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# 802.11n and Outdoor Mesh Wi-Fi: Market and Standards Update

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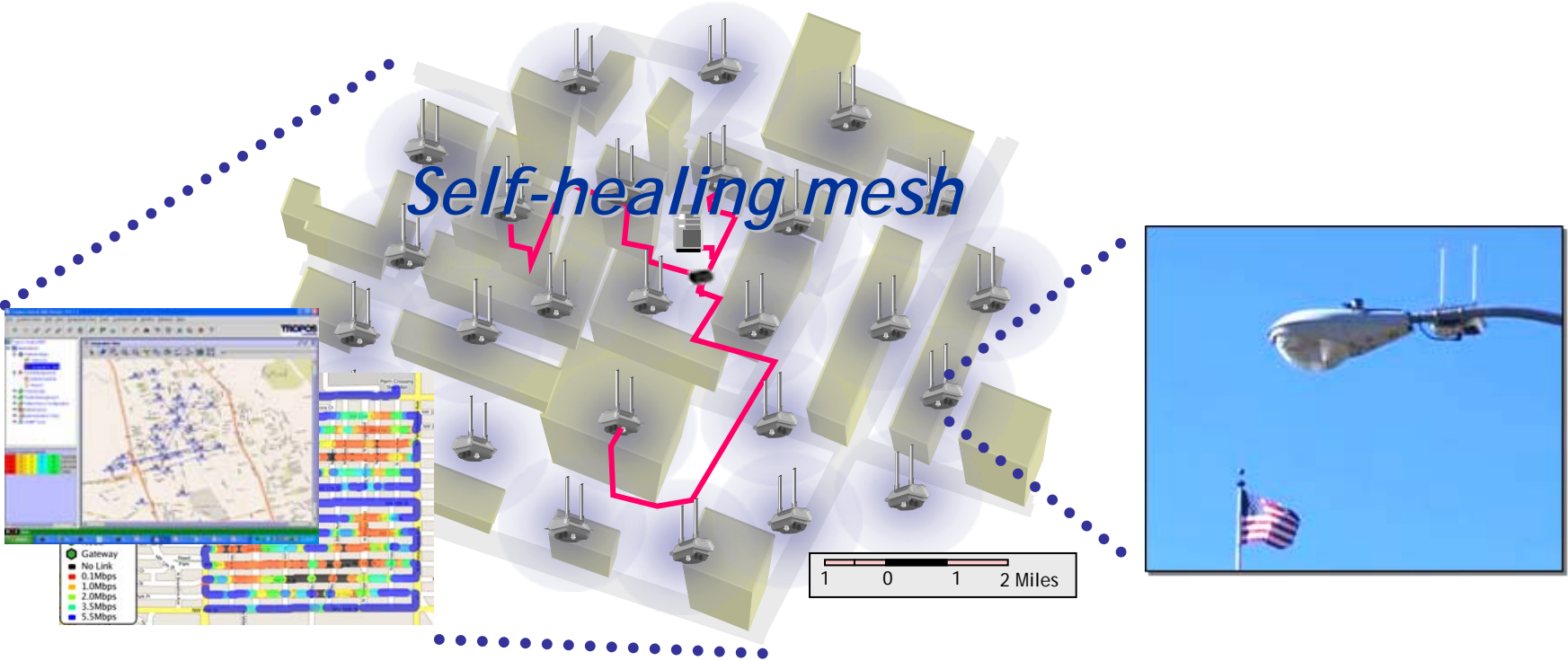
# Outline

- Brief Technical Overview of Mesh
- Status and Recent News
- Real Success Examples
- 802.11n Features and Update
- 802.11n in the Outdoors

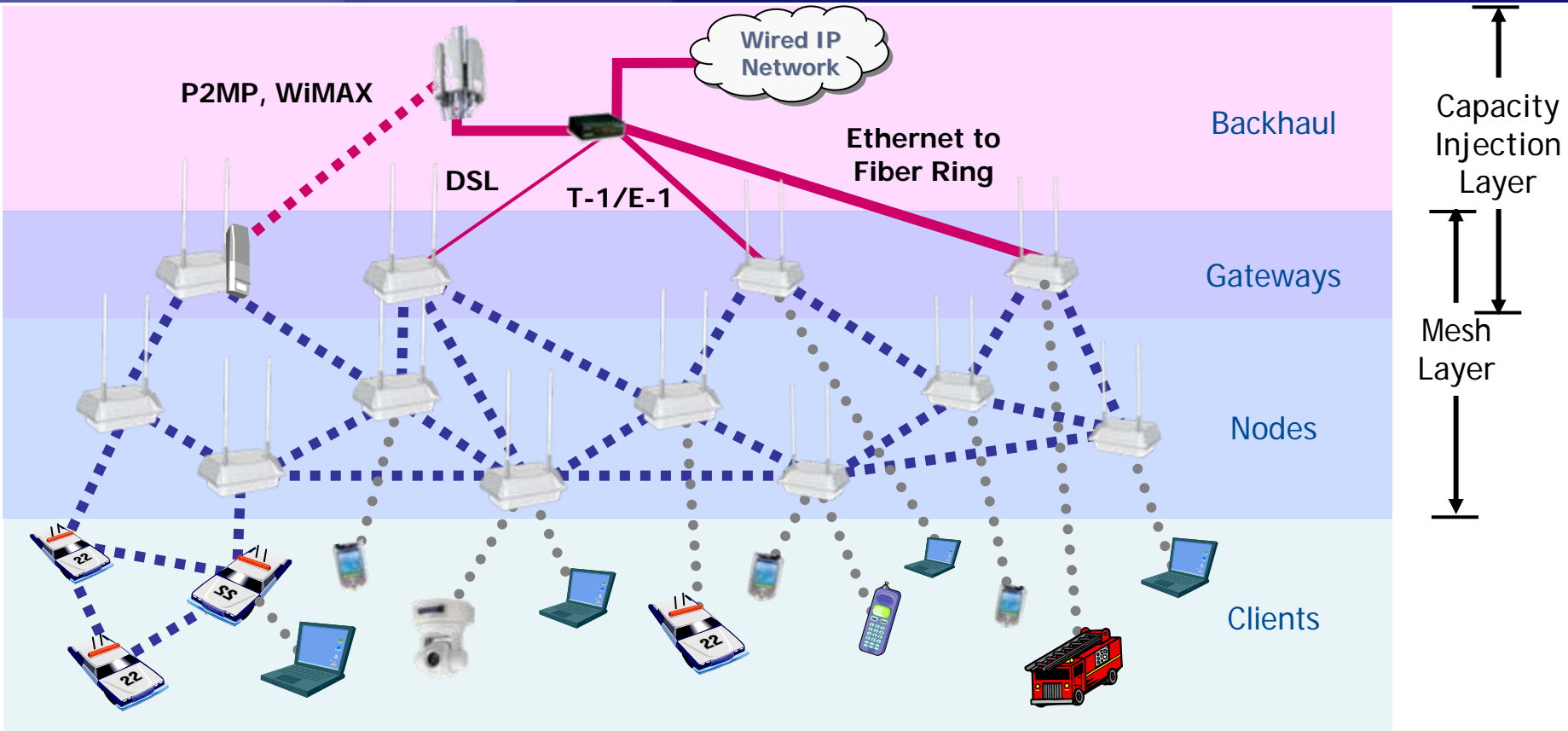
# Large-Scale Outdoor Systems

- Not home
- Not enterprise
- Not Starbucks
- Not one or two outdoor “access points”
- Large system spanning several square miles or square kilometers

# High-level Mesh Network Components



# High-level Mesh Network Architecture



- Fully distributed Mesh with no single point of failure
- Deploy Mesh Layer for coverage
- Inject capacity by adding Gateways / Backhaul

# Technical Advances

- Automation for Scaling
  - Dynamic Discovery
  - Dynamic Routing
  - Automatic Power and Rate Control
- Low-power clients
- Advances in reducing airtime occupancy
- Multiple radios and routing
- Network management
  - Software update
  - Statistics
  - Deployment

# Recent news sounds bad

- Earthlink leaves the “muni Wi-Fi” market
  - Philadelphia
  - Corpus Christi and Milpitas
- Kite Networks goes bankrupt
- Within the last week, MetroFi
- All these networks provided a usable service
- Technology was not the primary problem
- Conclusion: Free or low-cost internet access model does not generally work in current times

# There are positive examples

- Some cities are finding value in providing access to citizens, just not as well publicized
  - St. Cloud FL
  - Minneapolis, MN
  - Chaska, MN
- Well-known stories of networks providing service in an emergency: New Orleans (post-Katrina) and Minneapolis (I-35 bridge collapse)



# But more importantly...

- Meaningful advantages for city enterprise applications
  - Public safety (e.g., police, fire)
  - Public works
  - Building inspectors
  - Mobile City workers
  - Video Surveillance
  - Etc.

# Oklahoma City, OK

- **Coverage:**

- 640 sq miles
- 1,100 fixed nodes and 800+ mobile nodes

- **Applications:**

- Mobile Public Safety
  - Police and fire officers have broadband access to critical databases; file reports from the field
  - Tiburon CAD
  - ArcSDE Database Server
- Video Surveillance
  - 300 fixed IP cameras
- Mobile City Operations
  - Public Works Databases
  - Building Inspections
  - Zoning record access
  - Messaging with central office

- **Results:**

- Improved police/fire response times
- Reduces time for Utilities/Planning field workers to obtain information and file reports



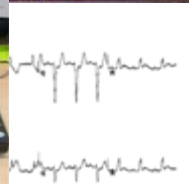
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# Tucson, AZ

- **Coverage:**
  - 225 sq miles
  - 308 fixed nodes and 17 mobile nodes
- **Applications:**
  - Mobile Telemedicine (e-Bridge)
    - Video relay from EMT vehicle
    - Telemetry data (EKG & Vitals)
    - Two-way communication between Doctor, EMT/Patient
  - Intelligent Transportation System
    - Traffic signal control
  - Considering: Mobile Police, Fire; Regional Expansion
- **Results:**
  - Hospital better prepared to treat trauma patients, saving lives
  - Eliminated \$200,000/year in traffic signal management telco costs (vs T1 leased lines)



# Milpitas, CA

- **Coverage:**

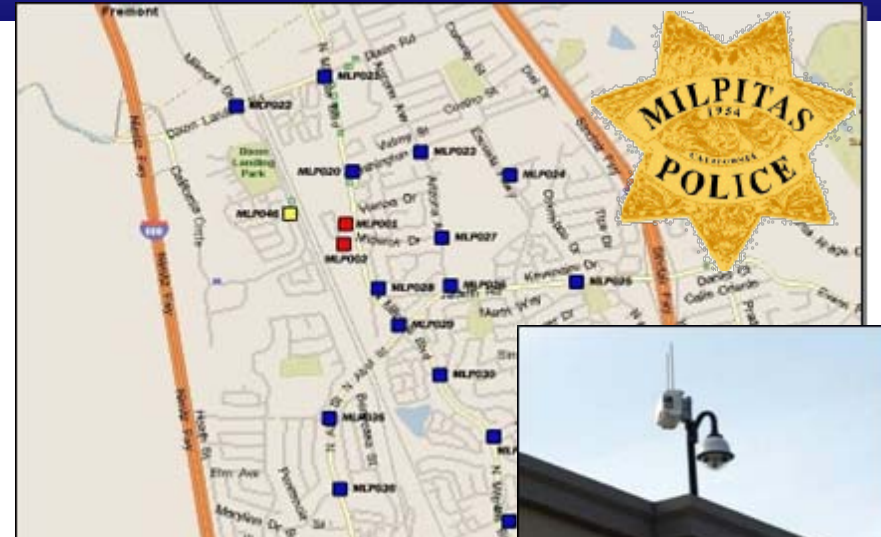
- 13.5 sq miles
- 300 fixed nodes and 50 mobile nodes

- **Applications:**

- Mobile Public Safety
  - Broadband connectivity to city's 30 police patrol vehicles and 20 fire trucks
  - Tactical fixed Video Surveillance
  - Vehicle dispatch via GPS
- Public access

- **Results:**

- Reduced response time by mobile emergency personnel up to 30%, improving community safety and saving lives
- Mobile access to DMV, gang, and other databases has raised effectiveness of police officers





# Municipal Communication Trends

- Municipalities harnessing the ubiquity of Wi-Fi
  - 440M Wi-Fi chipsets will ship in 2008 -- added to the hundreds of millions already shipped
  - Cost-efficient products, large installed base of devices for range of voice, data, video applications
- Municipalities maximizing ROI through multi-use
  - Leveraging Wi-Fi infrastructure for multiple applications
  - Servicing multiple constituents with common network
  - Network securely shared by municipal workers -- public safety, utilities, traffic management, building inspectors, ...
- Leveraging industry standards with Wi-Fi and IP networking
  - Accommodates wide range of applications
  - Provides benefits of vendor choice and superior economics
- Municipalities Building vs. Renting
  - Flexibility to add coverage and capacity where needed
  - Ability to set prioritized access for mission-critical apps
  - Resiliency and fault tolerant architecture
  - Higher capacity for bandwidth-intensive applications such as video

# IEEE P802.11n Update

- In progress for over 4 years
- Have voted on 4 official drafts, Draft 5.0 to be voted on within a month
- Draft 1.0 received 12,000+ comments
- Draft 4.0 received just 349
- Wi-Fi Alliance has already certified 200+ products to Draft 2.0 document

# 802.11n is many things

- More than just “MIMO” [multiple-input, multiple output]
- PHY and MAC changes

# PHY

- 40 MHz channels in addition to 20 MHz
  - Coexistence issues
- Support for up to 4 spatial streams
  - Up to 600 Mb/s data rate with 4x4 @ 64-QAM, 40 MHz, highest coding rate 5/6
- Beam-forming support
- Space-time block codes
- Short guard-interval

Refs: General PHY tutorial: <http://www.wirelessnetdesignline.com/showArticle.jhtml?articleID=199601155>

IEEE P802.11n Draft 4.00, Section 20, March 2008.



# MAC

MSDU Aggregation	Extended Range	Power-Save Multi-poll PSAD/MMP	EIFS
Block Ack	Reverse Direction Data flow	Coexistence	Capabilities
PSDU Aggregation	HT Control Field	EPP (PLCP spoofing)	Link Adaptation

Refs: IEEE 802.11 document 11-05-1221r1

PSMP doc: [http://www.cwnp.com/community/index2.php?option=com\\_content&do\\_pdf=1&id=57](http://www.cwnp.com/community/index2.php?option=com_content&do_pdf=1&id=57)

# 11n in the outdoors

- Maximum ratio combining
  - Provides significant advantage compared to simple selection diversity
- Higher modulation (64-QAM) and code rates (up to 5/6)
  - Virtually impossible to achieve the SNR necessary to utilize these modulation/coding schemes outdoors at any distance
- Channel bonding
  - Doubles the noise bandwidth, other than niche applications not so useful. Coexistence worries?
- Multiple spatial streams
  - Needs more investigation, will there be enough scattering?
- Transmit beamforming
  - Generally complicated and expensive. Has been used in other industries and is being researched heavily. Claimed gains have not often worked out in practice.
- Packet aggregation
  - Improve efficiency by joining packets and ACKs. Likely will be useful for outdoor networks.

# Future expectations

- Final 802.11n amendment complete mid-2009
- 11n becomes the default (just as 11 to 11b to 11g)
- Wi-Fi Alliance will certify to completed amendment
- VHT study group already well underway on the next thing (Gb/s WLAN?)
- Expect that to be a task group by the end of this year (perhaps 802.11ab)

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