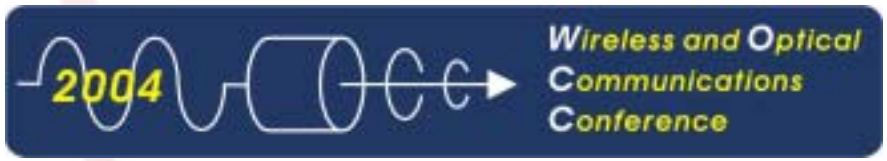


Shared Wireless Distributed Antenna Solution

Dr. Kang Yueh

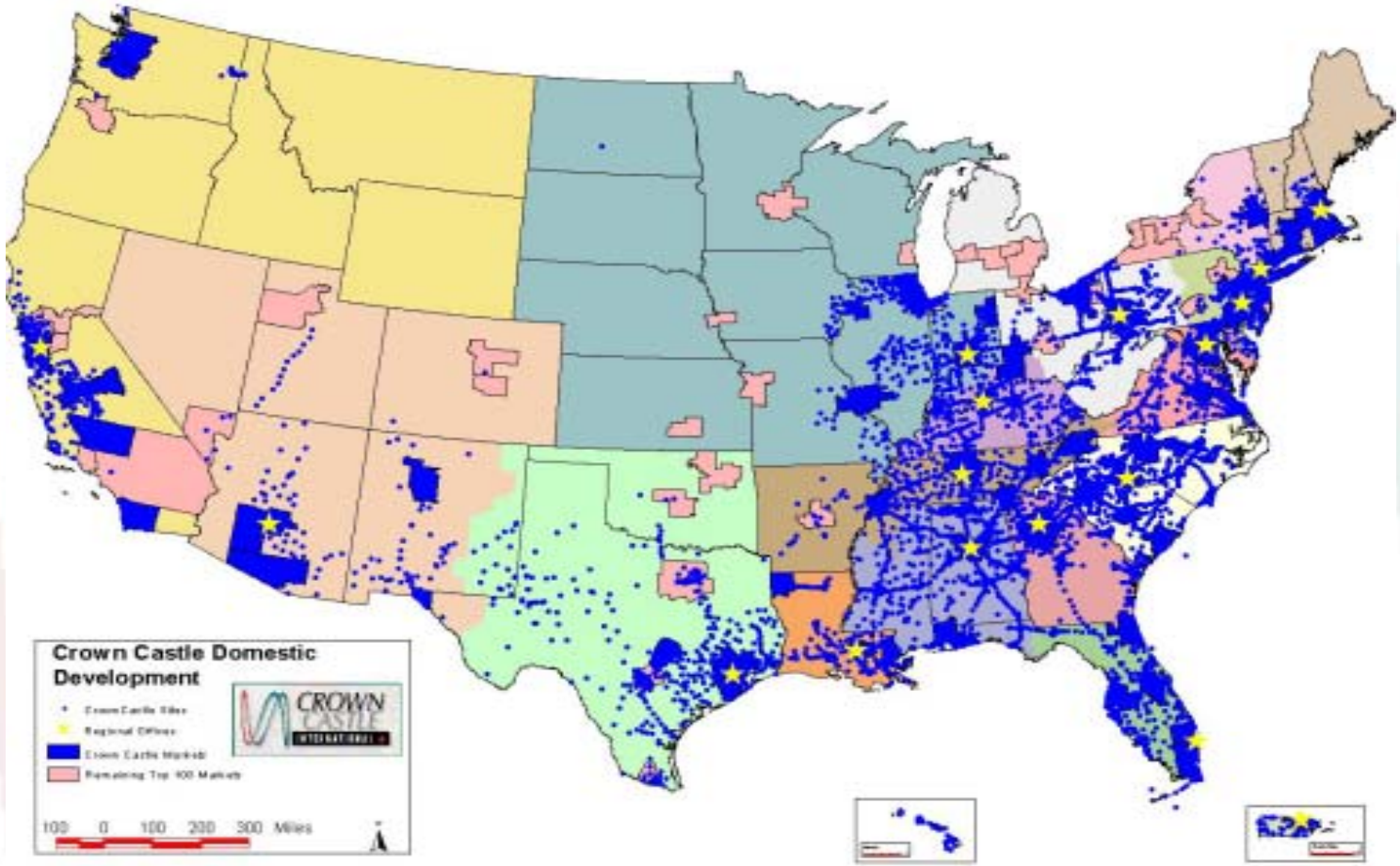
Crown Castle International

March 8, 2004

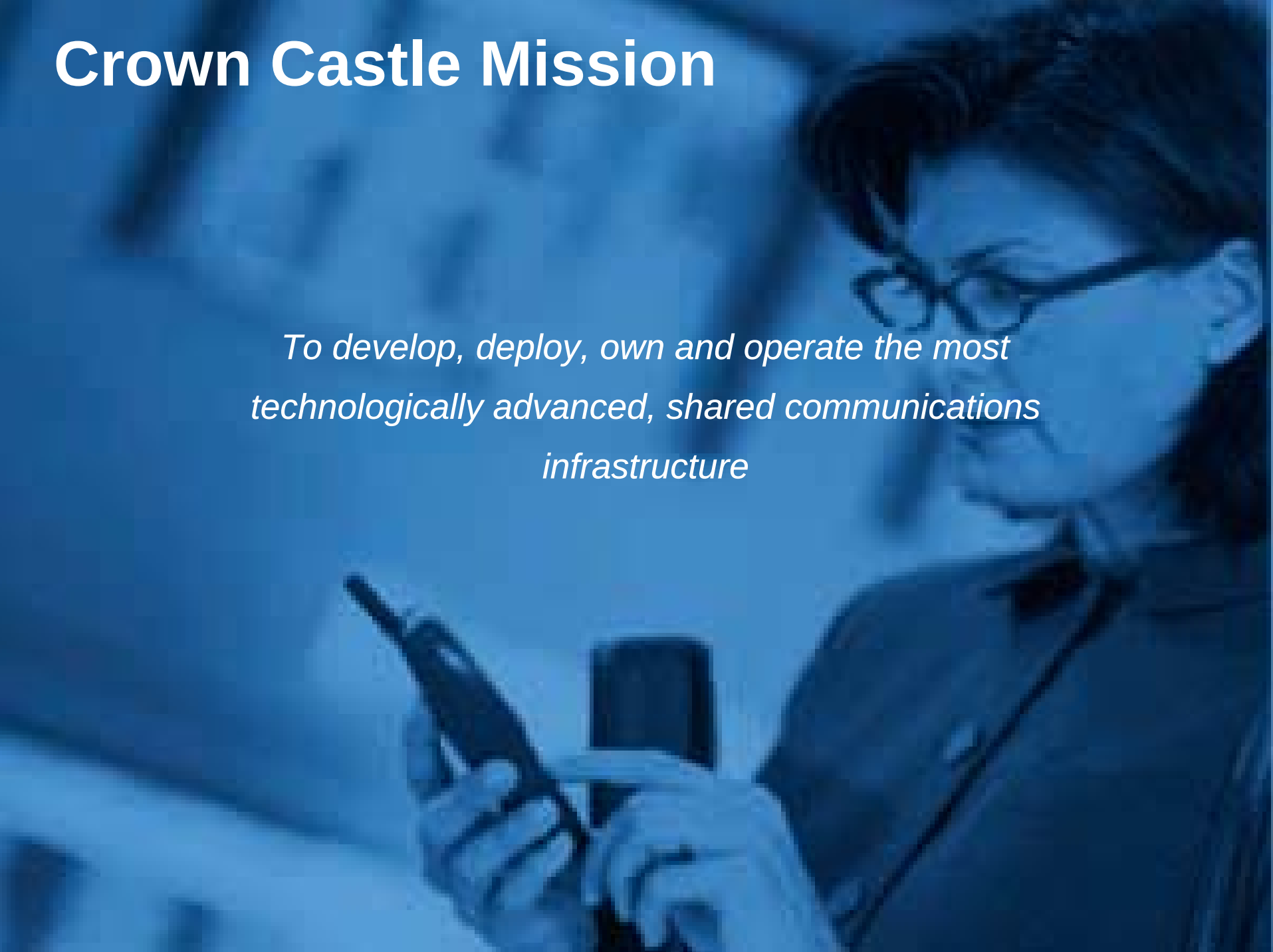
shaping the wireless world sm

Crown Castle - USA Tower Footprint

Over 15,500 towers cover US, UK and Australia



Crown Castle Mission



To develop, deploy, own and operate the most technologically advanced, shared communications infrastructure

Challenges

- **More cell sites and antennas are needed**
  - Keep up with higher demand
  - Provide better coverage
  - Provide 3G data services
- **Local zoning restrictions**
  - Reluctant to grant new cell sites
  - Restrict the antenna tower height
  - Restrict number of antennas on a tower

CROWN CASTLE INTERNATIONAL

Crown Castle Solutions Corp.

Introducing….

OptiNet™

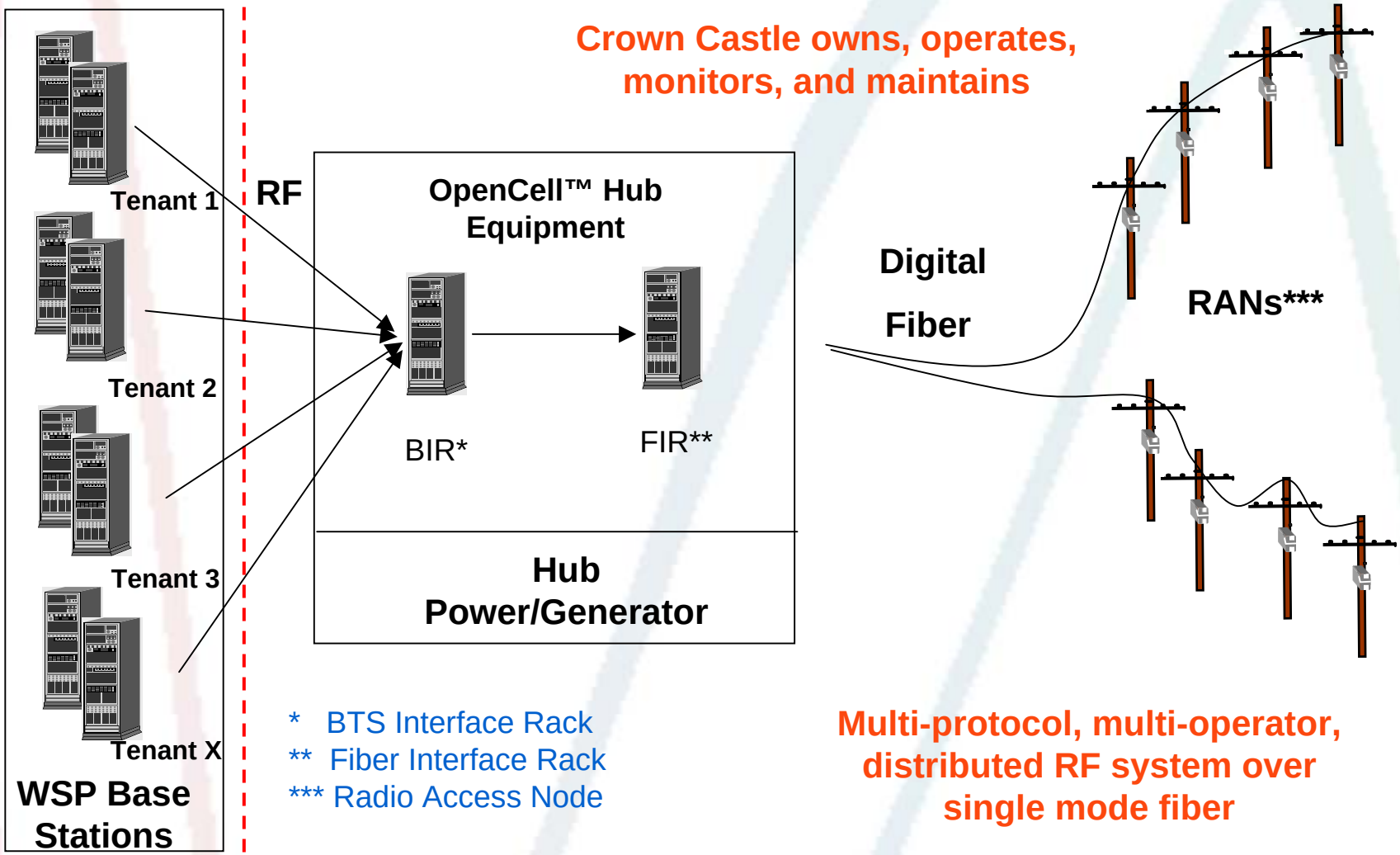
- *OptiNet™ is a Crown Castle Fiber Fed Distributed Antenna Network utilizing the OpenCell™ product and architecture from OpenCell Corp.*

shaping the wireless world℠

OptiNet™ Overview

- Fully digital, fiber-fed distributed antenna system
- Utilizes BTS “Hotel”/Hub concept with digital fiber transport
- Wideband system architecture ensuring 2.5/3G compatibility
- Full turn-key system with robust Network Management System (NMS) and Carrier grade NOC
- Cost effective solution that maintains individual design flexibility and autonomy by Wireless Carrier
- Attractive solution to municipalities due to multi-carrier capability and low visual impact

OptiNet™ Network Overview



OptiNet™ Deployment Scenarios

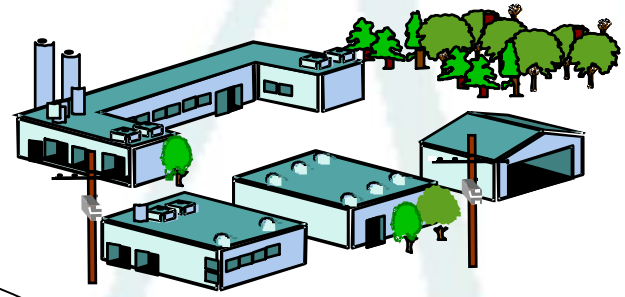
Urban

- **Capacity Relief**
- **Quality Improvement**

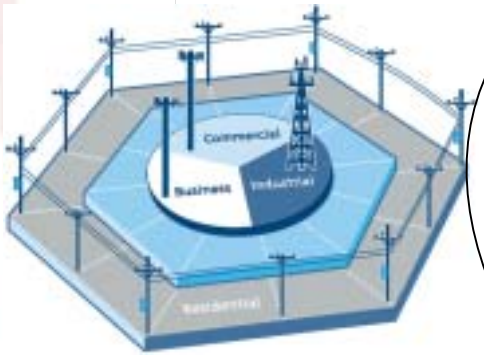
Flexible H/W Placement

- **Building**
- **Light Standards**
- **Utility Poles**

Fiber Loop



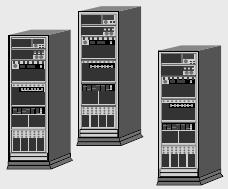
Campus Coverage

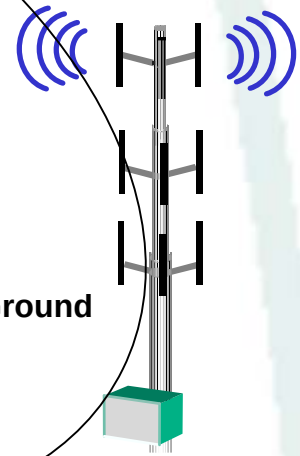


Residential

- **Use of Existing Structures for placement of antenna**
- **Low visual impact**
- **Open Access for all WSPs**

Base Station "Hotel"

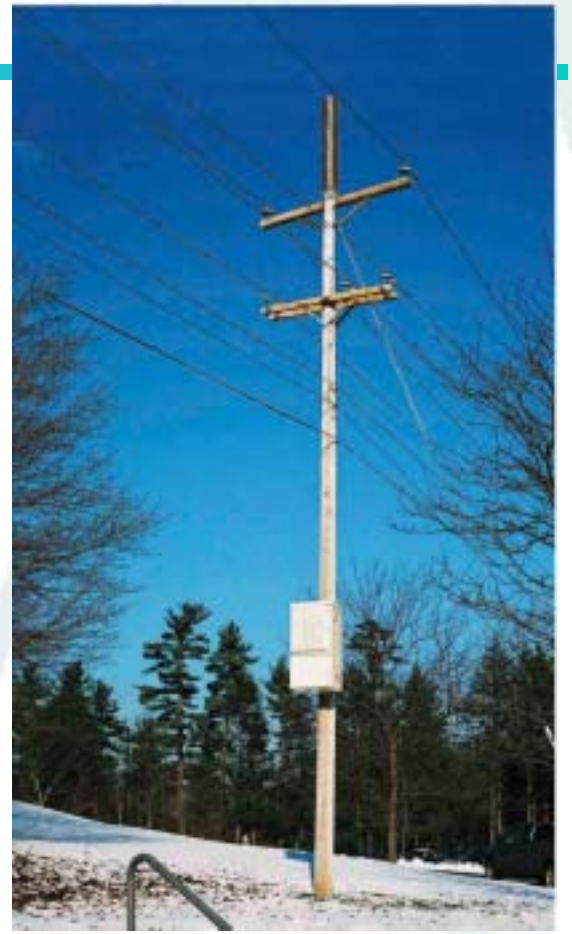




Limited Ground Space

Deployment Concepts

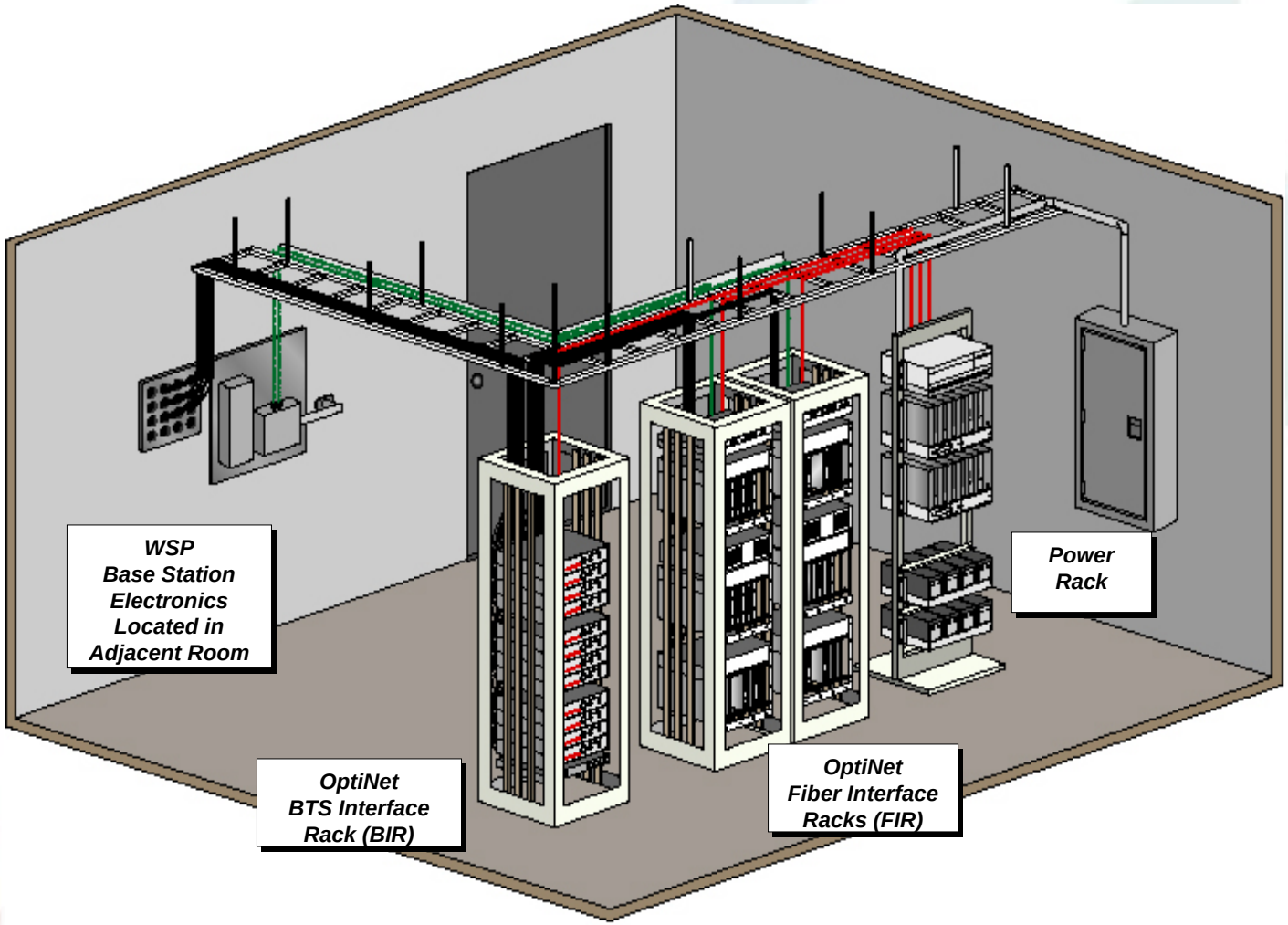
- Utility Pole Deployment
- Two Boxes, One Antenna
- Up to 4 Wireless Carriers per Box



Multi-band Pole Top Antenna

- PCS, Cell, SMR Bands
  - 806-894 MHz (Cell,SMR), 2.5 dBi gain
  - 1850-1990 (PCS band), 9 dBi gain
- Horizontal Beamwidth: Omni-directional
- Vertical Polarization
- Vertical Spatial Diversity
- Available With 2” or 9” Radome
- Height: 8 Feet
- Integral GPS antenna
- Five Feed Cables

Typical Hub Layout



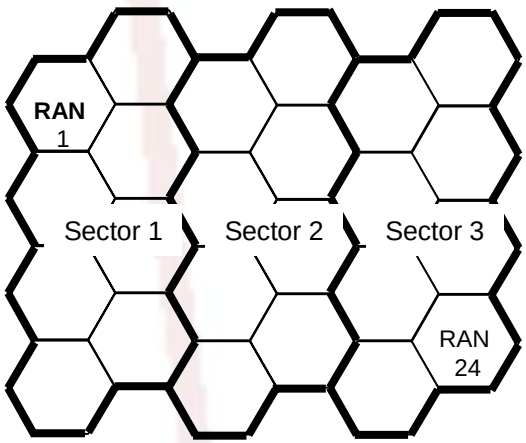
RF Coverage Range

- **Coverage range between .25 to .5 miles**
  - Actual designs & performance driven by local terrain and topology
  - Suburban w/ building penetration, antenna height of 42 ft, typical
- **RF link (forward and reverse) balanced across all protocols**
  - Forward link trades carrier count for range (set by PA power)
  - Reverse link trades number of RANs in simulcast for range (NF)

Customized RF Coverage

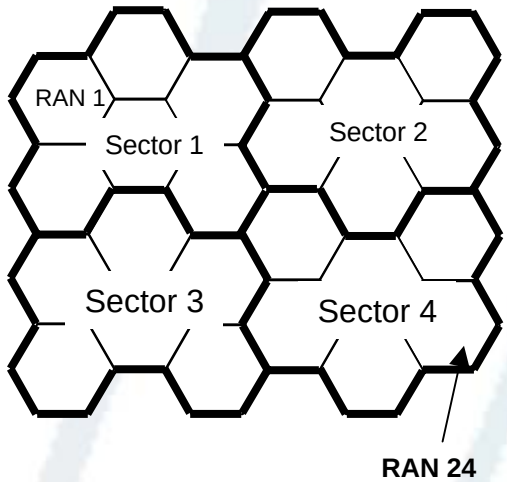
- Each diagram represents a different tenant slice of the same co-located RANs

Tenant Number 1
Simulcast of 8
3 BTS Sectors of Capacity

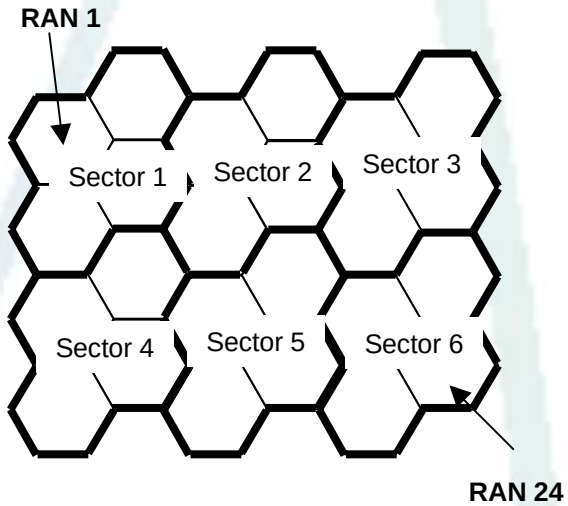


Coverage scenario

Tenant Number 2
Simulcast of 6
4 BTS Sectors of Capacity



Tenant Number 3
Simulcast of 4
6 BTS Sectors of Capacity



Capacity scenario

Deployment Logistics

- Wireless carrier owns and manages its BTS systems Hub site
- Network designs coordinated by Crown Castle with wireless carriers
- Physical and Operating System security is maintained by Crown Castle
- OptiNet™ network elements are monitored and controlled separately by Crown Castle
  - Each WSP tenant functions in distinctly separated manner
  - Robust monitoring and control capability built into OptiNet™, via SNMP based MIBs

First Deployment-Indiana Twp., PA

Trial Objectives – To Demonstrate….

- Quality of Service within coverage area
- Transparency to BTS functions
- Isolation specs exceeded between WSPs
- Reverse Link-Desensitization Verification
- Expandability/interoperability of OptiNet™
- OptiAccess™ NMS capabilities

Call Processing

- **Maximum call loading – Maximized # of calls/carrier**
  - Initiated maximum number of calls with available channels
  - Used OCNS to simulate load (CDMA)-Forward Link
  - Used 9 dB Pad for In-Vehicle Loss
  - No call performance degradation under loaded conditions

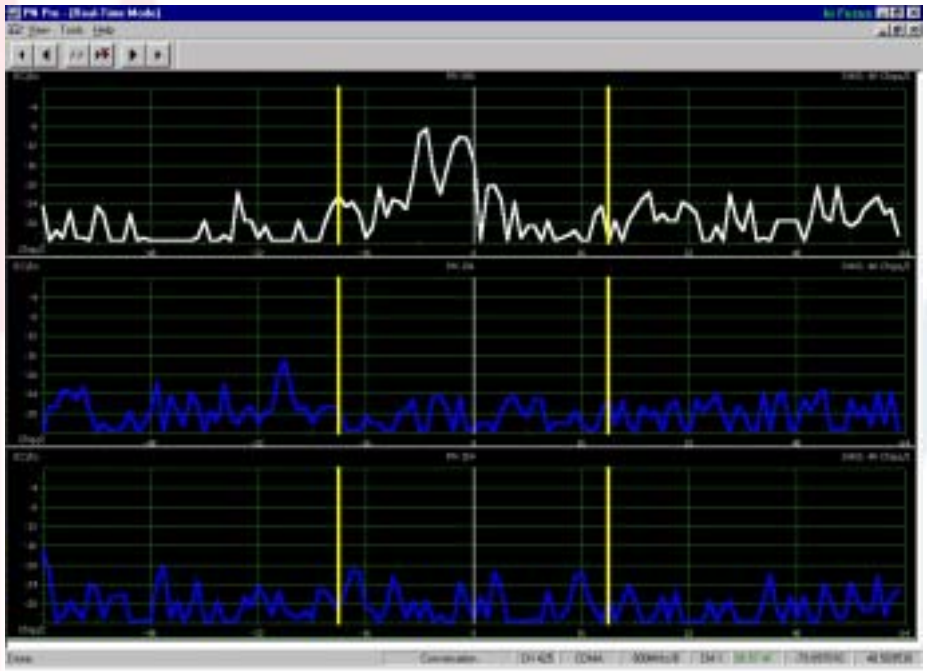
Hand-off Performance

- **Hand-off Testing - Successful**
  - Simulcast – RAN to RAN (microcell) within Simulcast boundary
    - **100% success for both WSPs**
  - RAN to RAN – Between Sectors on each RAN location
    - **100% success for both WSPs**
  - RAN to Macrocell and Macrocell to RAN
    - **100% success for both WSPs**
- **Maximum fiber delay – 10 miles**
  - No impact to performance (hand-offs, coverage)

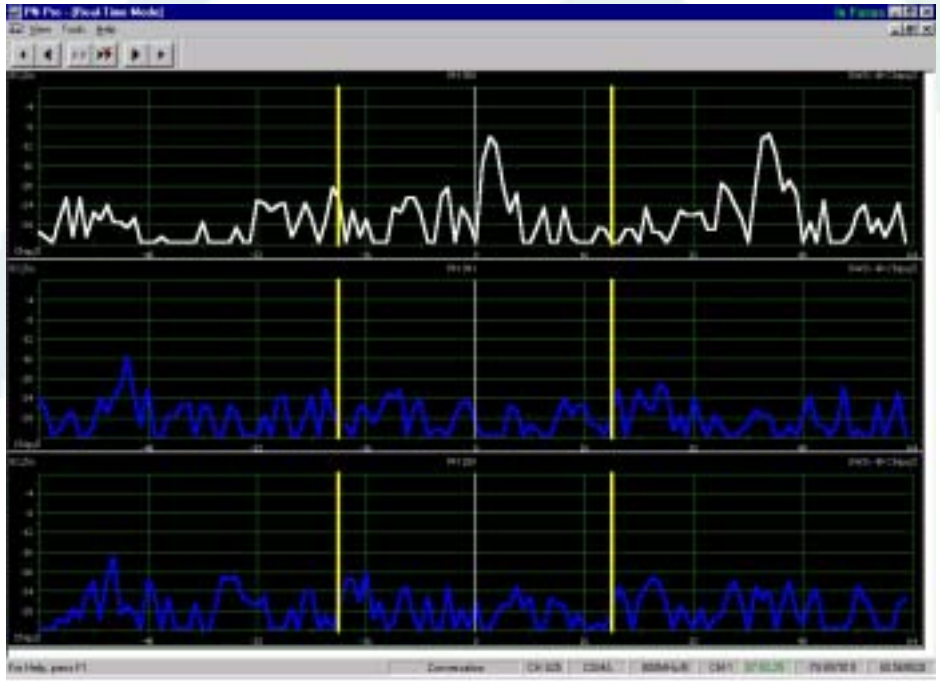
OptiNet™ Meets WSP Needs

- **OptiNet™ Provided RF Coverage Hole Application for WSP1**
  - WSP1 had marginal coverage in trial area
  - OptiNet™ provided solid RF coverage to fill holes
  - OptiNet™ also filled gaps because of difficult terrain
- **OptiNet™ provided Capacity Improvement for WSP2**
  - WSP2 had some existing coverage in trial area
  - OptiNet™ provided added capacity
  - OptiNet™ integrated seamlessly with existing macrocellular network

Delay Management



2 usec skew (standard configuration)



16 usec skew

- GPS based delay management
- Optimize rake rx and search window

Multi-Tenant Isolation Testing

- Georgia Tech Isolation Testing - Met or exceeded performance
  - RAN isolation – TX/TX
    - Target 70 dB
    - Measured > 80 dB
  - RAN Isolation - TX/RX
    - Target: No noise rise in receive band
    - Measured: Noise rise not detectable
  - Hub isolation – TX-TX
    - Target: 30 dB
    - Measured: > 80 dB
  - Hub Isolation - TX/RX
    - Target: No noise rise in receive band
    - Measured: Noise rise not detectable

Multi-Tenant Isolation and Data Tests

- **Multiple Tenant Data and Call Quality Verification**
  - Compared WSP1 mobile data with WSP2 off (on RANs) vs. on
  - No noticeable differences in SQE and RSSI
  - Same results when WSP2 measured
- **Desensitization Drive**
  - Purpose: To demonstrate that non-tenants would not cause call quality degradation on either the forward or reverse path for the tenants on the OptiNet™ network.
  - Successful for all tenants.
- **Tests Successfully Verified Call Quality and Data Throughput Under Loaded and Unloaded Conditions**

Trial Summary

- **OptiNet™ Trial Was a Success!**
  - Functional performance met all objectives
    - **Call origination/termination, hand-offs, isolation, integration with macrocells**
  - OptiNet™ performed reliably throughout trial
    - **No unplanned outages**
  - OptiAccess™ NMS was used to configure, manage, and monitor OptiNet™

Quotes From Pittsburgh Participants

"Call quality and handoff performance same as macrocell network - - very good!"

—Scott Harlan, Performance Team

"Call performance and coverage has been fine and no problems seen integrating with existing network"

—Derek Dragisich, Performance Engineer

"Isolation measurements not even close to being a potential problem"

—Dr. Barry Mitchell, Senior Research Engineer, Georgia Tech Research Institute

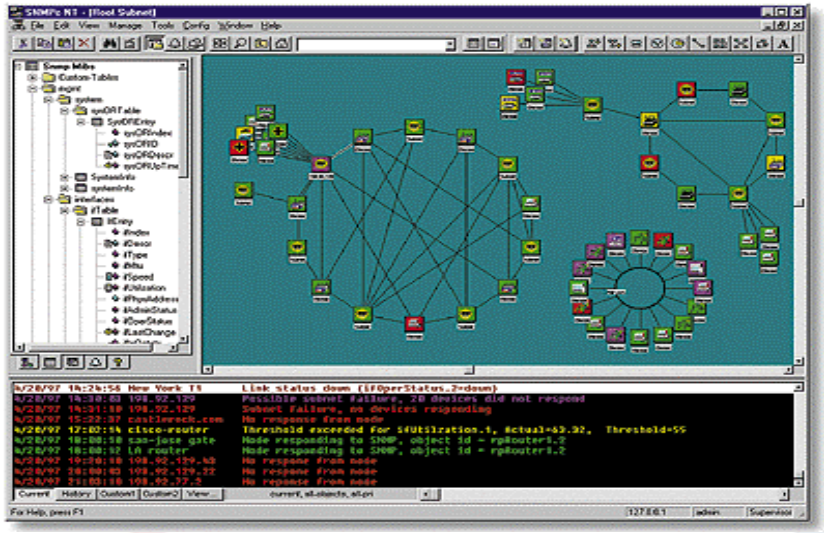
"Installation and optimization has gone very smoothly and has not been a problem"

—Ron Farrell, Performance Manager

OptiNet™ Benefits

- **Economical Solution**
  - Network cost sharing – Zoning/permitting, fiber build, pole rent, etc.
  - Reduced opex – Central hub for reduced Telco, maintenance, rental space, utilities, etc.
  - Better capex utilization of base station and switch investment
  - Alternative to traditional expensive urban deployments (roof tops)

OptiNet™ Benefits (continued)



- **RF Design Flexibility, Autonomy, & Remote Access**
  - Independent RF control & optimization
  - Increased infrastructure utilization - Up to an 8-to-1 simulcast from a single BTS sector
  - Surgically place RF to meet coverage & capacity requirements
  - Fully digital system that supports all wireless protocols. 2.5/3G compatibility.
  - Robust NMS, OptiAccess™, and carrier grade NOC

OptiNet™ Benefits (continued)

- **Low Visibility, More Esthetically Appealing to Local Zoning**
  - Improved time to market – Zoning friendly
  - Alternative to costly stealth installations
  - Capture untapped residential market revenue. Increased ARPU on average 30-40%.
  - Reduced opex costs by replacing most expensive site locations.

Adding Value

Creative Solutions for that “No Solution” Neighborhood

Thank You