Smart Cities

Bruce Collins
Director, Product Management
Vision: Complete Network Lifecycle Management

**cnMaestro**
- Planning
- Network Management
- Inventory Management
- WiFi Controller
- Support & Warranty Services

*From 200 km to 2 m*

**Long Distance:** PTP 650, 820

**Distribution Access:** PMP 450, ePMP

**Edge Access:** cnPilot

- Home + Small Business
- Outdoor Entr
  - Single Band
  - Dual Band
- Indoor Entr
  - 802.11n, 802.11ac Indoor & Outdoor
Market Drivers

• High standards for quality

• Efficiency and economics of automation
  – Reduce loss and waste
  – Reduce service outage and repair times
  – Reduce communication costs
  – Operation continuity / disaster recovery

• Improve operation security
  – Personnel safety
  – Asset protection
  – Cyber threat avoidance
Critical Infrastructure

• Security
  – Reducing the risk to critical infrastructure by physical means or defense cyber measures to intrusions, attacks, or the effects of natural or man-made disasters

• Resilience
  – Prepare for and adapt to changing conditions, withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents
Smart Cities

- High capacity connectivity
- Secure communications
- Affordable and rapidly deployed
- Reliable to perform in harsh conditions
Benefits

• Video surveillance
• Connectivity at special events
• Infrastructure monitoring and control
• Automatic metering infrastructure
• Public WiFi connectivity
• Traffic control and digital signage
• Street light controls
• Parking lot automation
Case Study: HCSO

- City-wide video surveillance of traffic intersections
- Integrated with Automatic License Plate Recognition (ALPR)
- Surveillance of key meeting areas
- Solution
  - PMP 450 unlicensed distribution network
Case Study: Budapest Video Surveillance

- City-wide video surveillance
- Leverages streets as radio transmission conduit
- Installed in a matter of weeks at a fraction of the cost of wired solutions
- Expanding network to add new coverage areas
- Solution
  - ePMP unlicensed distribution network
Case Study: City of Chicago, USA

• Office of Emergency Management Communications (OEMC) deployed city-wide video surveillance

• Wireless connectivity enabled the system to be installed rapidly at a reasonable cost

• Network has performed for years in harsh weather

• Solution
  – PMP 450 distribution network
Case Study: Ramos Arizpe

• City-wide connectivity for 20,000 users
• Connectivity at hospitals, schools, parks, and businesses in a 15 square km area
• Rapidly deployed
• Solution
  – ePMP unlicensed distribution network
  – cnPilot E500 enterprise outdoor WiFi
Case Study: Lorain County Fair

- High-speed connectivity for guests
- Indoor and outdoor WiFi coverage
- PCI wireless security for event vendors
- Leverage for video surveillance

Solution
- PTP 650 unlicensed wireless backhaul
- ePMP unlicensed distribution network
- cnPilot E400 indoor enterprise WiFi
- cnPilot E500 outdoor enterprise WiFi
Case Study: South Asia Games

- 4,500 athletes from eight nations
- Indoor and outdoor coverage for dormitories and venues
- High capacity for spectators and media
- Solution
  - PTP 650 unlicensed backhaul
  - PTP 450 unlicensed backhaul
  - PMP 450 unlicensed distribution
  - cnPilot E400 enterprise indoor WiFi
  - cnPilot E500 enterprise outdoor WiFi
The Cambium Networks Difference

• Spectral Efficiency
• Scalability
• Security
• Reliability
• Total Cost of Ownership
• Sustainability
## PTP Portfolio Overview

The table below provides an overview of the PTP 450i, PTP 650, and PTP 820 models, detailing their features and specifications.

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>PTP 450i</th>
<th>PTP 650</th>
<th>PTP 820</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Bands (GHz)</td>
<td>4.9-5.925 GHz</td>
<td>4.9 – 6.05</td>
<td>6-42</td>
</tr>
<tr>
<td>Technology</td>
<td>TDD</td>
<td>TDD</td>
<td>FDD</td>
</tr>
<tr>
<td>Max. Throughput</td>
<td>125 agg.</td>
<td>450 agg.</td>
<td>1 Gbps+ Full duplex</td>
</tr>
</tbody>
</table>

- **Unlicensed Sub 6GHz**
  - Immediate roll-out
  - No fee
  - LOS/NLOS
  - Low Cost

- **Licensed 6-38 GHz**
  - Licensed spectrum
  - license fee
  - LOS
  - Highest capacity
Dynamic Spectrum Optimization

- Always-on, wide-band spectrum analyzer
- Real-time and historical analytics
- Find available channels; identify sources of interference
- Scans all bands and channels from 4.9 GHz to 6.05 GHz
Security

• Physical Security
  • Detect physical tampering
  • Prevent unauthorized software
  • Encrypt sensitive configuration data
  • Defend against network attacks

• Management Security
  • Prevent unauthorized access
  • Audit trail of changes

• Data Security
  • Encryption of over-the-air data
  • Prevent decoding of network transmissions

• Process Security
  – Gain validation from third parties
Designed for Harsh Environments

- **Wind Survival**
  - 200 mph survivability

- **Dust / Water Intrusion (IP66/67)**
  - Water jets from any direction
  - Immersion in 1 m water
  - Dust tight

- **Salt Fog Environment (MIL-STD-810G)**
  - Tests resistance to corrosion if face of extended exposure to salt spray

- **Shock / Vibration (MIL-STD-810G)**
  - Handling, transportation, long-term deployment
Quick Deploy Positioner

• Applications
  – First responders (public safety / national guard / CIVLEA)
  – Rapid tactical deployment (DoD)
  – Oil/Gas re-alignment after re-location of mast head
  – Cell on wheels / temporary deployments

•Eliminates need for on-site techs
• Tightly integrated all-outdoor solution
• Goes live in <3 minutes
• Compatible with PTP 650, 700, 450i, and PMP 450i
Multipoint Distribution – PMP 450
Dynamic Interference Filtering Technology

Spectrum

Traditional Fixed Filter
Makes radio susceptible to neighboring channel interference

Cambium’s Dynamic Filtering
Wraps around selected channel, filtering out interference from neighboring channels
PMP 450i

• Ultra Wide-band 4900-5925 MHz
  – Supports 4.9, 5.1, and 5.2 MHz

• Enhanced Performance
  – Dynamic interference filtering
  – Increased transmit power
  – Better receive sensitivity

• Rugged IP66/67 Enclosure

• Agile
  – 802.3at PoE compatible
  – Auxiliary port with PoE output
  – 5, 10, 15, 20, 30 and 40 MHz channel
PMP 450m

- Massive MU-MIMO technology
- Industry leading spectral efficiency
  - Delivers 500 Mbps throughput in a 20 MHz channel
- Links with up to 7 SMs simultaneously
- Increases sector capacity by 3 – 4X
- Improved performance in high interference
- Uses current PMP 450 SMs
Superior Performance in Real World Conditions

• Unlicensed spectrum is congested!

• eFortify technology increases interference tolerance to provide higher performance and consistent latency under external interference

• GPS Synchronization provides a solid foundation for your network’s deployment and growth

• Rate adapt algorithms adjust radio operation automatically to boost performance and resiliency
GPS Synchronization Allows for Frequency Re-use

Within Sectorized Site

One Site with 2 Channels

Across Contiguous Network

The Entire Network with 4 Channels
ePMP 2000 Access Point with Intelligent Filtering

- Next Generation ePMP Access Point
- Frequency reuse via GPS synchronization
- Supports up to 120 SMs
- Available in Lite (10 SM) or Full models
  - License Key to upgrade Lite to Full
- 802.3at compliant gigabit Ethernet port
- Wide Frequency range: 5150 – 5970 MHz
- Intelligent Filtering to reduce impact of off-channel interferers
- Interface to optional Smart Antenna
Intelligently managed, Affordable, Quick to deploy & Easy to Operate

Wi-Fi for

Enterprise
Indoor, Outdoor

Service Providers
Indoor

Industrial
Indoor, Outdoor
cnPilot Applications

HOMES
RETAIL
PUBLIC WIFI
SCHOOLS
INDUSTRIAL WiFi

cnPilot Controller Managed WiFi
cnPilot E400 Enterprise Indoor AP

• RF
  – 802.11a/b/g/n/ac
  – 2x2 MIMO
  – 2.4/5 GHz
  – Max TX power = 24/25 dB

• Physical
  – Dimensions: 180x180x26-31mm
  – Software controlled LED
  – Operating temp 0-45º C

• Installation
  – Installable shoes for table mount
  – Detached back-plate for easy ceiling mount

• Port – 802.3af PoE gigabit
cnPilot E500 Enterprise Outdoor AP

• RF
  – 802.11a/b/g/n/ac
  – 2x2 MIMO
  – 2.4/5 GHz
  – Max TX power
    • 28 dBm @ 2.4 GHz
    • 29 dBm @ 5 GHz
  – LTE co-existence filter
  – Ruggedized circuitry

• Physical
  – 200x162x40mm
  – 881g
cnPilot ePMP Hotspot

• Hardware
  – Proven in the field – as ePMP and hotspot Access Point
  – Single band 802.11n – 2.4 & 5 GHz models
  – Can be converted to a Backhaul AP or SM or vice versa
  – Versatile – Ethernet or wireless backhaul

• Specifications
  • 2 10/100 Ethernet ports
  • Power consumption: 5W (typical)/7W (max)
  • Weight < 0.5 Kg
  • Dimensions: 30x15x9
  • Certification: IP55
  • Canopy PoE out PMP 450/ePMP
  • Temperature rating: -30° C ~ + 60° C
  • Single Band 802.11n [2.4, or 5 GHz]
IIoT Connectivity - cnReach™
# cnReach Narrow-Band Platform

## Deployment Flexibility
- PTP/PMP/Store-and-Forward Relay
- Optional digital / analog I/O
- Dual-band 900 MHz (MAS / ISM)
- Dual-radio options

## Reliability
- 100% factory testing over temperature
- ATEX/HAZLOC
- Made in the USA

## Low Power Consumption
Simple integration with existing power (including solar)

## Scalable
- Access Point synchronization
- Adaptive modulation

## Secure
- 128/256-bit AES encryption

## Manageable
- Cloud or NOC-based cnMaestro
- LINKPlanner planning and BOMs
## cnReach 900 MHz Narrow-Band Radio

<table>
<thead>
<tr>
<th></th>
<th>MAS Licensed</th>
<th>ISM Unlicensed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>928 – 960 MHz</td>
<td>902 - 928 MHz</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>10 mW to 3W</td>
<td>10 mW to 1W</td>
</tr>
<tr>
<td><strong>Channel Sizes</strong></td>
<td>12.5 / 25 / 50 kHz</td>
<td>76 / 154 / 207 / 310 / 600 / 900 / 1200 kHz</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>10 kbps – 210 kbps</td>
<td>57 kbps – 4.4 Mbps</td>
</tr>
<tr>
<td><strong>Modulations</strong></td>
<td>Up to 32QAM</td>
<td>Up to 64QAM</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>Up to 70 miles</td>
<td></td>
</tr>
<tr>
<td><strong>Encryption</strong></td>
<td>128/256-bit AES</td>
<td></td>
</tr>
<tr>
<td><strong>I/O</strong></td>
<td>2 x 10/100 Ethernet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 x Serial Port</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Optional Digital/Analog I/O</td>
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## cnReach 700 MHz Narrow-Band Radio

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<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>757-758 MHz &amp; 787-788 MHz</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>100 mW to 5 W (20 dBm to 37 dBm)</td>
</tr>
<tr>
<td><strong>Channel Sizes</strong></td>
<td>12.5 / 25 / 50 / 100 / 200 / 250 kHz</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>9.6 kbps to 1.0 Mbps</td>
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<td><strong>Modulations</strong></td>
<td>Up to 32QAM</td>
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<tr>
<td></td>
<td>2 x serial port</td>
</tr>
<tr>
<td></td>
<td>Optional digital/analog I/O</td>
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# cnReach 450 MHz Narrow-Band Radio

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cnReach Deployment Topologies – Single/Dual Radios

Point to Point

Point to Multipoint

Store-and-Forward Repeater PTP and PMP
cnReach Connectivity

- RS-232 serial ports with command line interfaces
- RS-422/485 serial bus sensors
- SCADA control systems (DNP3, MODBUS RTU, MODBUS TCP protocols)
- Terminal server/client interfaces
- Ethernet ports for TCP/IP communications
- Analog input signals
- Digital I/O signals
cnReach Data Capabilities

• Switching Fabric
  – Integrated Ethernet switch
  – Static layer 3 routing

• OR
  – Layer 2 flat network
  – VLAN tagging support

• Benefits
  – Keep licensed and unlicensed traffic separate
  – Prevent broadcast data from using narrow-band channels
  – Store-and-forward
  – Shared Serial / IP network
    • Terminal server
    • Terminal client
    • MODBUS RTU server
    • MODBUS TCP
    • DNP3
cnReach Physical Interfaces

- 2 x 10/100 Ethernet
- 2 x serial interfaces
  - RS-232/-422/-485
- 1 or 2 radios
- Optional 8-ports analog/digital I/O
Web-based Management Interface

- Secure web management
- Distributed firmware updates
- File-based configuration backup/restore
End-to-End Network Management - cnMaestro™
cnMaestro End-to-End Management

- Single pane of glass
- Map location of devices
- Hierarchical device organization
- Summary view of UP & DOWN devices
- Sticky alarms – critical, major & minor
cnMaestro Network Troubleshooting

- Preloaded status of all the component of end to end network - from mobile device having problem to the backhaul
- Remote packet capture and RF analysis tools
- Easily identify the mobile device through their names and manufacturer
• Free network planning software improves success rate of first installation
• Path profile
• Configuration details
  – Bill of materials tailored for each link
• Performance summary
References
Cambium Community

- Learn from network operators around the world
- Community Forum
  - Products
  - Network planning
  - Languages
  - Business issues
- Knowledge Base with technical detail documents
- Submit development ideas
- Real-world connectivity stories
Technical Certification Training

• Certification on all products

• 2-Day classes
  – Certified instructors
  – Live hands-on training
  – Proficiency test

• 8 classes per month

• Courses offered around the world in multiple languages

• Option to take test online to achieve certification
Social Media

- Follow Cambium Networks to get the latest information
- Facebook
- Google+
- Instagram
- LinkedIn
- Twitter
- Weibo
- YouTube