is a line of fixed-configuration, enterprise-class switches that include IEEE 802.3af and Cisco prestandard Power over Ethernet (PoE) functionality in Fast Ethernet and Gigabit Ethernet configurations. The Cisco Catalyst 3560 is an ideal access layer switch for small enterprise LAN access or branch-office environments, combining both 10/100/1000 and PoE configurations for maximum productivity and investment protection while enabling the deployment of new applications such as IP telephony, wireless access, video surveillance, building management systems, and remote video kiosks. Customers can deploy networkwide intelligent services-such as advanced quality of service (QoS), rate limiting, access control lists (ACLs), multicast management, and high-performance IP routing-while maintaining the simplicity of traditional LAN switching. Available for the Cisco Catalyst 3560 Series at no charge, the Cisco Network Assistant is a centralized management application that simplifies the administration tasks for Cisco switches, routers, and wireless access points. Cisco Network Assistant provides configuration wizards that greatly simplify the implementation of converged networks and intelligent network services.

The Cisco Catalyst 3560 is part of a larger and more scalable family of Cisco Catalyst switches that includes the Cisco Catalyst 3560-E Series switches, the Cisco Catalyst 3750 and 3750-E Series switches with Cisco StackWise™ technology, and the Cisco Catalyst 4500 and Catalyst 6500 modular switches. United by Cisco IOS® Software, the entire family offers industry-leading availability, integrated security, optimized delivery, and manageability.

Configurations

The Cisco Catalyst 3560 Series comprises the following switches (refer to Figure 1):

Figure 1. Cisco Catalyst 3560 Switches

- Cisco Catalyst 3560-8PC: 8 Ethernet 10/100 ports with PoE and 1 dual-purpose 10/100/1000 and SFP port; compact form factor with no fan
- Cisco Catalyst 3560-12PC: 12 Ethernet 10/100 ports with PoE and 1 dual-purpose 10/100/1000 and SFP port; compact form factor with no fan
- Cisco Catalyst 3560-24TS: 24 Ethernet 10/100 ports and 2 Small Form-Factor Pluggable (SFP)-based Gigabit Ethernet ports; 1 rack unit (RU)

- Cisco Catalyst 3560-48TS: 48 Ethernet 10/100 ports and 4 SFP-based Gigabit Ethernet ports; 1RU
- Cisco Catalyst 3560-24PS: 24 Ethernet 10/100 ports with PoE and 2 SFP-based Gigabit Ethernet ports; 1 RU
- Cisco Catalyst 3560-48PS: 48 Ethernet 10/100 ports with PoE and 4 SFP-based Gigabit Ethernet ports; 1RU
- Cisco Catalyst 3560G-24TS: 24 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports; 1RU
- Cisco Catalyst 3560G-48TS: 48 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports; 1RU
- Cisco Catalyst 3560G-24PS: 24 Ethernet 10/100/1000 ports with PoE and 4 SFP-based Gigabit Ethernet ports; 1RU
- Cisco Catalyst 3560G-48PS: 48 Ethernet 10/100/1000 ports with PoE and 4 SFP-based Gigabit Ethernet ports; 1RU

The Cisco Catalyst 3560 Series can be purchased with the IP Base or IP Services licenses pre-installed. The IP Base license offers advanced QoS, rate limiting, ACLs, and basic static and Routing Information Protocol (RIP) routing functions. The IP Services license provides a richer set of enterprise-class features, including advanced hardware-based IPv6 unicast and IPv6 Multicast routing as well as policy-based routing (PBR). The IP Services license upgrades Cisco Catalyst 3560 Series switches to include IPv6 routing support. Upgrade licenses are available to upgrade a switch from the IP Base license to the IP Services license.

The SFP-based GE ports accommodate a range of SFP transceivers, including the Cisco 1000BASE-T, 1000BASE-SX, 1000BASE-LX, 1000BASE-ZX, and CWDM SFP transceivers. These ports also support the Cisco Catalyst 3560 SFP Interconnect Cable for establishing a low-cost Gigabit Ethernet point-to-point connection.

Power over Ethernet

The Cisco Catalyst 3560 Series can provide a lower total cost of ownership (TCO) for deployments that incorporate Cisco IP phones, Cisco Aironet® wireless LAN (WLAN) access points, or any IEEE 802.3af-compliant end device. PoE removes the need for wall power to each PoE-enabled device and eliminates the cost for additional electrical cabling that would otherwise be necessary in IP phone and WLAN deployments. The Cisco Catalyst 3560 8-port PoE and 24-port PoE configurations can support 8 and 24 simultaneous full-powered PoE ports at 15.4W for maximum powered-device support. The Cisco Catalyst 3560 12-port PoE can support 8 ports at 15.4W or 12 ports at 10W or any combination in between. Taking advantage of Cisco Catalyst Intelligent Power Management, the 48-port PoE configurations can deliver the necessary power to support 24 ports at 15.4W, 48 ports at 7.7W, or any combination in between. Maximum power availability for a converged voice and data network is attainable when a Cisco Catalyst 3560 switch is combined with the Cisco RPS 2300 Redundant Power System for transparent protection against internal power supply failures and an uninterruptible power supply (UPS) system to safeguard against power outages.

Gigabit Ethernet

At speeds of 1000 Mbps, Gigabit Ethernet provides the bandwidth to meet new and evolving network demands, alleviate bottlenecks, and boost performance while increasing the return on

existing infrastructure investments. Today's workers are placing higher demands on networks, running multiple, concurrent applications. For example, a worker joins a team conference call through an IP videoconference, sends a 10-MB spreadsheet to meeting participants, broadcasts the latest marketing video for the team to evaluate, and queries the customer-relationship-management database for the latest real-time feedback. Meanwhile, a multigigabyte system backup starts in the background and the latest virus updates are delivered to the client. The Cisco Catalyst 3560 provides a means to intelligently scale the network beyond 100 Mbps over existing Category 5 copper cabling and simultaneously support PoE for maximum productivity and investment protection.

Intelligence in the Network

Networks of today are evolving to address four new developments at the network edge:

- Increase in desktop computing power
- Introduction of bandwidth-intensive applications
- Expansion of highly sensitive data on the network
- Presence of multiple device types, such as IP phones, WLAN access points, and IP video cameras

These new demands are contending for resources with many existing mission-critical applications. As a result, IT professionals must view the edge of the network as critical to effectively manage the delivery of information and applications.

As companies increasingly rely on networks as the strategic business infrastructure, it is more important than ever to help ensure their high availability, security, scalability, and control. By adding Cisco intelligent functions for LAN access, customers can now deploy networkwide intelligent services that consistently address these requirements from the desktop to the core and through the WAN.

With Cisco Catalyst Intelligent Ethernet switches, Cisco Systems® helps enable companies to realize the full benefits of adding intelligent services into their networks. Deployment of capabilities that make the network infrastructure highly available to accommodate time-critical needs, scalable to accommodate growth, secure enough to protect confidential information, and capable of differentiating and controlling traffic flows is critical to further optimizing network operations.

Cisco EnergyWise Technology

Cisco EnergyWise is an innovative architecture, added to the Cisco Catalyst 3560 switches, promoting companywide sustainability by reducing energy consumption across an entire corporate infrastructure and affecting more than 50 percent of global greenhouse gas emissions created by worldwide building infrastructure, a much greater effect than the 2 percent generated by the IT industry. Cisco EnergyWise enables companies to measure the power consumption of network infrastructure and network-attached devices and manage power consumption with specific policies, reducing power consumption to realize increased cost savings, potentially affecting any powered device.

EnergyWise encompasses a highly intelligent network based approach to communicate messages that measure and control energy between network devices and endpoints. The network discovers Cisco EnergyWise manageable devices, monitors their power consumption, and takes action based on business rules to reduce power consumption. EnergyWise uses a unique domain-naming system to query and summarize information from large sets of devices, making it simpler

than traditional network management capabilities. Cisco EnergyWise's management interfaces allow facilities and network management applications to communicate with endpoints and each other using the network as a unifying fabric. The management interface uses standard SNMP or SSL to integrate Cisco and third-party management systems.

Cisco EnergyWise extends the network as a platform for power control plane for gathering, managing, and reducing power consumption of all devices, resulting in companywide optimized power delivery and reduced energy costs.

Enhanced Security

With the wide range of security features that the Cisco Catalyst 3560 Series offers, businesses can protect important information, keep unauthorized people off the network, guard privacy, and maintain uninterrupted operation.

Cisco Identity Based Networking Services (IBNS) provides authentication, access control, and security policy administration to secure network connectivity and resources. Cisco IBNS in the Cisco Catalyst 3560 Series prevents unauthorized access and helps ensure that users get only their designated privileges. It provides the ability to dynamically administer granular levels of network access. Using the 802.1x standard and the Cisco Access Control Server (ACS), users can be assigned a VLAN or an ACL upon authentication, regardless of where they connect to the network. This setup allows IT departments to enable strong security policies without compromising user mobility-and with minimal administrative overhead.

To guard against denial-of-service and other attacks, ACLs can be used to restrict access to sensitive portions of the network by denying packets based on source and destination MAC addresses, IP addresses, or TCP/UDP ports. ACL lookups are done in hardware, so forwarding performance is not compromised when implementing ACL-based security.

Port security can be used to limit access on an Ethernet port based on the MAC address of the device to which it is connected. It also can be used to limit the total number of devices plugged into a switch port, thereby protecting the switch from a MAC flooding attack as well as reducing the risks of rogue wireless access points or hubs.

With Dynamic Host Configuration Protocol (DHCP) snooping, DHCP spoofing can be thwarted by allowing only DHCP requests (but not responses) from untrusted user-facing ports. Additionally, the DHCP Interface Tracker (Option 82) helps enable granular control over IP address assignment by augmenting a host IP address request with the switch port ID. Building further on the DHCP snooping capabilities, IP address spoofing can be thwarted using Dynamic ARP Inspection and IP Source Guard.

The MAC Address Notification feature can be used to monitor the network and track users by sending an alert to a management station so that network administrators know when and where users entered the network. The Private VLAN feature isolates ports on a switch, helping ensure that traffic travels directly from the entry point to the aggregation device through a virtual path and cannot be directed to another port.

Secure Shell (SSH) Protocol Version 2, Kerberos, and Simple Network Management Protocol Version 3 (SNMPv3) encrypt administrative and network-management information, protecting the network from tampering or eavesdropping. TACACS+ or RADIUS authentication enables centralized access control of switches and restricts unauthorized users from altering the configurations. Alternatively, a local username and password database can be configured on the

switch itself. Fifteen levels of authorization on the switch console and two levels on the Web-based management interface provide the ability to give different levels of configuration capabilities to different administrators.

Availability and Scalability

The Cisco Catalyst 3560 Series is equipped with a robust set of features that allow for network scalability and higher availability through IP routing as well as a complete suite of Spanning Tree Protocol enhancements aimed to maximize availability in a Layer 2 network.

The Cisco Catalyst 3560 switches deliver high-performance, hardware-based IP routing. The Cisco Express Forwarding-based routing architecture allows for increased scalability and performance. This architecture allows for very high-speed lookups while also helping ensure the stability and scalability necessary to meet the needs of future requirements. In addition to dynamic IP unicast routing, the Cisco Catalyst 3560 Series is perfectly equipped for networks requiring multicast support. Protocol Independent Multicast (PIM) and Internet Group Management Protocol (IGMP) snooping in hardware make the Cisco Catalyst 3560 Series switches ideal for intensive multicast environments.

Implementing routed uplinks to the core improves network availability by enabling faster failover protection and simplifying the Spanning Tree Protocol algorithm by terminating all Spanning Tree Protocol instances at the aggregator switch. If one of the uplinks fails, quicker failover to the redundant uplink can be achieved with a scalable routing protocol such as Open Shortest Path First (OSPF) or Enhanced Interior Gateway Routing Protocol (EIGRP) rather than relying on standard Spanning Tree Protocol convergence. Redirection of a packet after a link failure using a routing protocol results in faster failover than a solution that uses Layer 2 spanning-tree enhancements. Additionally, routed uplinks allow better bandwidth use by implementing equal cost routing (ECR) on the uplinks to perform load balancing. Routed uplinks optimize the utility of uplinks out of the LAN Access by eliminating unnecessary broadcast data flows into the network backbone.

The Cisco Catalyst 3560 also offers dramatic bandwidth savings as a wiring-closet switch in a multicast environment. Using routed uplinks to the network core eliminates the requirement to transmit multiple streams of the same multicast from the upstream content servers to LAN access switches. For example, if three users are assigned to three separate VLANs and they all want to view multicast ABC, then three streams of multicast ABC must be transmitted from the upstream router to the wiring-closet switch-assuming the wiring-closet switch is not capable of routed uplinks. Deploying IP routing to the core with Cisco Catalyst 3560 switches allows users to create a scalable, multicast-rich network. The Cisco IP Services license offers IPv6 routing , including support for simultaneous IPv4 and IPv6 forwarding. IPv6 protocol support includes OSPFv3, and EIGRPv6. IPv6 management and MLD Snooping are supported on all Cisco Catalyst 3560 software images.

Enhancements to the standard Spanning Tree Protocol, such as Per-VLAN Spanning Tree Plus (PVST+), Uplink Fast, and PortFast, maximize network uptime. PVST+ allows for Layer 2 load sharing on redundant links to efficiently use the extra capacity inherent in a redundant design. Uplink Fast, PortFast, and BackboneFast all greatly reduce the standard 30- to 60-second Spanning Tree Protocol convergence time. Loop guard and bridge-protocol-data-unit (BPDU) guard provide Spanning Tree Protocol loop avoidance.

Advanced QoS

The Cisco Catalyst 3560 offers superior multilayer, granular QoS features to help ensure that network traffic is classified and prioritized, and that congestion is avoided in the best possible manner. Configuration of QoS is greatly simplified through automatic QoS (Auto QoS), a feature that detects Cisco IP phones and automatically configures the switch for the appropriate classification and egress queuing. This optimizes traffic prioritization and network availability without the challenge of a complex configuration.

The Cisco Catalyst 3560 can classify, reclassify, police, mark, queue, and schedule incoming packets, and can queue and schedule packets at egress. Packet classification allows the network elements to discriminate between various traffic flows and enforce policies based on Layer 2 and Layer 3 QoS fields.

To implement QoS, the Cisco Catalyst 3560 Series Switch first identifies traffic flows or packet groups, and classifies or reclassifies these groups using the Differentiated Services Code Point (DSCP) field or the 802.1p Class of Service (CoS) field. Classification and reclassification can be based on criteria as specific as the source or destination IP address, source or destination MAC address, or the Layer 4 TCP or UDP port. At the ingress, the Cisco Catalyst 3560 also polices to determine whether a packet is in or out of profile, marks to change the classification label, passes through or drops out of profile packets, and queues packets based on classification. Control- and data-plane ACLs are supported on all ports to help ensure proper treatment on a per-packet basis.

The Cisco Catalyst 3560 supports four egress queues per port, allowing the network administrator to be more discriminating and specific in assigning priorities for the various applications on the LAN. At egress, the switch performs scheduling and congestion control. Scheduling is an algorithm or process that determines the order in which the queues are processed. The Cisco Catalyst 3560 Series Switch supports shaped round robin (SRR) and strict priority queuing. The SRR algorithm helps ensure differential prioritization.

These QoS features allow network administrators to prioritize mission-critical and bandwidth-intensive traffic, such as enterprise resource planning (ERP) (Oracle, etc.), voice (IP telephony traffic), and computer-aided design (CAD) or computer-aided manufacturing (CAM) over less-time-sensitive applications such as FTP or e-mail. For example, it would be highly undesirable to have a large file download destined to one port on a wiring-closet switch and have quality implications such as increased latency in voice traffic destined to another port on this switch. This condition is avoided by making sure that voice traffic is properly classified and prioritized throughout the network. Other applications, such as Web browsing, can be treated as low priority and handled on a best-effort basis.

The Cisco Catalyst 3560 Series can perform rate limiting through its support of the Cisco Committed Information Rate (CIR) function. Through CIR, bandwidth can be guaranteed in increments as low as 8 kbps. Bandwidth can be allocated based on several criteria, including MAC source address, MAC destination address, IP source address, IP destination address, and TCP or UDP port number. Bandwidth allocation is essential when network environments require service-level agreements or when it is necessary for the network manager to control the bandwidth given to certain users.

Management

The new Cisco Express Setup feature simplifies the initial configuration of a switch. Users now have the option to set up the switch through a Web browser, eliminating the need for more complex terminal-emulation programs and knowledge of the command-line interface (CLI). Cisco Express Setup reduces the cost of deployment by helping less-skilled personnel quickly and simply set up switches.

Cisco Network Assistant is a PC-based network-management application optimized for LANs of small and medium-sized businesses with up to 250 users. Cisco Network Assistant offers centralized management of Cisco switches, routers, and WLAN access points. It supports a wide range of Cisco Catalyst intelligent switches from Cisco Catalyst 2950 through Cisco Catalyst 4506. Through a user-friendly GUI, users can configure and manage a wide array of switch functions and start the device manager of Cisco routers and Cisco wireless access points. A few mouse clicks enable the Cisco recommended security, availability, and QoS features without the need to consult a detailed design guide. The Security wizard automatically restricts unauthorized access to servers with sensitive data. Smartports and wizards save hours of time for network administrators, eliminate human errors, and help ensure that the configuration of the switch is optimized for these applications. Available at no cost, Cisco Network Assistant can be downloaded from Cisco.com.

In addition to the Cisco Network Assistant, the Cisco Catalyst 3560 Series switches provide for extensive management using SNMP network-management platforms such as CiscoWorks LAN Management Solution (LMS). LMS is a suite of powerful management tools that simplify the configuration, administration, monitoring, and troubleshooting of Cisco networks. It integrates these capabilities into a world-class solution for improving the accuracy and efficiency of your operations staff, while increasing the overall availability of your network. LMS supports over 400 different device types providing:

- Network discovery, topology views, end-station tracking, and VLAN management
- Real-time network fault analysis with easy-to-deploy device specific best-practice templates
- Hardware and software inventory management, centralized configuration tools, and syslog monitoring
- Network response time and availability monitoring and tracking
- Real-time device, link, and port traffic management, analysis, and reporting

Cisco Catalyst 3560 SFP Interconnect Cable

The Cisco Catalyst 3560 SFP Interconnect Cable (see Figure 2) provides for a low-cost point-to-point Gigabit Ethernet connection between Cisco Catalyst 3560 switches. The 50cm cable is an alternative to using SFP transceivers when interconnecting Cisco Catalyst 3560 switches through their SFP ports over a short distance.

Figure 2. Cisco Catalyst 3560 SFP Interconnect Cable

Table 1 gives the features and benefits of the Cisco Catalyst 3560 Series. Table 2 gives the hardware specifications, and Table 3 gives the power specifications. Table 4 lists the management and standards support, and Table 5 provides the safety and compliance information.

Table 1. Features and Benefits of Cisco Catalyst 3560 Series

Feature	Benefit
Ease of Use and Deployment	• Cisco Express Setup simplifies initial configuration with a Web browser, eliminating the need for more complex terminal emulation programs and CLI knowledge. • IEEE 802.3af and Cisco prestandard PoE support comes with automatic discovery to detect a Cisco prestandard or IEEE 802.3af endpoint and provide the necessary power without any user configuration. • DHCP autoconfiguration of multiple switches through a boot server eases switch deployment. • Automatic QoS (Auto QoS) simplifies QoS configuration in voice-over-IP (VoIP) networks by issuing interface and global switch commands to detect Cisco IP phones, classify traffic, and enable egress queue configuration. • Autosensing on each 10/100 port detects the speed of the attached device and automatically configures the port for 10- or 100-Mbps operation, easing switch deployment in mixed 10- and 100-Mbps environments. • Autonegotiating on all ports automatically selects half- or full-duplex transmission mode to optimize bandwidth. • Dynamic Trunking Protocol (DTP) helps enable dynamic trunk configuration across all switch ports. • Port Aggregation Protocol (PAgP) automates the creation of Cisco Fast EtherChannel® groups or Gigabit EtherChannel groups to link to another switch, router, or server. • Link Aggregation Control Protocol (LACP) allows the creation of Ethernet channeling with devices that conform to IEEE 802.3ad. This feature is similar to Cisco EtherChannel technology and PAgP. • DHCP Server enables a convenient deployment option for the assignment of IP addresses in networks that do not have a dedicated DHCP server. • DHCP Relay allows a DHCP relay agent to broadcast DHCP requests to the network DHCP server. • IEEE 802.3z-compliant 1000BASE-SX, 1000BASE-LX/LH, 1000BASE-ZX, 1000BASE-T, and coarse wavelength-division multiplexing (CWDM) physical interface support through a field-replaceable SFP module provides unprecedented flexibility in switch deployment. • Support for the Cisco Catalyst 3560 SFP Interconnect Cable facilitates a low-cost, point-to-point gigabit connection between Cisco Catalyst 3560 Series switches. • The default configuration stored in Flash memory helps ensure that the switch can be quickly connected to the network and can pass traffic with minimal user intervention. • Automatic medium-dependent interface crossover (Auto-MDIX) automatically adjusts transmit and receive pairs if an incorrect cable type (crossover or straight-through) is installed on a 10/100 port. • Time Domain Reflectometry (TDR) to diagnose and resolve cabling problems on copper Ethernet 10/100/1000 ports.
Cisco EnergyWise	• Cisco EnergyWise for greenhouse gas emissions and operational cost optimization by measuring, reporting, and reducing energy consumption across the entire corporate infrastructure, well beyond the scope of IT.

Availability and Scalability	
Superior Redundancy for Fault Backup	• Cisco Uplink Fast and BackboneFast technologies help ensure quick failover recovery, enhancing overall network stability and reliability. • IEEE 802.1w Rapid Spanning Tree Protocol (RSTP) provides rapid spanning-tree convergence independent of spanning-tree timers and the benefit of distributed processing. • Per-VLAN Rapid Spanning Tree Plus (PVRST+) allows rapid spanning-tree reconvergence on a per-VLAN spanning-tree basis, without requiring the implementation of spanning-tree instances. • Cisco Hot Standby Router Protocol (HSRP) is supported to create redundant, fail-safe routing topologies. • Command-switch redundancy enabled in Cisco Network Assistant software allows designation of a backup command switch that takes over cluster-management functions if the primary command switch fails. • Unidirectional Link Detection Protocol (UDLD) and Aggressive UDLD allow unidirectional links to be detected and disabled to avoid problems such as spanning-tree loops. • Switch port autorecovery (errdisable) automatically attempts to reenable a link that is disabled because of a network error. • Cisco RPS 2300 support provides superior internal power-source redundancy, resulting in improved fault tolerance and network uptime. • Equal cost routing (ECR) provides load balancing and redundancy. • Bandwidth aggregation up to 8 Gbps through Cisco Gigabit EtherChannel technology and up to 800 Mbps through Cisco Fast EtherChannel technology enhances fault tolerance and offers higher-speed aggregated bandwidth between switches and to routers and individual servers.
High-Performance IP Routing	• Cisco Express Forwarding hardware routing architecture delivers extremely high-performance IP routing. • Basic IP unicast routing protocols (static, RIPv1, RIPv2 and RIPng) are supported for small-network routing applications. • Advanced IP unicast routing protocols (OSPF, Interior Gateway Routing Protocol [IGRP], EIGRP, Border Gateway Protocol Version 4 [BGPv4] and IS-ISv4) are supported for load balancing and constructing scalable LANs. The IP Services license is required. • IPv6 routing capability (OSPFv3, EIGRPv6) is support. IP Services license is required. • Policy-Based Routing (PBR) allows superior control by enabling flow redirection regardless of the routing protocol configured. • Inter-VLAN IP routing provides for full Layer 3 routing between two or more VLANs. • Protocol Independent Multicast (PIM) for IP Multicast routing is supported, including PIM sparse mode (PIM-SM), PIM dense mode (PIM-DM), and PIM sparse-dense mode. The IP Services license is required. • Fallback bridging forwards non-IP traffic between two or more VLANs.
Integrated Cisco IOS Software Features for Bandwidth Optimization	• Per-port broadcast, multicast, and unicast storm control prevents faulty end stations from degrading overall systems performance. • IEEE 802.1d Spanning Tree Protocol support for redundant backbone connections and loop-free networks simplifies network configuration and improves fault tolerance. • PVST+ allows for Layer 2 load sharing on redundant links to efficiently use the extra capacity inherent in a redundant design. • IEEE 802.1s Multiple Spanning Tree Protocol (MSTP) allows a spanning-tree instance per VLAN, enabling Layer 2 load sharing on redundant links. • ECR provides load balancing and redundancy. • VPN routing/forwarding (VRF)-Lite enables a service provider to support two or more VPNs, with overlapping IP addresses. • Local Proxy Address Resolution Protocol (ARP) works in conjunction with Private VLAN Edge to minimize broadcasts and maximize available bandwidth. • VLAN1 minimization allows VLAN1 to be disabled on any individual VLAN trunk link. • VLAN Trunking Protocol (VTP) pruning limits bandwidth consumption on VTP trunks by flooding broadcast traffic only on trunk links required to reach the destination devices. • Internet Group Management Protocol v3 (IGMP) Snooping for IPv4 and IPv6 MLD v1 and v2 Snooping provide fast client joins and leaves of multicast streams and limits bandwidth-intensive video traffic to only the requestors. • IGMP filtering provides multicast authentication by filtering out nonsubscribers and limits the number of concurrent multicast streams available per port. • Multicast VLAN registration (MVR) continuously sends multicast streams in a multicast VLAN while isolating the streams from subscriber VLANs for bandwidth and security reasons.

QoS and Control	
Advanced QoS	• Standard 802.1p CoS and DSCP field classification are provided, using marking and reclassification on a per-packet basis by source and destination IP address, source and destination MAC address, or Layer 4 TCP or UDP port number. • Cisco control- and data-plane QoS ACLs on all ports help ensure proper marking on a per-packet basis. • Four egress queues per port enable differentiated management of up to four traffic types. • SRR scheduling helps ensure differential prioritization of packet flows by intelligently servicing the ingress and egress queues. • Weighted tail drop (WTD) provides congestion avoidance at the ingress and egress queues before a disruption occurs. • Strict priority queuing guarantees that the highest-priority packets are serviced ahead of all other traffic. • There is no performance penalty for highly granular QoS functions.
Granular Rate Limiting	• The Cisco Committed Information Rate (CIR) function guarantees bandwidth in increments as low as 8 kbps. • Rate limiting is provided based on source and destination IP address, source and destination MAC address, Layer 4 TCP and UDP information, or any combination of these fields, using QoS ACLs (IP ACLs or MAC ACLs), class maps, and policy maps. • Asynchronous data flows upstream and downstream from the end station or on the uplink are easily managed using ingress policing and egress shaping. • Up to 64 aggregate or individual policers are available per Fast Ethernet or Gigabit Ethernet port.
Security	
Networkwide Security Features	• IEEE 802.1x allows dynamic, port-based security, providing user authentication. • IEEE 802.1x with VLAN assignment allows a dynamic VLAN assignment for a specific user regardless of where the user is connected. • IEEE 802.1x with voice VLAN permits an IP phone to access the voice VLAN irrespective of the authorized or unauthorized state of the port. • IEEE 802.1x and port security are provided to authenticate the port and manage network access for all MAC addresses, including those of the client. • IEEE 802.1x with an ACL assignment allows for specific identity-based security policies regardless of where the user is connected. • IEEE 802.1x with Guest VLAN allows guests without 802.1x clients to have limited network access on the guest VLAN. • Web authentication for non-802.1x clients allows non-802.1x clients to use an SSL-based browser for authentication. • Multi-Domain Authentication allows an IP phone and a PC to authenticate on the same switch port while placing them on appropriate Voice and Data VLAN. • MAC Auth Bypass (MAB) for voice allows third-party IP phones without an 802.1x supplicant to get authenticated using their MAC address. • Cisco security VLAN ACLs (VACLs) on all VLANs prevent unauthorized data flows from being bridged within VLANs. • Cisco standard and extended IP security router ACLs (RACLs) define security policies on routed interfaces for control- and data-plane traffic. • Port-based ACLs (PACLs) for Layer 2 interfaces allow application of security policies on individual switch ports. • Unicast MAC filtering prevents the forwarding of any type of packet with a matching MAC address. • Unknown unicast and multicast port blocking allows tight control by filtering packets that the switch has not already learned how to forward. • SSHv2, Kerberos, and SNMPv3 provide network security by encrypting administrator traffic during Telnet and SNMP sessions. SSHv2, Kerberos, and the cryptographic version of SNMPv3 require a special cryptographic software image because of U.S. export restrictions. • Private VLAN Edge provides security and isolation between switch ports, helping ensure that users cannot snoop on other users' traffic. • Private VLANs restrict traffic between hosts in a common segment by segregating traffic at Layer 2, turning a broadcast segment into a nonbroadcast multi-access-like segment. • Bidirectional data support on the Switched Port Analyzer (SPAN) port allows the Cisco Secure Intrusion Detection System (IDS) to take action when an intruder is detected. • TACACS+ and RADIUS authentication enable centralized control of the switch and restrict unauthorized users from altering the configuration. • MAC address notification allows administrators to be notified of users added to or removed from the network. • Dynamic ARP Inspection (DAI) helps ensure user integrity by preventing malicious users from exploiting the insecure nature of the ARP protocol. • DHCP snooping allows administrators to help ensure consistent mapping of IP to MAC

	addresses. This can be used to prevent attacks that attempt to poison the DHCP binding database, and to rate limit the amount of DHCP traffic that enters a switch port. • IP source guard prevents a malicious user from spoofing or taking over another user's IP address by creating a binding table between the client's IP and MAC address, port, and VLAN. • DHCP Interface Tracker (Option 82) augments a host IP address request with the switch port ID. • Port security secures the access to an access or trunk port based on MAC address. • After a specific timeframe, the aging feature removes the MAC address from the switch to allow another device to connect to the same port. • Trusted Boundary provides the ability to trust the QoS priority settings if an IP phone is present and to disable the trust setting if the IP phone is removed, thereby preventing a malicious user from overriding prioritization policies in the network. • Multilevel security on console access prevents unauthorized users from altering the switch configuration. • The user-selectable address-learning mode simplifies configuration and enhances security. • BPDU Guard shuts down Spanning Tree Protocol PortFast-enabled interfaces when BPDUs are received to avoid accidental topology loops. • Spanning-Tree Root Guard (STRG) prevents edge devices not in the network administrator's control from becoming Spanning Tree Protocol root nodes. • IGMP filtering provides multicast authentication by filtering out nonsubscribers and limits the number of concurrent multicast streams available per port. • Dynamic VLAN assignment is supported through implementation of VLAN Membership Policy Server (VMPS) client functions to provide flexibility in assigning ports to VLANs. Dynamic VLAN helps enable the fast assignment of IP addresses. • Cisco Network Assistant software security wizards ease the deployment of security features for restricting user access to a server as well as to a portion of or the entire network. • Two thousand access control entries (ACEs) are supported.
Manageability	
Superior Manageability	• Cisco IOS CLI support provides a common user interface and command set with all Cisco routers and Cisco Catalyst desktop switches. • Cisco Discovery Protocol version 2 (CDPv2) allows the Cisco Catalyst 3560 Series Switch to negotiate a more granular power setting when connecting to a Cisco powered device, such as IP phones or access points, than what is provided by IEEE classification. • The PoE MIB provides proactive visibility into power usage and allows customers to set different power level thresholds. • Switching Database Manager templates for access, routing, and VLAN deployment scenarios allow the administrator to easily maximize memory allocation to the desired features based on deployment-specific requirements. • Generic On-Line Diagnostic (GOLD) checks the health of hardware components and verifies proper operation of the system data and control plane at run time and boot time. • VLAN trunks can be created from any port, using either standards-based 802.1Q tagging or the Cisco Inter-Switch Link (ISL) VLAN architecture. • Up to 1024 VLANs and up to 128 spanning-tree instances per switch are supported. • Four thousand VLAN IDs are supported. • Voice VLAN simplifies telephony installations by keeping voice traffic on a separate VLAN for easier administration and troubleshooting. • Cisco VTP supports dynamic VLANs and dynamic trunk configuration across all switches. • IGMPv3 snooping provides fast client joins and leaves of multicast streams and limits bandwidth-intensive video traffic to only the requestors. • Remote SPAN (RSPAN) allows administrators to remotely monitor ports in a Layer 2 switch network from any other switch in the same network. • For enhanced traffic management, monitoring, and analysis, the Embedded Remote Monitoring (RMON) software agent supports four RMON groups (history, statistics, alarms, and events). • Layer 2 traceroute eases troubleshooting by identifying the physical path that a packet takes from source to destination. • All nine RMON groups are supported through a SPAN port, which permits traffic monitoring of a single port, a group of ports from a single network analyzer or RMON probe. • Domain Name System (DNS) provides IP address resolution with user-defined device names. • Trivial File Transfer Protocol (TFTP) reduces the cost of administering software upgrades by downloading from a centralized location. • Network Timing Protocol (NTP) provides an accurate and consistent timestamp to all intranet switches.

	• Multifunction LEDs per port for port status; half-duplex and full-duplex mode; and 10BASE-T, 100BASE-TX, and 1000BASE-T indication as well as switch-level status LEDs for system, redundant power supply, and bandwidth use provide a comprehensive and convenient visual management system.
Cisco Network Assistant Software	• Cisco Network Assistant is a free, Windows-based application that simplifies the administration of networks of up to 250 users. It supports a wide range of Cisco Catalyst intelligent switches from Cisco Catalyst 2950 through Cisco Catalyst 4506. With Cisco Network Assistant, users can manage Cisco Catalyst switches plus launch the device managers of Cisco integrated services routers (ISRs) and Cisco Aironet WLAN access points. • The easy-to-use graphical interface provides both a topology map and front-panel view of the switch. • Cisco AVVID (Architecture for Voice, Video and Integrated Data) wizards need just a few user inputs to automatically configure the switch to optimally handle different types of traffic: voice, video, multicast, and high-priority data. • A security wizard is provided to restrict unauthorized access to applications, servers, and networks. • Upgrading the Cisco IOS Software on Cisco Catalyst switches is a simple matter of pointing and clicking, with one-click upgrades. • Cisco Network Assistant supports multilayer feature configurations such as routing protocols, ACLs, and QoS parameters. • Multidevice and multiport configuration capabilities allow administrators to save time by configuring features across multiple switches and ports simultaneously. • The user-personalized interface allows modification of polling intervals, table views, and other settings. • Alarm notification provides automated e-mail notification of network errors and alarm thresholds.
Cisco Express Setup	• Cisco Express Setup simplifies initial configuration of a switch through a Web browser, eliminating the need for more complex terminal emulation programs and CLI knowledge. • The Web interface helps less-skilled personnel quickly and simply set up switches, thereby reducing the cost of deployment.
CiscoWorks Support	• CiscoWorks network-management software provides management capabilities on a per-port and per-switch basis, providing a common management interface for Cisco routers, switches, and hubs. • SNMP v1, v2c, and v3 and Telnet interface support delivers comprehensive in-band management, and a CLI-based management console provides detailed out-of-band management. • Cisco Discovery Protocol Versions 1 and 2 help enable a CiscoWorks network-management station for automatic switch discovery. • The CiscoWorks LAN Management Solution supports the Cisco Catalyst 3560 Series.

Table 2. Cisco Catalyst 3560 Series Switch Hardware

Description	Specification
Performance	• 32 Gbps forwarding bandwidth • Forwarding rate based on 64-byte packets: • 38.7 Mpps (Cisco Catalyst 3560G-48TS, Catalyst 3560G-48PS, Catalyst 3560G-24TS, and Catalyst 3560G-24PS); • 13.1 Mpps (Cisco Catalyst 3560-48TS and Catalyst 3560-48PS); • 6.5 Mpps (Cisco Catalyst 3560-24TS and Catalyst 3560-24PS); • 3.2 Mpps (Cisco Catalyst 3560-12PC) • 2.7 Mpps (Cisco Catalyst 3560-8PC) • 128 MB DRAM • 32 MB Flash memory (Cisco Catalyst 3560G-24TS, Catalyst 3560G-24PS, Catalyst 3560G-48TS, Catalyst 3560G-48PS, Catalyst 3560-24TS, Catalyst 3560-48TS, and Catalyst 3560-8PC); • 16-MB Flash memory (Cisco Catalyst 3560-48PS and Catalyst 3560-24PS) • Configurable up to 12,000 MAC addresses • Configurable up to 11,000 unicast routes • Configurable up to 1000 IGMP groups and multicast routes • Configurable maximum transmission unit (MTU) of up to 9000 bytes, with a maximum Ethernet frame size of 9018 bytes (Jumbo frames), for bridging on Gigabit Ethernet ports, and up to 1546 bytes for bridging of Multiprotocol Label Switching (MPLS) tagged frames on 10/100 ports
Connectors and Cabling	• 10BASE-T ports: RJ-45 connectors, two-pair Category 3, 4, or 5 unshielded twisted-pair (UTP) cabling • 10BASE-T PoE ports: RJ-45 connectors, two-pair Category 3, 4, or 5 UTP cabling power pins 1,2 (negative) and 3,6 (positive)

	• 100BASE-TX ports: RJ-45 connectors, two-pair Category 5 UTP cabling • 100BASE-TX PoE ports: RJ-45 connectors, two-pair Category 5 UTP cabling, power on pins 1,2 (negative) and 3,6 (positive) • 1000BASE-T ports: RJ-45 connectors, four-pair Category 5 UTP cabling • 1000BASE-T SFP-based ports: RJ-45 connectors, four-pair Category 5 UTP cabling • 1000BASE-SX, -LX/LH, -ZX, and CWDM SFP-based ports: LC fiber connectors (single/multimode fiber) • Cisco Catalyst 3560 SFP Interconnect Cable: two-pair shielded cabling, 50 cm • Management console port: RJ-45-to-DB-9 cable for PC connections; for terminal connections, use RJ-45-to-DB-25 female data-terminal-equipment (DTE) adaptor (can be ordered separately from Cisco; part number ACS-DSBUASYN=)
Power Connectors	• Customers can provide power to a switch by using either the internal power supply or the Cisco RPS 2300. The connectors are located at the back of the switch. Note: The Cisco Catalyst 3560-8PC and Catalyst 3560-12PC do not have an RPS port. • Internal-Power-Supply Connector • The internal power supply is an autoranging unit. • The internal power supply supports input voltages between 100 and 240 VAC. • Use the supplied AC power cord to connect the AC power connector to an AC power outlet. • Cisco RPS Connector • The connector offers connection for an optional Cisco RPS 2300 that uses AC input and supplies DC output to the switch. • The connector supports up to six external network devices and provides power to two failed devices at a time. • The connector automatically senses when the internal power supply of a connected device fails and provides power to the failed device, preventing loss of network traffic. • Only the Cisco RPS 2300 (model PWR-RPS2300) should be attached to the redundant-power-supply receptacle.
Indicators	• Per-port status LEDs: Link integrity, disabled, activity, speed, full-duplex indications, PoE applied, PoE error, and PoE disabled indications • System-status LEDs: System, RPS, link status, link duplex, link speed, and PoE indications
Dimensions (H x W x D)	• Cisco Catalyst 3560-8PC: 1.73 x 10.6 x 9.1 in. (4.4 x 27 x 23 cm) • Cisco Catalyst 3560-12PC: 1.73 x 10.6 x 9.1 in. (4.4 x 27 x 23 cm) • Cisco Catalyst 3560-24TS: 1.73 x 17.5 x 11.8 in. (4.4 x 44.5 x 30 cm) • Cisco Catalyst 3560-48TS: 1.73 x 17.5 x 11.8 in. (4.4 x 44.5 x 30 cm) • Cisco Catalyst 3560-24PS: 1.73 x 17.5 x 11.8 in. (4.4 x 44.5 x 30 cm) • Cisco Catalyst 3560-48PS: 1.73 x 17.5 x 14.9 in. (4.4 x 44.5 x 37.8 cm) • Cisco Catalyst 3560G-24TS: 1.73 x 17.5 x 14.9 in. (4.4 x 44.5 x 37.8 cm) • Cisco Catalyst 3560G-48TS: 1.73 x 17.5 x 16.1 in. (4.4 x 44.5 x 40.9 cm) • Cisco Catalyst 3560G-24PS: 1.73 x 17.5 x 14.9 in. (4.4 x 44.5 x 37.8 cm) • Cisco Catalyst 3560G-48PS: 1.73 x 17.5 x 16.1 in. (4.4 x 44.5 x 40.9 cm)
Weight	• Cisco Catalyst 3560-8PC: 5 lb (2.3 kg) • Cisco Catalyst 3560-12PC: 5 lb (2.3 kg) • Cisco Catalyst 3560-24TS: 8.5 lb (3.9 kg) • Cisco Catalyst 3560-48TS: 9.1 lb (4.1 kg) • Cisco Catalyst 3560-24PS: 11.3 lb (5.1 kg) • Cisco Catalyst 3560-48PS: 13.2 lb (6.0 kg) • Cisco Catalyst 3560G-24TS: 12 lb (5.4 kg) • Cisco Catalyst 3560G-24PS: 13.5 lb (6.1 kg) • Cisco Catalyst 3560G-48TS: 14.0 lb (6.4 kg) • Cisco Catalyst 3560G-48PS: 15.5 lb (7.0 kg)
Environmental Ranges	• Operating temperature: 32 to 113ºF (0 to 45ºC) • Storage temperature: -13 to 158ºF (-25 to 70ºC) • Operating relative humidity: 10 to 85% (noncondensing) • Operating altitude: Up to 10,000 ft (3049m) • Storage altitude: Up to 15,000 ft (4573m)
Acoustic Noise	• ISO 7779: Bystander position operating to an ambient temperature of 25℃ • Cisco Catalyst 3560-8PC: 0 dBa (no fan) • Cisco Catalyst 3560-12PC: 0 dBa (no fan) • Cisco Catalyst 3560-24TS: 42 dBa • Cisco Catalyst 3560-48TS: 42 dBa

	• Cisco Catalyst 3560-24PS: 42 dBa • Cisco Catalyst 3560-48PS: 42 dBa • Cisco Catalyst 3560G-24TS: 42 dBa • Cisco Catalyst 3560G-48TS: 48 dBa • Cisco Catalyst 3560G-24PS: 38-44 dBa • Cisco Catalyst 3560G-48PS: 52-58 dBa
Mean Time Between Failure (MTBF)	• Cisco Catalyst 3560-8PC: 367,586 hours • Cisco Catalyst 3560-12PC: 406,470 hours • Cisco Catalyst 3560-24TS: 326,100 hours • Cisco Catalyst 3560-48TS: 280,900 hours • Cisco Catalyst 3560-24PS: 224,100 hours • Cisco Catalyst 3560-48PS: 173,500 hours • Cisco Catalyst 3560G-24TS: 230,700 hours • Cisco Catalyst 3560G-24PS: 186,300 hours • Cisco Catalyst 3560G-48TS: 173,400 hours • Cisco Catalyst 3560G-48PS: 147,000 hours

Table 3. Power Specifications for Cisco Catalyst 3560 Series Switch

Description	Specification		
Power Supply Rated Maximum	• 204W (Cisco Catalyst 3560-8PC, Catalyst 3560-12PC) • Dissipated power: 80W, 273 BTUs per hour • PoE: 124W • 45W (Cisco Catalyst 3560-24TS) • 485W (Cisco Catalyst 3560-24PS) • Dissipated power: 115W, 393 BTUs per hour • PoE: 370W • 65W (Cisco Catalyst 3560-48TS) • 530W (Cisco Catalyst 3560-48PS) • Dissipated power: 160W, 546 BTUs per hour • PoE: 370W • 100W (Cisco Catalyst 3560G-24TS) • 540W (Cisco Catalyst 3560G-24PS) • Dissipated power: 170W, 534 BTUs per hour • PoE: 370W • 160W (Cisco Catalyst 3560G-48TS) • 590W (Cisco Catalyst 3560G-48PS) • Dissipated power: 220W, 690 BTUs per hour • PoE: 370W		
Measured 100% Throughput Power Consumption	**Cisco Catalyst 3560 Series**	**Switch Power**	**Total Output BTU**
	3560-8PC	19W	64 BTU/hour
	3560-12PC	22W	73 BTU/hour
	3560-24TS	27W	89 BTU/hour
	3560-48TS	45W	153 BTU/hour
	3560-24PS	43W	144 BTU/hour
	3560-48PS	86W	293 BTU/hour
	3560G-24TS	74W	249 BTU/hour
	3560G-24PS	96W	325 BTU/hour
	3560G-48TS	124W	422 BTU/hour
	3560G-48PS	130W	443 BTU/hour
Measured 5% Throughput Power Consumption	**Cisco Catalyst 3560 Series**	**Switch Power**	**Total Output BTU**
	3560-8PC	18W	60 BTU/hour
	3560-12PC	20W	68 BTU/hour
	3560-24TS	24W	82 BTU/hour
	3560-48TS	41W	138 BTU/hour

	3560-24PS	40W		134 BTU/hour
	3560-48PS	72W		245 BTU/hour
	3560G-24TS	66W		225 BTU/hour
	3560G-24PS	86W		293 BTU/hour
	3560G-48TS	113W		386 BTU/hour
	3560G-48PS	123W		418 BTU/hour
Measured 100% Throughput Power Consumption (with maximum possible PoE loads)	**Cisco Catalyst 3560 Series**	**Switch Power**	**PoE Power**	**Total Output BTU**
	3560-8PC	145W	124W	70 BTU/hour
	3560-12PC	145W	124W	72 BTU/hour
	3560-24PS	449W	370W	267 BTU/hour
	3560-48PS	483W	370W	383 BTU/hour
	3560G-24PS	496W	370W	429 BTU/ hour
	3560G-48PS	534W	370W	559 BTU/hour
Measured 5% Throughput Power Consumption (with 50% PoE loads)	**Cisco Catalyst 3560 Series**	**Switch Power**	**PoE Power**	**Total Output BTU**
	3560-8PC	82W	62W	69 BTU/hour
	3560-12PC	86W	63W	76 BTU/hour
	3560-24PS	247W	188W	197 BTU/hour
	3560-48PS	275W	184W	311 BTU/hour
	3560G-24PS	287W	186W	345 BTU/ hour
	3560G-48PS	328W	189	474 BTU/hour
AC Input Voltage and Current	• 100-240 VAC (autoranging), 2.5-1.3A, 50-60 Hz (Cisco Catalyst 3560-8PC) • 100-240 VAC (autoranging), 2.5-1.3A, 50-60 Hz (Cisco Catalyst 3560-12PC) • 100-240 VAC (autoranging), 450-190mA, 50-60 Hz (Cisco Catalyst 3560-24TS) • 100-240 VAC (autoranging), 650-270mA, 50-60 Hz (Cisco Catalyst 3560-48TS) • 100-240 VAC (autoranging), 5.5-2.8A, 50-60 Hz (Cisco Catalyst 3560-24PS and Catalyst 3560-48PS) • 100-240 VAC (autoranging), 3.0-1.5A, 50-60Hz (Cisco Catalyst 3560G-24TS and Catalyst 3560G-48TS) • 100-240 VAC (autoranging), 8.0-4.0A, 50-60Hz (Cisco Catalyst 3560G-24PS and Catalyst 3560G-48PS)			
Power Rating	• Cisco Catalyst 3560-8PC: 0.2 kVA • Cisco Catalyst 3560-12PC: 0.2 kVA • Cisco Catalyst 3560-24TS: 0.075 kVA • Cisco Catalyst 3560-48TS: 0.110 kVA • Cisco Catalyst 3560-24PS: 0.485 kVA • Cisco Catalyst 3560-48PS: 0.530 kVA • Cisco Catalyst 3560G-24TS: 0.10 kVA • Cisco Catalyst 3560G-48TS: 0.16 kVA • Cisco Catalyst 3560G-24PS: 0.52 kVA • Cisco Catalyst 3560G-48PS: 0.56 kVA			
DC Input Voltages (RPS Input)	• +12V at 5A (Cisco Catalyst 3560-24TS and Catalyst 3560-48TS); 7.5A (Cisco Catalyst 3560-24PS and Catalyst 3560-48PS); 10.5A (Cisco Catalyst 3560G-24TS); 17.5A (Cisco Catalyst 3560G-48TS); 14A (Cisco Catalyst 3560G-24PS and Catalyst 3560G-48PS) • -48V at 7.8A (PoE switches)			
PoE	• Maximum power supplied per port: 15.4W • Total power dedicated to PoE: 370W • Total power dedicated to PoE: 124W (Cisco Catalyst 3560-8PC, Catalyst 3560-12PC)			

Note:

Disclaimer: All power consumption numbers were measured under controlled laboratory conditions and are provided as an estimate.

The wattage rating on the power supply does not represent actual power draw. It indicates the maximum power draw possible by the power supply. This rating can be used for facility capacity

planning. For PoE switches, cooling requirements are smaller than the actual power consumption as a significant portion of PoE loads are dissipated in the endpoints.

Non-PoE Power Consumption

100 Percent Throughput Switch Power Consumption

The numbers indicate the power consumed by a typical switch under normal conditions. Normal conditions signify a temperature of 25 degrees Celsius, atmospheric pressure in the range of 860 to 1060 mbar, and relative humidity from 30 to 75 percent. Typically such power draws are only seen when encountering a 100 percent traffic load made up entirely of 64-byte packets on the switch and the uplinks.

5 Percent Throughput Switch Power Consumption

The numbers indicate the power consumed by a typical switch under normal conditions. Normal conditions signify a temperature of 25 degrees Celsius, atmospheric pressure in the range of 860 to 1060 mbar, and relative humidity from 30 to 75 percent. The numbers below indicate a 5 percent traffic load on the switch and its uplinks.

PoE Power Consumption

100 Percent Throughput Switch Power Consumption (no PoE loads)

The numbers indicate the power consumed by a typical switch under normal conditions. Normal conditions signify a temperature of 25 degrees Celsius, atmospheric pressure in the range of 860 to 1060 mbar, and relative humidity from 30 to 75 percent. Typically such power draws are only seen when encountering a 100 percent traffic load made up entirely of 64-byte packets with no PoE loads on the switch and uplinks.

Measured 5 Percent Throughput Switch Power Consumption (no PoE loads)

The numbers indicate the power consumed by a typical switch under normal conditions. Normal conditions signify a temperature of 25 degrees Celsius, atmospheric pressure in the range of 860 to 1060 mbar and relative humidity from 30 to 75 percent. The numbers below indicate a 5 percent traffic load on the switch and its uplinks

100 Percent Throughput Switch Power Consumption (with maximum PoE loads)

The numbers indicate the power consumed by a typical system (the switch and the corresponding PoE loads) under normal conditions. Normal conditions signify a temperature of 25 degrees Celsius, atmospheric pressure in the range of 860 to 1060 mbar and relative humidity from 30 to 75 percent. Typically this power draw is realized when a switch is running 100 percent traffic load of 64 byte sized packets on all its ports and uplinks and also drawing 100 percent PoE load .

5 Percent Throughput Switch Power Consumption (with 50 percent PoE loads).

The numbers indicate the power consumed by a typical system (the switch and the corresponding PoE loads) under normal conditions. Normal conditions signify a temperature of 25 degrees Celsius, atmospheric pressure in the range of 860 to 1060 mbar and relative humidity from 30 to 75 percent. The numbers below indicate a 5 percent traffic load and 50 percent PoE load on the switch and its uplinks.

Table 4. Management and Standards Support for Cisco Catalyst 3560 Series Switch

Description	Specification	
Management	• BRIDGE-MIB • CISCO-CDP-MIB • CISCO-CLUSTER-MIB • CISCO-CONFIG-MAN-MIB • CISCO-ENTITY-FRU-CONTROL-MIB • CISCO-ENVMON-MIB • CISCO-FLASH-MIB • CISCO-FTP-CLIENT-MIB • CISCO-HSRP-MIB • CISCO-HSRP-EXT-MIB • CISCO-IGMP-FILTER-MIB • CISCO-IMAGE-MIB • CISCO-IP-STAT-MIB • CISCO-L2L3-INTERFACE-CONFIG-MIB • CISCO-MAC-NOTIFICATION-MIB • CISCO-MEMORY-POOL-MIB • CISCO-PAGP-MIB • CISCO-PING-MIB • CISCO-PROCESS-MIB • CISCO-RTTMON-MIB • CISCO-STP-EXTENSIONS-MIB • CISCO-SYSLOG-MIB • CISCO-TCP-MIB • CISCO-VLAN-IFTABLE-RELATIONSHIP-MIB • CISCO-VLAN-MEMBERSHIP-MIB	• CISCO-VTP-MIB • ENTITY-MIB • ETHERLIKE-MIB • IF-MIB • IGMP-MIB • IPMROUTE-MIB • OLD-CISCO-CHASSIS-MIB • OLD-CISCO-FLASH-MIB • OLD-CISCO-INTERFACES-MIB • OLD-CISCO-IP-MIB • OLD-CISCO-SYS-MIB • OLD-CISCO-TCP-MIB • OLD-CISCO-TS-MIB • OSPF-MIB (RFC 1253) • PIM-MIB • RFC1213-MIB • RFC1253-MIB • RMON-MIB • RMON2-MIB • SNMP-FRAMEWORK-MIB • SNMP-MPD-MIB • SNMP-NOTIFICATION-MIB • SNMP-TARGET-MIB • SNMPv2-MIB • TCP-MIB • UDP-MIB
Standards	• IEEE 802.1s • IEEE 802.1w • IEEE 802.1x • IEEE 802.3ad • IEEE 802.3af • IEEE 802.3x full duplex on 10BASE-T, 100BASE-TX, and 1000BASE-T ports • IEEE 802.1D Spanning Tree Protocol • IEEE 802.1p CoS Prioritization • IEEE 802.1Q VLAN • IEEE 802.3 10BASE-T specification • IEEE 802.3u 100BASE-TX specification • IEEE 802.3ab 1000BASE-T specification • IEEE 802.3z 1000BASE-X specification	• 1000BASE-X (SFP) • 1000BASE-SX • 1000BASE-LX/LH • 1000BASE-ZX • 1000BASE-CWDM SFP 1470 nm • 1000BASE-CWDM SFP 1490 nm • 1000BASE-CWDM SFP 1510 nm • 1000BASE-CWDM SFP 1530 nm • 1000BASE-CWDM SFP 1550 nm • 1000BASE-CWDM SFP 1570 nm • 1000BASE-CWDM SFP 1590 nm • 1000BASE-CWDM SFP 1610 nm • RMON I and II standards • SNMPv1, SNMPv2c, and SNMPv3

Table 5. Safety and Compliance

Description	Specification
Safety Certifications	• UL 60950-1, First Edition • CUL to CAN/CSA 22.2 No. 60950-1, First Edition • TUV/GS to EN 60950-1, First Edition • CB to IEC 60950-1 with all country deviations • AS/NZS 60950-1, First Edition • NOM (through partners and distributors) • CE Marking
Electromagnetic Emissions Certifications	• FCC Part 15 Class A • EN 55022 Class A (CISPR22) • EN 55024 (CISPR24) • AS/NZS CISPR22 Class A • CE • CNS 13438 Class A

	• MIC • GOST • China EMC Certifications
Telco	Common Language Equipment Identifier (CLEI) code
Warranty	Limited lifetime warranty

Cisco Services for Access Switching

Cisco and our partners can help you create a robust, dependable Cisco Access Switching solution. The Cisco lifecycle approach to services defines the requisite activities at each phase of the solution lifecycle. Assessments help align your solution to business goals and gauge readiness to support new technology. Effective planning and design expedite solution adoption. Award-winning technical support increases operational efficiency, and optimization improves performance, resiliency, stability, and predictability and prepares your network and teams for change. For more information, visit http://www.cisco.com/go/services.

Table 6. Cisco Services and Support Programs

Service and Support	Features	Benefits
Advanced Services		
• Cisco Total Implementation Solutions (TIS), available direct from Cisco • Cisco Packaged TIS, available through resellers • Cisco SMARTnet® and SMARTnet Onsite support, available direct from Cisco • Cisco Packaged SMARTnet support program, available through resellers	• Project management • Site survey, configuration, and deployment • Installation, text, and cutover • Training • Major moves, adds, and changes • Design review and product staging • Access to software updates 24 hours • Web access to technical repositories • Telephone support through the Cisco Technical Assistance Center (TAC) • Advance Replacement of hardware parts	• Supplements existing staff • Helps ensure that functions meet needs • Mitigates risk • Helps enable proactive or expedited issue resolution • Lowers TCO by taking advantage of Cisco expertise and knowledge • Minimizes network downtime

Ordering Information

Table 7 gives ordering information for the Cisco Catalyst 3560 Series switches.

Table 7. Ordering Information for Cisco Catalyst 3560 Series Switches

Part Numbers	Description
WS-C3560-8PC-S	• 8 Ethernet 10/100 ports and 1 dual-purpose 10/100/1000 and SFP port • Compact form-factor with no fan • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard Power over Ethernet • IP Base software feature set (IPB)
WS-C3560-12PC-S	• 12 Ethernet 10/100 ports and 1 dual-purpose 10/100/1000 and SFP port • Compact form-factor with no fan • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard Power over Ethernet • IP Base software feature set (IPB)
WS-C3560-24TS-S	• 24 Ethernet 10/100 ports and 2 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IP Base software feature set (IPB)
WS-C3560-24TS-E	• 24 Ethernet 10/100 ports and 2 SFP-based Gigabit Ethernet ports • RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge

	• IP Services software feature set (IPS) • Provides full IPv6 dynamic routing
WS-C3560-48TS-S	• 48 Ethernet 10/100 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IP Base software feature set (IPB)
WS-C3560-48TS-E	• 48 Ethernet 10/100 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IP Services software feature set (IPS) • Provides full IPv6 dynamic routing
WS-C3560-24PS-S	• 24 Ethernet 10/100 ports and 2 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard Power over Ethernet • IP Base software feature set (IPB)
WS-C3560-24PS-E	• 24 Ethernet 10/100 ports and 2 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard Power over Ethernet • IP Services software feature set (IPS) • Provides full IPv6 dynamic routing
WS-C3560-48PS-S	• 48 Ethernet 10/100 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard Power over Ethernet • IP Base software feature set (IPB)
WS-C3560-48PS-E	• 48 Ethernet 10/100 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard Power over Ethernet • IP Services software feature set (IPS) • Provides full IPv6 dynamic routing
WS-C3560G-24TS-S	• 24 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IP Base software feature set (IPB)
WS-C3560G-24TS-E	• 24 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IP Services software feature set (IPS) • Provides full IPv6 dynamic routing
WS-C3560G-48TS-S	• 48 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IP Base software feature set (IPB)
WS-C3560G-48TS-E	• 48 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IP Services software feature set (IPS) • Provides full IPv6 dynamic routing
WS-C3560G-24PS-S	• 24 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard • IP Base software feature set (IPB)
WS-C3560G-24PS-E	• 24 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports

	• 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard Power over Ethernet • IP Services software feature set (IPS) • Provides full IPv6 dynamic routing
WS-C3560G-48PS-S	• 48 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard Power over Ethernet • IP Base software feature set (IPB)
WS-C3560G-48PS-E	• 48 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports • 1RU fixed-configuration, multilayer switch • Enterprise-class intelligent services delivered to the network edge • IEEE 802.3af and Cisco prestandard Power over Ethernet • IP Services software feature set (IPS) • Provides full IPv6 dynamic routing
CD-3560G-EMI=	• IP Services License (formerly EMI) upgrade kit for IP Base versions of the Cisco Catalyst 3560G-24TS, Catalyst 3560G-24PS, Catalyst 3560G-48TS and Catalyst 3560G-48PS • Advanced IPv6 routing
CD-3560-EMI=	• IP Services License (formerly EMI) upgrade kit for IP Base versions of the Cisco Catalyst 3560-24PS, Catalyst 3560-48PS, Catalyst 3560-24TS, Catalyst 3560-48TS, and Catalyst 3560-8PC • Advanced IPv6 routing
PWR-RPS2300	Cisco RPS 2300 with one connector cable
RCKMNT-1RU=	Spare rack-mount kit for the Cisco Catalyst 3560
RCKMNT-REC-1RU=	1RU recessed rack-mount kit for the Cisco Catalyst 3560
RCKMNT-19-CMPCT=	Rack-mount kit for the Cisco Catalyst 3560-8PC and Catalyst 3560-12PC compact switches
CBLGRD-C3560-8PC=	Cable guard for the Cisco Catalyst 3560-8PC compact switch
CBLGRD-C3560-12PC=	Cable guard for the Cisco Catalyst 3560-12PC compact switch
GLC-LH-SM=	1000BASE-LX/LH SFP transceiver module for MMF and SMF, 1300-nm wavelength
GLC-SX-MM=	1000BASE-SX SFP transceiver module for MMF, 850-nm wavelength
GLC-ZX-SM=	1000BASE-ZX SFP transceiver module for SMF, 1550-nm wavelength
GLC-T=	1000BASE-T SFP transceiver module for Category 5 copper wire Not supported on the Cisco Catalyst 3560-8PC compact switch
GLC-BX-D=	1000BASE-BX10 SFP transceiver module for single strand SMF, 1490-nm TX / 1310-nm RX wavelength
GLC-BX-U=	1000BASE-BX10 SFP transceiver module for single strand SMF, 1310-nm TX / 1490-nm RX wavelength
GLC-GE-100FX=	• 100BASE-FX SFP transceiver module for Gigabit Ethernet ports, 1310 nm wavelength, 2 km over MMF • Not supported on the Cisco Catalyst 3560-8PC and Catalyst 3560-12PC compact switches
GLC-FE-100FX=	• 100BASE-FX SFP transceiver module for 100-Mb ports, 1310 nm wavelength, 2 km over MMF • Only supported on the Cisco Catalyst 3560-8PC and Catalyst 3560-12PC compact switches
GLC-FE-100LX=	• 100BASE-FX SFP transceiver module for 100-Mb ports, 1310 nm wavelength, 10 km over SMF • Only supported on the Cisco Catalyst 3560-8PC and Catalyst 3560-12PC compact switches
GLC-FE-100BX-D=	• 100BASE-BX10-D SFP transceiver module for 100-Mb ports, 1550 nm TX /1310 nm RX wavelength, 10 km over single-strand SMF • Only supported on the Cisco Catalyst 3560-8PC and Catalyst 3560-12PC compact switches

GLC-FE-100BX-U=	• 100BASE-BX10-U SFP transceiver module for 100-Mb ports, 1310 nm TX/1550 nm RX wavelength, 10 km over single-strand SMF • Only supported on the Cisco Catalyst 3560-8PC and Catalyst 3560-12PC compact switches
CWDM-SFP-1470=	Cisco CWDM SFP 1470 nm; Gigabit Ethernet and 1G/2G FC (gray)
CWDM-SFP-1490=	Cisco CWDM SFP, 1490 nm; Gigabit Ethernet and 1G/2G FC (violet)
CWDM-SFP-1510=	Cisco CWDM SFP, 1510 nm; Gigabit Ethernet and 1G/2G FC (blue)
CWDM-SFP-1530=	Cisco CWDM SFP, 1530 nm; Gigabit Ethernet and 1G/2G FC (green)
CWDM-SFP-1550=	Cisco CWDM SFP, 1550 nm; Gigabit Ethernet and 1G/2G FC (yellow)
CWDM-SFP-1570=	Cisco CWDM SFP, 1570 nm; Gigabit Ethernet and 1G/2G FC (orange)
CWDM-SFP-1590=	Cisco CWDM SFP, 1590 nm; Gigabit Ethernet and 1G/2G FC (red)
DWDM-SFP-3033=	DWDM SFP 1530.33 nm SFP (100 GHz ITU grid)
DWDM-SFP-3112=	DWDM SFP 1531.12 nm SFP (100 GHz ITU grid)
DWDM-SFP-3190=	DWDM SFP 1531.90 nm SFP (100 GHz ITU grid)
DWDM-SFP-3268=	DWDM SFP 1532.68 nm SFP (100 GHz ITU grid)
DWDM-SFP-3425=	DWDM SFP 1534.25 nm SFP (100 GHz ITU grid)
DWDM-SFP-3504=	DWDM SFP 1535.04 nm SFP (100 GHz ITU grid)
DWDM-SFP-3582=	DWDM SFP 1535.82 nm SFP (100 GHz ITU grid)
DWDM-SFP-3661=	DWDM SFP 1536.61 nm SFP (100 GHz ITU grid)
DWDM-SFP-3819=	DWDM SFP 1538.19 nm SFP (100 GHz ITU grid)
DWDM-SFP-3898=	DWDM SFP 1538.98 nm SFP (100 GHz ITU grid)
DWDM-SFP-3977=	DWDM SFP 1539.77 nm SFP (100 GHz ITU grid)
DWDM-SFP-4056=	DWDM SFP 1540.56 nm SFP (100 GHz ITU grid)
DWDM-SFP-4214=	DWDM SFP 1542.14 nm SFP (100 GHz ITU grid)
DWDM-SFP-4294=	DWDM SFP 1542.94 nm SFP (100 GHz ITU grid)
DWDM-SFP-4373=	DWDM SFP 1543.73 nm SFP (100 GHz ITU grid)
DWDM-SFP-4453=	DWDM SFP 1544.53 nm SFP (100 GHz ITU grid)
CWDM-SFP-1610=	Cisco CWDM SFP, 1610 nm; Gigabit Ethernet and 1G/2G FC (brown)
CAB-SFP-50CM=	Cisco Catalyst 3560 SFP Interconnect Cable (50 dcm)
CAB-SM-LCSC-1M	1m-fiber single-mode LC-to-SC connectors
CAB-SM-LCSC-5M	5m-fiber single-mode LC-to-SC connectors

For more information about Cisco products, contact:

- United States and Canada: (toll free) 800 553-NETS (6387)
- Europe: 32 2 778 4242
- Australia: 612 9935 4107
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Americas Headquarters
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Singapore

Europe Headquarters
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Amsterdam, The Netherlands

Cisco has more than 200 offices worldwide. Addresses, phone numbers, and fax numbers are listed on the Cisco Website at www.cisco.com/go/offices.

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D.7. Firewall Palo Alto Networks PA-2050

PA-2000 Series

Key PA-2000 Series next-generation firewall features:

CLASSIFY ALL APPLICATIONS, ON ALL PORTS, ALL THE TIME WITH APP-ID™.

- Identify the application, regardless of port, encryption (SSL or SSH) or evasive technique employed.
- Use the application, not the port, as the basis for all safe enablement policy decisions: allow, deny, schedule, inspect, apply traffic shaping.
- Categorize unidentified applications for policy control, threat forensics, custom App-ID creation, or packet capture for App-ID development.

EXTEND SAFE APPLICATION ENABLEMENT POLICIES TO ANY USER, AT ANY LOCATION, WITH USER-ID™ AND GLOBALPROTECT™.

- Agentless integration with Active Directory, LDAP, eDirectory Citrix and Microsoft Terminal Services.
- Integrate with NAC, 802.1X wireless and other non-standard user repositories with an XML API.
- Deploy consistent policies to local and remote users running Microsoft Windows, Mac OS X, Linux, Android or iOS platforms.

PROTECT AGAINST ALL THREATS—BOTH KNOWN AND UNKNOWN—WITH CONTENT-ID™ AND WILDFIRE™.

- Block a range of known threats including exploits, malware and spyware, across all ports, regardless of common threat evasion tactics employed.
- Limit unauthorized transfer of files and sensitive data, and control non-work-related web surfing.
- Identify unknown malware, analyze for more than 100 malicious behaviors, automatically create and deliver a signature in the next available update.

paloalto NETWORKS
the network security company™


PA-2050


PA-2020

The Palo Alto Networks™ PA-2000 Series is comprised of two high performance platforms, the PA-2050 and the PA-2020, both of which are targeted at high speed Internet gateway deployments. The PA-2000 Series manages network traffic flows using dedicated processing and memory for networking, security, threat prevention and management.

The high speed backplane is divided into separate data and control planes, thereby ensuring that management access is always available, irrespective of the traffic load. The controlling element of the PA-2000 Series is PAN-OS™, a security-specific operating system that allows organizations to safely enable applications using App-ID, User-ID, Content-ID, GlobalProtect, and WildFire.

PERFORMANCE AND CAPACITIES[1]	PA-2050	PA-2020
Firewall throughput (App-ID enabled)	1 Gbps	500 Mbps
Threat prevention throughput	500 Mbps	200 Mbps
IPSec VPN throughput	300 Mbps	200 Mbps
New sessions per second	15,000	15,000
Max sessions	250,000	125,000
IPSec VPN tunnels/tunnel interfaces	2,000	1,000
GlobalProtect (SSL VPN) concurrent users	1,000	500
SSL decrypt sessions	1,000	1,000
SSL inbound certificates	25	25
Virtual routers	10	10
Virtual systems (base/max2)	1/6	1/6
Security zones	40	40
Max. number of policies	5,000	2,500

[1] Performance and capacities are measured under ideal testing conditions using PAN-OS 5.0.

[2] Adding virtual systems to the base quantity requires a separately purchased license.

For a complete description of the PA-2000 Series next-generation firewall feature set, please visit www.paloaltonetworks.com/literature.

HARDWARE SPECIFICATIONS

I/O

- PA-2050: (16) 10/100/1000, (4) SFP optical gigabit
- PA-2020: (12) 10/100/1000, (2) SFP optical gigabit

MANAGEMENT I/O

- (1) 10/100/1000 out-of-band management port, (1) RJ-45 console port

STORAGE CAPACITY

- 160GB HDD

POWER SUPPLY (AVG/MAX POWER CONSUMPTION)

- 250W (105W/120W)

MAX BTU/HR

- 409

INPUT VOLTAGE (INPUT FREQUENCY)

- 100-240VAC (50-60Hz)

MAX CURRENT CONSUMPTION

- 1.5A@100VAC

MEAN TIME BETWEEN FAILURE (MTBF)

- 7.3 years

MAX INRUSH CURRENT

- 70A@230VAC; 35A@115VAC

RACK MOUNTABLE (DIMENSIONS)

- 1U, 19" standard rack (1.75"H x 17"D x 17"W)

WEIGHT (STAND ALONE DEVICE/AS SHIPPED)

- 15lbs/20lbs

SAFETY

- UL, CUL, CB

EMI

- FCC Class A, CE Class A, VCCI Class A, TUV

CERTIFICATIONS

- FIPS 140 Level 2, Common Criteria EAL2, ICSA, UCAPL

ENVIRONMENT

- Operating temperature: 32 to 122 F, 0 to 50 C
- Non-operating temperature: -4 to 158 F, -20 to 70 C

NETWORKING

INTERFACE MODES

- L2, L3, Tap, Virtual wire (transparent mode)

ROUTING

- Modes: OSPF, RIP, BGP, Static
- Forwarding table size (entries per device/per VR): 5,000/2,500 (PA-2050), 2,500/2,500 (PA-2020)
- Policy-based forwarding
- Point-to-Point Protocol over Ethernet (PPPoE)
- Multicast: PIM-SM, PIM-SSM, IGMP v1, v2, and v3

HIGH AVAILABILITY

- Modes: Active/Active, Active/Passive
- Failure detection: Path monitoring, Interface monitoring

ADDRESS ASSIGNMENT

- Address assignment for device: DHCP Client/PPPoE/Static
- Address assignment for users: DHCP Server/DHCP Relay/Static

IPV6

- L2, L3, tap, virtual wire (transparent mode)
- Features: App-ID, User-ID, Content-ID, WildFire and SSL decryption

VLANS

- 802.1q VLAN tags per device/per interface: 4,094/4,094
- Max interfaces: 2,048 (PA-2050), 1,024 (PA-2020)
- Aggregate interfaces (802.3ad)

NAT/PAT

- Max NAT rules: 1,000
- Max NAT rules (DIPP): 200
- Dynamic IP and port pool: 254
- Dynamic IP pool: 16,234
- NAT Modes: 1:1 NAT, n:n NAT, m:n NAT
- DIPP oversubscription (Unique destination IPs per source port and IP): 2
- NAT64

VIRTUAL WIRE

- Max virtual wires: 1,024 (PA-2050), 512 (PA-2020)
- Interface types mapped to virtual wires: physical and subinterfaces

L2 FORWARDING

- ARP table size/device: 2,500 (PA-2050), 1,000 (PA-2020)
- MAC table size/device: 2,500 (PA-2050), 1,000 (PA-2020)
- IPv6 neighbor table size: 1,000

SECURITY

FIREWALL

- Policy-based control over applications, users and content
- Fragmented packet protection
- Reconnaissance scan protection
- Denial of Service (DoS)/Distributed Denial of Services (DDoS) protection
- Decryption: SSL (inbound and outbound), SSH

WILDFIRE

- Identify and analyze targeted and unknown files for more than 100 malicious behaviors
- Generate and automatically deliver protection for newly discovered malware via signature updates
- Signature update delivery in less than 1 hour, integrated logging/reporting; access to WildFire API for programmatic submission of up to 100 samples per day and up to 1,000 report queries by file hash per day (Subscription Required)

FILE AND DATA FILTERING

- File transfer: Bi-directional control over more than 60 unique file types
- Data transfer: Bi-directional control over unauthorized transfer of CC# and SSN
- Drive-by download protection

USER INTEGRATION (USER-ID)

- Microsoft Active Directory, Novell eDirectory, Sun One and other LDAP-based directories
- Microsoft Windows Server 2003/2008/2008r2, Microsoft Exchange Server 2003/2007/2010
- Microsoft Terminal Services, Citrix XenApp
- XML API to facilitate integration with non-standard user repositories

IPSEC VPN (SITE-TO-SITE)

- Key Exchange: Manual key, IKE v1
- Encryption: 3DES, AES (128-bit, 192-bit, 256-bit)
- Authentication: MD5, SHA-1, SHA-256, SHA-384, SHA-512
- Dynamic VPN tunnel creation (GlobalProtect)

THREAT PREVENTION (SUBSCRIPTION REQUIRED)

- Application, operating system vulnerability exploit protection
- Stream-based protection against viruses (including those embedded in HTML, Javascript, PDF and compressed), spyware, worms

URL FILTERING (SUBSCRIPTION REQUIRED)

- Pre-defined and custom URL categories
- Device cache for most recently accessed URLs
- URL category as part of match criteria for security policies
- Browse time information

QUALITY OF SERVICE (QOS)

- Policy-based traffic shaping by application, user, source, destination, interface, IPSec VPN tunnel and more
- 8 traffic classes with guaranteed, maximum and priority bandwidth parameters
- Real-time bandwidth monitor
- Per policy diffserv marking
- Physical interfaces supported for QoS: 4

SSL VPN/REMOTE ACCESS (GLOBALPROTECT)

- GlobalProtect Gateway
- GlobalProtect Portal
- Transport: IPSec with SSL fall-back
- Authentication: LDAP, SecurID, or local DB
- Client OS: Mac OS X 10.6, 10.7 (32/64 bit), 10.8 (32/64 bit), Windows XP, Windows Vista (32/64 bit), Windows 7 (32/64 bit)
- Third party client support: Apple iOS, Android 4.0 and greater, VPNC IPSec for Linux

MANAGEMENT, REPORTING, VISIBILITY TOOLS

- Integrated web interface, CLI or central management (Panorama)
- Multi-language user interface
- Syslog, Netflow v9 and SNMP v2/v3
- XML-based REST API
- Graphical summary of applications, URL categories, threats and data (ACC)
- View, filter and export traffic, threat, WildFire, URL, and data filtering logs
- Fully customizable reporting

For a complete description of the PA-2000 Series next-generation firewall feature set, please visit www.paloaltonetworks.com/literature.

paloalto NETWORKS
the network security company™

3300 Olcott Street
Santa Clara, CA 95054

Main: +1.408.573.4000
Sales: +1.866.320.4788
Support: +1.866.898.9087

www.paloaltonetworks.com

D.8. Servidor Dell PowerEdge R410

Dell PowerEdge R410

The Dell™ PowerEdge™ R410 was developed with a purposeful design—energy-optimized technology, advanced virtualization capabilities, and simplified systems management.

The Dell PowerEdge R410 is a powerful and ultra-dense 2-socket 1U server that offers the performance of Intel® Xeon® processor 5500 and 5600 series, DDR3 memory, the availability of up to four hard drives (3.5" or 2.5"), and an exceptional value.

The PowerEdge R410 features include an available "open" HPCC (High Performance Computing Cluster) software stack, excellent diagnostics with an interactive LCD, and an optimum chassis depth of 24" for space-constrained data centers and HPCC environments.

Purposeful Design

The PowerEdge R410 takes advantage of Dell's outstanding system commonality and reliability. Quick-release rack latching and purposeful placement of interface ports and power supplies enable easy installation and redeployment. Robust metal hard drive carriers and an all steel control arm can further increase structural integrity.

The purposeful design of the PowerEdge R410 provides reduced complexity, showcasing clutter-free cable routing for more efficient airflow and easier maintenance. An LCD screen positioned by the front of the bezel provides aisle-level access to deploy the server.

Energy-Optimized Technology

The PowerEdge R410 features energy-tuned technologies that reduce power consumption while increasing performance capacity so you can compute more while consuming less. The energy-efficient power supply units are right-sized for system requirements, with improved system-level design efficiency, policy-driven power and thermal management, and highly efficient standards-based Energy Smart components. A robust fan cage design with single-pull fan modules provides efficient airflow and eases maintenance. Energy efficient and compact, the PowerEdge R410 is designed with value and reliability for HPCC environments.

Simplified Systems Management

The next-generation of Dell OpenManage™ suite of management tools is designed to provide efficient operations and standards-based commands that integrate with existing systems for effective control.

Dell Management Console (DMC) powered by Altiris™ from Symantec™ helps simplify operations and create stability by shrinking infrastructure management to one console. This console delivers a single view and a common data source into the entire infrastructure management. DMC has an easily extensible, modular foundation that can provide basic hardware management or more advanced functions, such as asset and security management. Dell Management Console is designed to reduce or eliminate manual processes, enabling you to save time and money for more strategic technology usage.

Secure and efficient, the Dell Lifecycle Controller delivers integrated manageability through a single access point. The Unified Server Configurator (USC) interface enables easy access to the tool which is embedded and integrated into the system for significant flexibility and capability. The Lifecycle Controller is an integrated interface for deploying operating systems with built-in driver installations, BIOS and firmware update and rollback, hardware configuration, and diagnostics.

Dell Services

Dell Services can help reduce IT complexity, lower costs, and eliminate inefficiencies by making IT and business solutions work harder for you. The Dell Services team takes a holistic view of your needs and designs solutions for your environment and business objectives while leveraging proven delivery methods, local talent, and in-depth domain knowledge for the lowest TCO.

Energy efficient and compact, the PowerEdge R410 is designed with the performance and reliability needed for High Performance Computing.

Feature	Technical Specification	
Form Factor	1U rack	
Processors	Quad-core or six-core Intel® Xeon® processor 5500 and 5600 series	
Processor Sockets	2	
Front Side Bus or HyperTransport	Intel® QuickPath Interconnect (QPI)	
Cache	Up to 12MB	
Chipset	Intel® 5500	
Memory[1]	Up to 128GB (8 DIMM slots): 1GB/2GB/4GB/8GB/16GB DDR3 up to 1333MHz	
I/O Slots	**1 PCIe G2 slot + 1 storage slot:** One x16 slot One storage x4 slot	
RAID Controller	**Internal:** PERC H200 (6Gb/s) PERC H700 (6Gb/s) with 512MB battery-backed cache; 512MB, 1GB Non-Volatile battery-backed cache SAS 6/iR PERC 6/i with 256MB battery-backed cache PERC S100 (software based) PERC S300 (software based)	**External:** PERC H800 (6Gb/s) with 512MB of battery-backed cache; 512MB, 1GB Non-Volatile battery cache PERC 6/E with 256MB or 512MB of battery-backed cache **External HBAs (non-RAID):** 6Gbps SAS HBA SAS 5/E HBA LSI2032 PCIe SCSI HBA
Drive Bays	**Cabled or hot-swap options available:** 4 x 3.5" cabled hard drives or 4 x 3.5" hot-swap hard drives or 4 x 2.5" hot-swap hard drives and One slim type drive bay for DVD-ROM or DVD+/-RW	
Maximum Internal Storage	Up to 8TB	
Hard Drives[1]	**Hot-plug Hard Drive Options:** 2.5" SATA SSD, SAS (10K) 3.5" SAS (15K), nearline SAS (7.2K), SATA (7.2K) **Cabled Hard Drive Options:** 3.5" SAS (15K, 10K), nearline SAS (7.2K), SATA (7.2K)	
Communications	Embedded Dual-port Broadcom® NetXtreme® II 5716 Gigabit Ethernet Intel® Gigabit ET Dual Port Server Adapter and Intel® Gigabit ET Quad Port Server Adapter Intel® 10GbE NIC Intel® Single Port 1GbE NIC Intel® Dual Port 1GbE NIC	Intel® Quad Port 1GbE NIC Broadcom® 10GbE NIC Broadcom® Dual Port 1GbE NIC Brocade® CNA Dual-port adapter Brocade® FC4 and 8 GB HBAs Emulex® CNA iSCSI HBA stand up adapter OCE10102-IX-D
Power Supply	Non-Redundant, 480W (80+ BRONZE) Optional Redundant, 500W (80+ GOLD)	
Availability	Quad-pack LED Diagnostic or LCD diagnostic with hot-swap HDD chassis; TPM; optional hot-swap hard drives; optional hot-swap redundant power supply; optional PERC 6/i RAID controller with battery-backed cache; toolless hot-swap hard drive chassis	
Video	Integrated Matrox® G200	
Remote Management	BMC, IPMI2.0 compliant Optional iDRAC6 Enterprise, iDRAC6 Express	
Systems Management	Dell™ OpenManage™ Microsoft® System Center Essential (SCE) 2010 v2	
Rack Support	ReadyRails™ sliding rails with optional cable management arm for 4-post racks (optional adapter brackets required for threaded hole racks); ReadyRails™ static rails for 2-post and 4-post racks	
Operating Systems	Microsoft® Windows® Small Business Server 2011 Microsoft® Windows® Small Business Server 2008 Microsoft® Windows Server® 2008 SP2, x86/x64 (x64 includes Hyper-V™) Microsoft® Windows Server® 2008 R2, x64 (includes Hyper-V™ v2) Microsoft® Windows® HPC Server 2008 Novell® SUSE® Linux® Enterprise Server Red Hat® Enterprise Linux® For more information on the specific versions and additions, visit www.dell.com/OSsupport.	
Featured Database Application	Microsoft® SQL Server® solutions (see Dell.com/SQL)	

[1] GB means 1 billion bytes and TB equals 1 trillion bytes; actual capacity varies with preloaded material and operating environment and will be less.

OEM Ready Models Available

OEM Ready platforms are grab-and-go products for OEM customers delivering a fast and simple path to a custom-branded solution. For more information, please visit dell.com/OEM.

Learn more at Dell.com/PowerEdge

D.9. UPS Liebert GXT3 On-Line 5000 VA

AC Power
For *Business-Critical Continuity™*

Liebert® GXT3™, 500VA -3000VA Models

Reliable On-Line UPS Protection In A Compact 2U Package

Liebert GXT3 is a true on-line UPS that delivers continuous, high-quality AC power to IT equipment with no break when transferring to battery. It protects equipment from virtually all power disturbances due to blackouts, brownouts, sags, surges or noise interference. The UPS is available in rack/tower and mini-tower configurations.

One of the most affordable UPS systems in its class, Liebert GXT3 leads the industry in combining small size, high capacity and high reliability features:

- On-line design means zero transfer time from external to internal power. When utility power fails, your critical load remains supported by a seamless flow of power.
- Liebert GXT3 rated output power factor of 0.9 better matches up with switch-mode power supplies used in today's IT equipment.
  A higher output power factor allows for a more efficient utilization of the UPS.
- The UPS provides easy serviceability with user replaceable hot-swappable batteries.
- For maximum control, Liebert GXT3 is custom configurable to your needs using a specially designed Windows software package.
- Trade Compliance: Public sector customers may select from four capacities (1000, 1500, 2000 and 3000 VA, 120V) to provide TAA compliance. Refer to Liebert GXT3-GVG3 models.

Ideally suited for:

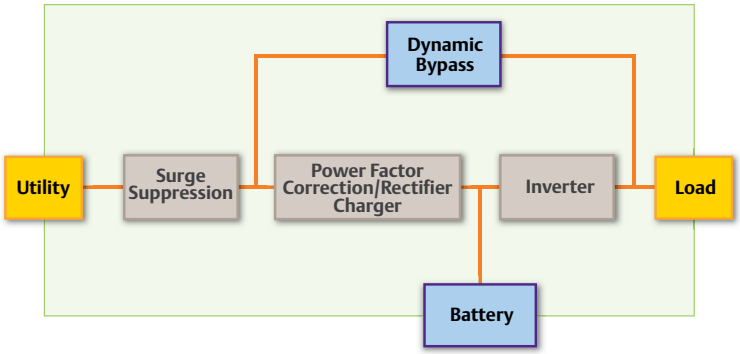
- PCs
- Network workstations
- Servers
- Network closets
- Large network peripherals
- VoIP

EMERSON™
Network Power

The Proven Reliability Of True On-Line Operation Plus The Features You Need Most

Although Liebert® GXT3™ requires just a slim 2U of rack space, it provides the capabilities of a physically larger system. Get up to 3kVA of capacity and battery backup, in 120V or 230V systems. External battery cabinets may be added for extended run time.

On-Line UPS Protection for Essential and Critical Applications



Liebert GXT3 is a true on-line power source, so whatever the quality of power coming in, the pure sinewave output meets the exacting standards of your equipment.

Liebert GXT3 includes:

- Power factor correction
- Internal batteries
- Frequency conversion
- Internal automatic bypass to utility in case of adverse UPS conditions
- Manual bypass capability
- Support for up to four external battery cabinets (rack/tower models)

Liebert GXT3 handles all these potential power problems:

- Power spikes and transients
- EMI/RFI noise
- Voltage sags and brownout conditions
- Harmonics
- Power-factor corrected loads
- Outages
- Frequency variations

Liebert GXT3 Standard Features

Flexibility:

Up To Six Battery-Backed Outlets
A generous quantity of battery-backed outlets allows more equipment to be protected by the UPS.

Rotatable Display Panel
The LED display panel rotates 90° to make the readout of the LED display easy to see in rack or tower position.

Automatic Frequency Sensing
The UPS automatically adjusts to the input frequency, 50Hz or 60Hz.

Mounting Flexibility
Optional telescoping rack rails mount to the sides of the UPS for easy installation into a rack enclosure. A standard tower support base ships with the UPS.

Liebert GXT3 is easily configured for either rackmount or tower applications. The LED display rotates for easy viewing in either orientation.

Liebert® GXT3™ contains internal batteries, and is also able to support up to four external battery cabinets – also 2U size.

Higher Availability:

Advance Early Warning of UPS System Status
Multiple audible and visual alarms immediately alert you to an output overload, low battery, bypass, battery discharge, battery loss or replace battery condition.

4-8 minutes of Battery Backup Time at Full load
Provides ample time for an orderly shutdown of connected equipment when utility power fails. Optional matching external battery cabinets offer additional backup time.

Overload Capability
Designed to handle output overload conditions.

Full Sequenced Battery Testing
Provides automatic and manual self-diagnostic battery testing capabilities. This provides a comprehensive analysis of the condition of the batteries within the UPS and will notify you when the internal batteries need to be replaced.

User Replaceable Hot Swappable Batteries
Easy to replace batteries increase product life and provide prolonged UPS reliability. Batteries are conveniently located behind the front bezel of the unit.

Power-Factor Correction
Prevents noise, harmonics and distortion from being passed on to connected loads or from being fed back to the utility.

Internal Automatic and Manual Bypass Capability
Assures continuity of power to critical loads during system problems or maintenance.

Intelligent Battery Management
Includes efficient three-stage charging technique and comprehensive discharging protection that extends battery life for greater availability.

Input Circuit Breaker
Provides increased protection to ease recovery from overloads.

Lightning and Surge Protection
The transient voltage surge suppression (TVSS) circuitry inside Liebert GXT3 provides additional protection for the connected equipment from incoming spikes, surges, and other power anomalies present on the incoming utility power source.

Lowest Total Cost Of Ownership:

0.9 Output Power Factor
Liebert GXT3 rated output power factor of 0.9 better matches up with switch-mode power supplies used in today's IT equipment. A higher output power factor allows for a more efficient utilization of the UPS.

Wide Input Voltage Window
Prolongs battery life by allowing the UPS to maximize the use of utility power before transferring to battery when input voltage exceeds specified limits.

Intelligent Fan Operation
Automatically changes rotation speed depending on system requirements to decrease power consumption and noise.

Efficient Operation
≥ 88% AC-AC, minimum.

Warranty Protection
The industry's best warranty – No-hassle two-year warranty with UPS replacement in the event of problems. Shipping is free for both original UPS return and the replacement unit. Optional one-year and three-year extensions also available.

Multiple Choices For Communication, Shutdown And Reporting:

SNMP And Web-Based Communication Options
Liebert IntelliSlot® Web Card provides SNMP (including SNMPv3) and IPv.6 and web-based management to your Liebert GXT3. Provides SNMP MIB to monitor and control your UPS from your network management station or any PC running Microsoft Internet Explorer.

- Network shutdown
- Sends both SNMP traps and emails for event notification, and automatically emails a daily UPS history
- Auto-senses 10M/100M Ethernet
- Compatible with shutdown software to ensure graceful computer shutdown

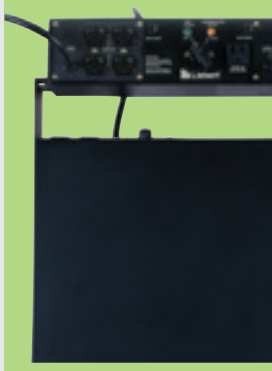
The Liebert GXT3 is also fully compatible with:

- Liebert MultiLink™ shutdown software –included with the Liebert GXT3 UPS
- Liebert Nform™ monitoring software
- Liebert Multiport multiplexing unit
- Liebert Intellislot Relay Interface Card

USB Communications
Windows (98 and later) built-in power management functions provide monitoring of UPS status and manage the automatic orderly shutdown of the computer if a power outage ever exceeds the battery capacity of the UPS. Liebert MultiLink shutdown software can also be used via USB connection.

Optional Liebert MicroPOD Output Distribution And Maintenance Bypass Module
When your computer system can't be without power, even for scheduled UPS maintenance, the Liebert MicroPOD Maintenance Bypass and Output Distribution Unit ensures continuous uptime. It allows you to manually transfer connected equipment to utility power via a maintenance bypass switch, permitting scheduled service or UPS replacement without the need to shut down connected equipment. Features include:

- 2U height minimizes rack space requirements
- Installs with plug-and-play ease
- Two-year, no-hassle replacement warranty



Liebert MicroPOD

Liebert GXT3 mini-tower model provides 1000VA capacity in a compact design.

Specifications

Model Number	GXT3-500RT120	GXT3-700RT120	GXT3-1000RT120 or GVG3-1000RT120	GXT3-1000MT120
Model Rating VA/W	500/450	700/630	1000/900	1000/900
Dimensions: in. (mm) DxWxH	19.7x16.9x3.4 (497x430x85)			15.4x6.9x8.9 (390x175x225)
Weight: lbs. (kg)	44 (20)			
Input AC Parameter				
Voltage Range	120VAC nominal; variable based on output load			
Frequency	40Hz ~ 70Hz; Auto Sensing			
Input Power Cord	10 ft. attached w/ NEMA 5-15P plug			
Output AC Parameter				
Output Receptacles	5-15R x 6			
Voltage	110/115/120/127VAC (user-configurable); ±3%			
Waveform	Sine wave			
Battery				
Full Load	12 minutes	6 minutes	5 minutes	5 minutes
Half Load	30 minutes	14 minutes	15 minutes	15 minutes
Recharge Time	3 Hours to 90% capacity after full discharge with 100% load till UPS auto-shutdown			
Agency				
Safety	UL 1778, cUL Listed			
RFI/EMI	FCC Part 15, Class A=CISPR22 Class B			
Surge Immunity	IEC 62040-2 2nd Ed			
Transportation	ISTA Procedure 1A			

Model Number	GXT3-1500RT120 or GVG3-1500RT120	GXT3-2000RT120 or GVG3-2000RT120	GXT3-3000RT120 or GVG3-3000RT120	GXT3-3000RT208
Model Rating VA/W	1500/1350	2000/1800	3000/2700	3000/2700
Dimensions: in. (mm) DxWxH	19.7x16.9x3.4 (497x430x85)		23.7x16.9x3.4 (602x430x85)	
Weight: lbs. (kg)	48.5 (22)	52.9 (24)	61.7 (28)	61.7 (28)
Input AC Parameter				
Voltage Range	120VAC nominal; variable based on output load			208VAC nominal; variable based on output load
Frequency	40Hz ~ 70Hz; Auto Sensing			
Input Power Cord	10 ft. attached w/ NEMA 5-15P plug	10 ft. attached w/ NEMA 5-20P plug	10 ft. attached w/ NEMA L5-30P plug	10 ft. attached w/ NEMA L6-20P plug
Output AC Parameter				
Output Receptacles	5-15R x 6	5-20R x 6	L5-30Rx1+5-20Rx6	L6-20Rx1+L6-15Rx2
Voltage	110/115/120/127VAC (user-configurable); ±3%			208/220/230/240 VAC (user-configurable); ±3%
Waveform	Sine wave			
Battery				
Full Load	5 minutes	4 minutes	4 minutes	4 minutes
Half Load	16 minutes	11 minutes	14 minutes	14 minutes
Recharge Time	3 Hours to 90% capacity after full discharge with 100% load till UPS auto-shutdown			
Agency				
Safety	UL 1778, cUL Listed			
RFI/EMI	FCC Part 15, Class A=CISPR22 Class B			
Surge Immunity	IEC 62040-2 2nd Ed			
Transportation	ISTA Procedure 1A			

GVG: TAA Compliant versions.

Emerson Network Power
Liebert Corporation World Headquarters
1050 Dearborn Drive
P.O. Box 29186
Columbus, Ohio 43229
United States Of America
800 877 9222 Phone (U.S. & Canada Only)
614 888 0246 Phone (Outside U.S.)
614 841 6022 FAX
Contact@EmersonNetworkPower.com

Emerson Network Power
Caribbean and Latin America
Office – United States of America
+1-954-984-3452 Phone
Ask.Cala@Emerson.com

Emerson Network Power
European Headquarters
Office – Italy
+39 049 9719 111 Phone
+39 049 5841 257 FAX
Marketing.EMEA@EmersonNetworkPower.com

Emerson Network Power
Asia Pacific
Office – Phillipines
+63 2 687 6615
+63 2 730 9572 FAX
Marketing.AP@Emerson.com

liebert.com
24 x 7 Tech Support
800 222 5877 Phone
614 841 6755 (outside U.S.)

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- Surge Protection